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FOREWORD

Researchers' responsibility does not end with conducting research, data collection and generating information or knowledge. They have obligation to publish and share research results to the public and professional community. It is only through this process that their research findings enter to the existing knowledge database and serve as a building block for the advancement of science in their field of investigation. It is only by doing so that researchers could show the relevance of their efforts to the development agenda of the country and also encourage government and donors to allocate adequate budget and facility for research. Therefore, publishing research results is as equally important as conducting research. In view of this fact, the Amhara Region Agricultural Research Institute is pioneer in organizing annual completed experiments review forum in the National Agricultural Research System. In this forum each research finding is critically evaluated, compiled and finally made available for users in the forum of proceedings. In the current proceeding numbers of research findings of immense relevance to the end users are compiled in the fields of crop and livestock production, forestry, soil and water management, and agricultural mechanization. I greatly hope that the research results in this proceeding would have impact towards improving agricultural productivity in our region and the country at large. The proceeding would also be a valued reference material for researchers, University lecturers, agricultural extension workers and investors in agriculture. Finally, I would like to thank those who shared their research findings in this proceeding and also encourage all researchers to publish their findings. I also would like to acknowledge the editor and reviewers for their technical input reflected on the scientific standard of this proceeding.

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AGRICULTURAL MECHANIZATION AND FOOD SCIENCE RESEARCH

Evaluation of naturally ventilated bulb onion storage structure around Ribb river

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Abstract

A comparative study of naturally ventilated bulb onion storage structure and traditional floor storage was conducted around river Ribb area in Fogra district, Ethiopia to determine their performances. Bulb onion of Bombay Red cultivar was stored for 90 days in naturally ventilated storage structure and on floor storage system inside the farmers' house. The study was conducted from end of April to Jun 2011. Hourly temperature and relative humidity of ambient and storage environment were monitored and physiological weight loss, sprouting and rotting percentage, and percentage of marketable bulbs for stored bulb were recorded at ten days interval. Results showed that the temperature profile of tha naturally ventilated storage structure followed similar pattern with the ambient environment. Higher relative humidity was recorded for the ambient and floor storage environment. Physiological weight loss of stored bulbs increased with an increase in storage period for both storage methods and higher values were observed in floor storage method.

Introduction

Bulb onion (*Allium cepa L.*) is one of the major commercial vegetable crops grown in most parts of Ethiopia. It forms part of a daily diet in almost all households throughout the year. The bulbs are used for flavoring of different food stuff which are directly consumed and also used as a preservative for food items that are shelved for quite some time. It is the most important source of incomes to small holder farmers, women and young people including all actors engaged in the production-consumption chain.

Bulb onion is currently produced by smallholder farmers around *Rib*b river of *Fogera* district. High water content and low pungent Bombay Red cultivar is widely adopted in the area. The production is mainly based on irrigation using the river *Ribb* during the warm climate season and the fresh produce is available in market from February to March. In the study area, onion is traditionally stored for a few days using conventional methods. These include: using fiber jute sacks, open shades in the field and floors in a house. Onion, having high water content, is a delicate product to store. It can be stored at low temperature (0-5 ^{O}C) and high temperature (25-30 ^{O}C) and relative humidity of 55-70%. The high perishable nature of bulb onion coupled with poor market and absence of improved storage structures has resulted to high postharvest loss. This has forced farmers to sell onion at any price set by dealers in the chain. Improved farm level storage system is, therefore, required to be evaluated and introduced to extend the shelf life of fresh onion produced, so as to reduce postharvest loss and increase its marketability throughout the year with reasonable price.

Materials and methods

The investigation was carried out around river *Ribb* in *Fogera* district, Ethiopia during April to end of June 2011. The area is located at 11^{0} 58' latitude and 37^{0} 41' longitude with an altitude of 1750 m above sea level which has an average annual rainfall of 1150 mm. Freshly harvested (24 March 2011) bulbs of var. Bombay Red were obtained from the experimental area. The bulbs used for the study were grown at farmers fields. Both the pre harvest and postharvest treatments, which have immense contribution on the effect of storage, were done according to farmers' practice. To hasten bulb maturity the field was trampled by human beings when 10% of leafs have fallen and left for about ten days. Then after, bulbs were harvested with local plow and piled under partial shed. The bulb tops were trimmed at a height of 3-2 cm as practiced by farmers in the area. These bulbs were allowed to dry in partial shed for 4 days under ambient environment so as to remove any traces of water on the surface of the bulbs. They were sorted for absence of defects and only marketable bulbs were filled in to the storage.

The storage methods used for this study were naturally ventilated bulb onion storage structure (NVBOSS) and the traditional method seldom used in the area which employed storing bulbs on floor inside the farmer's house. The foundation of NVBOSS was constructed as raised platform 70 cm above the ground level with down ventilation. This is because the experimental area was flooded during the rainy season up to a height of 70 cm. The storage structure walls were made from 40 cm X 20 cm X15 cm mud blocks and the roof was covered with 15 cm thick thatched grass (Figure 1). The storage was provided with bottom and top shelves for storing the bulbs where these shelves were constructed 25 cm and 125 cm above the plenum, respectively. Shelf width was 90 cm and the capacity of each shelf was estimated to be 0.35 tons. Access door was provided to fill and take out the bulb onion. Even though the constructed storage capacity of NVBOSS was 1.4 tons, only 0.6 tons bulb onion was filled for the test. The floor storage method used for this study was farmer's house. Its roof was covered with corrugated iron on a plinth area of 43 m^2 and a slated wall plastered with mud at the interior side. The first 40 days of storage period in the area was warm and less humid. During this storage period two liters of water was sprayed every two days at the base of naturally ventilated bulb onion storage structure in order to improve relative humidity of the storage environment.

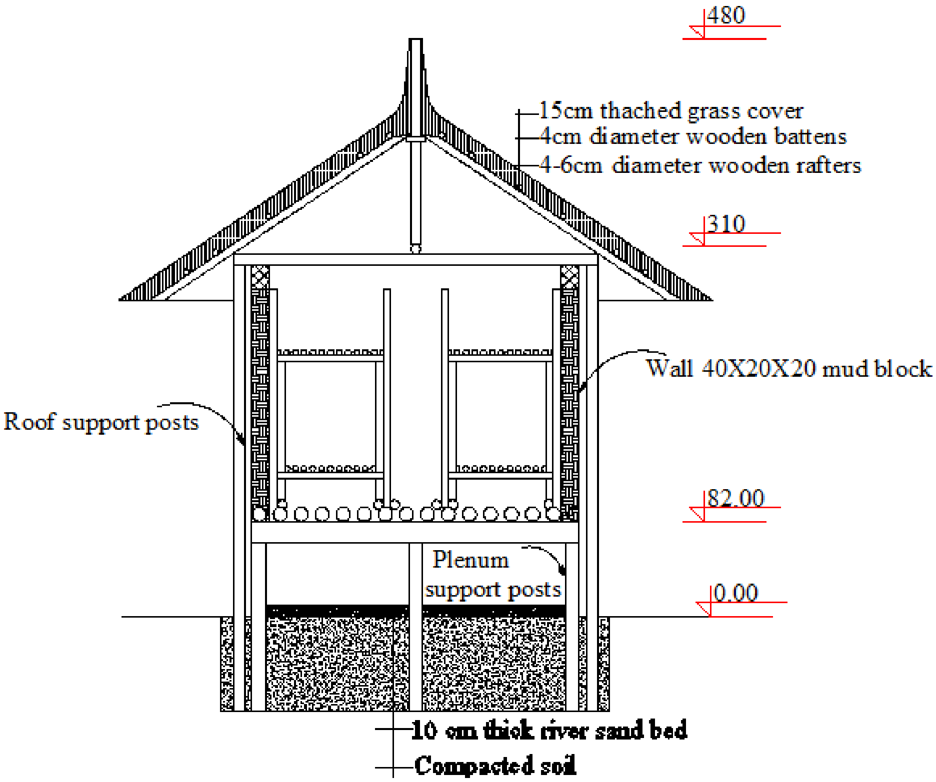

Figure 1. Naturally ventilated bulb onion storage structure.

Known weight and number (n = 70) of randomly selected sample bulbs were kept in grated plastic tray in three locations of each storage at two host farmers. These sample bulbs were visually assessed and weight data on rotting, physiological loss, sprouting and marketable bulb were recorded at ten days interval. A bulb was considered to have started rotting when there exists any sign of decay around the bulb neck and considered sprouted when the sprout leaves had emerged from the neck. The rotted and sprouted bulbs were sorted from the sample container tray after recording so as to avoid double counting (Laike and Shimelis, 2007). The physiological weight loss was measured using sensitive balance (OHAUS Corporation, USA, with an accuracy of ±1 g). The temperature and relative humidity of both the storage and ambient conditions were monitored on hourly basis throughout the storage period using data loggers (WatchDog data logger, Spectrum Technologies, Inc.). While determining the physiological response of bulb onion during storage, initial sample weight is the base for all calculations. The resulting data were subject to t-test using SAS statistical package (SAS Institute, 1999-2000).

Results and discussion

Temperature

The hourly temperature of ambient environment, traditional storage and NVBOSS during the storage period have been monitored as detailed earlier and daily mean value is plotted as shown in Figure 2.

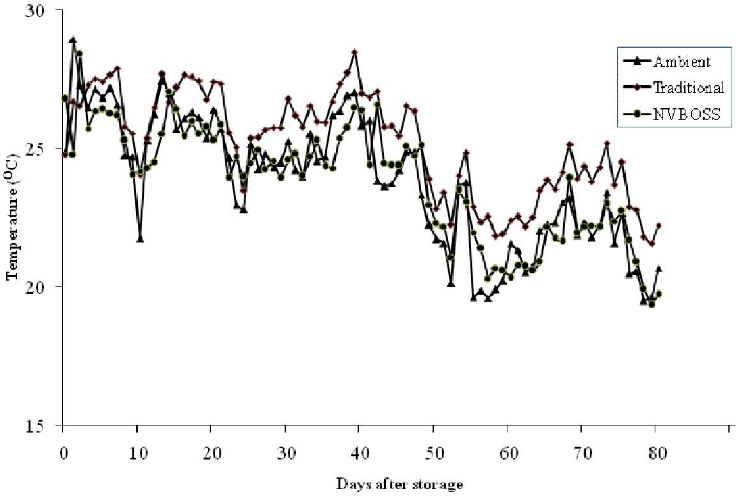

Figure 2. Variation of daily mean temperature of ambient and storage environment throughout the storage period.

The temperature records inside both storage methods follow a similar pattern with the prevailing ambient condition. Temperature records in the traditional storage method was higher than both the prevailing ambient condition and NVBOSS which showed significant ($P<0.05$) variations throughout the storage period. The daily mean temperature of traditional method in most occasions remained 0.4 to 3.3 ^{O}C higher than the ambient and NVBOSS temperature. The higher temperature record of traditional storage is due to high thermal conductivity of corrugated iron roofing and heat coming from dwellers living in it as well as kitchen fire as the house environment is a heat sink. There was no significant ($P>0.05$) variation of temperature records between the ambient condition and NVBOSS. The temperature in both environments for the first 45 days after storage was nearly in the optimum temperature range (25-30 ^{O}C) for bulb onion storage. After mid May, the ambient and storage daily mean temperature decreased below 25 ^{O}C, which is lower than the optimum temperature for bulb onion storage.

Relative humidity

The daily mean relative humidity records of both ambient and storage environments during the storage period have been recorded and plotted as shown in Figure 3.

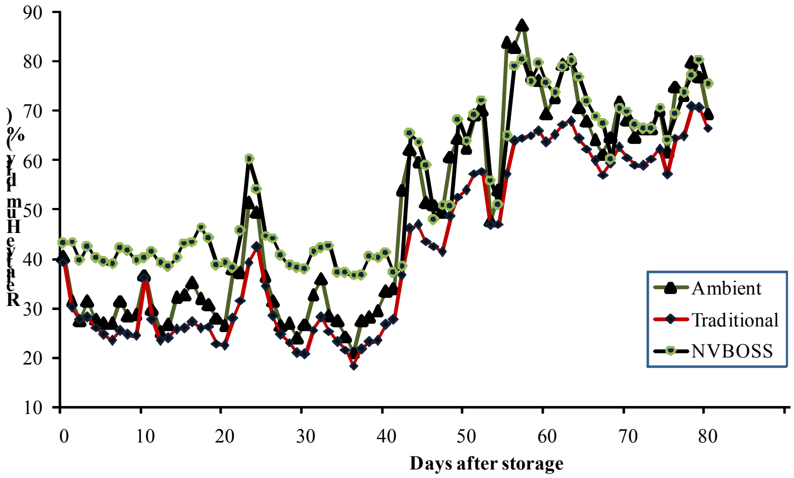

Figure 3. Variation of daily mean relative humidity of ambient and storage environment throughout the storage period (t-test at $P<0.05$).

The ambient relative humidity value in the area was very low until 40 days after storage (mid May 2011). During this storage period, the daily mean relative humidity values for ambient environment and traditional storage method were occasionally recorded below 30%. The relative humidity during this period in NVBOSS was around 40% which was still below the recommended optimum value (55-70 %) for bulb onion storage. After the onset of the rainy season, the relative humidity of ambient as well as storage environment has increased and higher values than the desired limit were recorded in ambient and NVBOSS for a few days.

Physiological weight loss

The physiological weight loss of stored bulbs increased progressively with increase in days after storage in both storage methods (Figure 4). The t-test showed significant (P<0.05) variation between storage methods with regards to overall percentage physiological weight loss of stored bulbs within 80 days after storage.

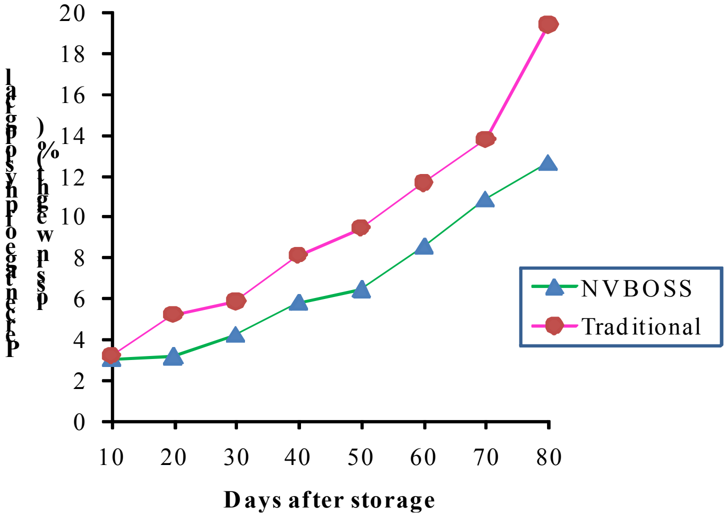

Figure 4. Effect of storage method and period on percentage of physiological weight loss in stored bulbs.

The percentage of physiological weight loss for bulbs stored in traditional method was higher than bulbs stored in NVBOSS. This is attributed to the lower relative humidity records in the traditional storage method during the first 40 days after storage. The initiation of sprouting after this time also contributed to increase in physiological weight loss in bulbs stored in both storage methods.

Sprouting loss

Sprouting in stored bulbs is a result of physiological change in which storage can only affect its rate. A perusal of data plotted in Figure 5 revealed that sprouting has not been observed until 30 days after storage in both storage methods. The first visible sprout was observed on the 40th day of storage in both storage methods and this presumably shows that it is the physiological rest period of the onion cultivar under test at the recorded temperature value and preharvest as well as postharvest treatments.

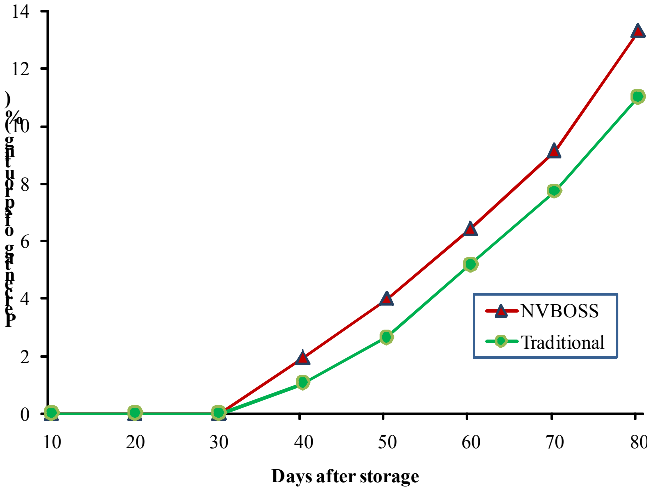

Figure 5. The effect of temperature and days after storage on percentage of bulb sprouting.

The percentage of sprouting in NVBOSS was higher than traditional method as the traditional storage method had higher temperature than NVBOSS. However, the overall sprouting percentage between storage methods throughout the storage period did not show significant (P>0.05) variation.

Percentage of rotting

Rotting was observed in the first 10 days in both storage methods (Figure 6). It was not observed for the rest period until 50 days after storage. The percentage of rotting on 50th day was 2.41% and 3.31% for NVBOSS and traditional method, respectively. It has shown an increasing trend with increase in storage periods for both methods and the values observed on the 80th day was 10.62% and 11.16% for the respective storage methods. The percentage of rotting in traditional storage was higher when compared to NVBOSS. However, the overall value did not show significant (P>0.05) variation. The occurrence of rotting during the first storage periods is attributed to availability of some moisture traces on the surface of bulb onion. Rotting after 40 days of storage was mainly due to higher relative humidity as this aggravates rotting.

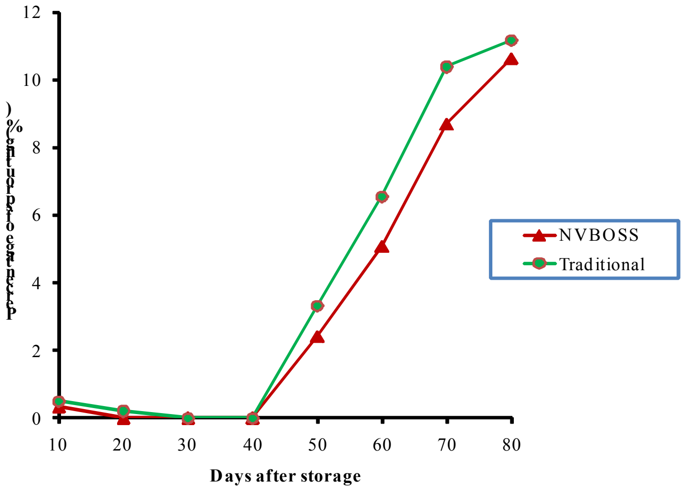

Figure 5. Rotting of stored bulb onion under naturally ventilated and traditional storages.

Percentage of marketable bulbs

The percentage of marketable bulbs in NVBOSS was significantly higher (P<0.05) than the traditional storage throughout the storage period. It decreased with an increase in storage time in both storage methods (Figure 6).

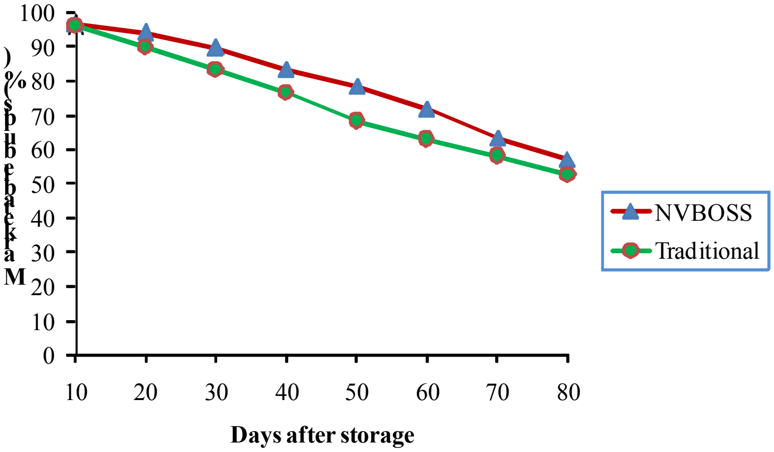

Figure 6. Percentage of marketable bulb under naturally ventilated and traditional storages.

The maximum percentage of marketable bulbs on the 10th day after storage was 96.9% and 96.3% for the NVBOSS and traditional method, respectively. This value has decreased to 78.6% and 68.5% on the 50th day after storage for the respective storage methods and storage after this time is uneconomical as percentage of marketable bulbs showed a remarkable decrease with increase in storage time.

Conclusion and recommendations

Based on this study, overall loss of bulb onion in traditional storage is higher than NVBOSS. This is due to the lower relative humidity which is below the optimum for bulb onion storage. This indicates that Bombay Red can be stored using naturally ventilated bulb onion storage structures at river *Ribb* area up to two months with a tolerable loss until market is secured. The structure can be built from locally available materials and skill with a reasonable cost.

References

Altaf Qadir, Fumio Hashinaga and Md Rezaul Karim. (2007). Effect of Pre-storage Treatment with Ethanol and CO_2 on Onion Dormancy. J. bio-sci. 15:55-62, 2007.

B. Herold; B. Oberbarnscheidt; M. Geyer. (1998). Mechanical Load and its Effect on Bulb Onions due to Harvest and Post-harvest Handling. *J. Agric. Engng Res*. (1998) 71, 373-383.

Gemma Amy Chope. (2006). Understanding the mechanism behind onion bulb dormancy in relation to potential for improved onion storage. PhD Thesis submitted to Carnfield University. Cranfield Health Plant Science Laboratory. Retrieved date:04/05/2011. https://dspace.lib.cranfield.ac.uk/.../1826/.../Gemma_Chope_Thesis_ *2006.p.*

Laike Kebede and Shimelis Aklilu. (2007). Development of Naturally Ventilatrd Onion Bulb Storage Structures. P. 128-136. In Firew Kelemu, Omar Taha and Gessessew Likeleh (Eds.) Proceedings of the first National Agricultural Mechanization completed research forum. June 5-7, 2007.

Laxman Kukanoor (2005). Post harvest studies in onion. PhD Thesis submitted to the University of Agricultural Sciences, Dharwad. Retrieved date: 18/04/2011 http://etd.uasd.edu/ft/th8441.pdf

SAS, 1999-2000. Statistical Analysis System User's Guide: Statistics. SAS. Inc. Cary, North Carolina.

Development and testing of pedal operated seed cleaner

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Abstract

Seed cleaning is one of the most challenging agricultural tasks facing the farmers in the countryside. Farmers still use traditional ways of seed cleaning using equipment such as 'sefed' and 'wonifete' (sieve) so as to blow by wind. These methods are time and energy consuming; besides, there is a great loss of grain and chaff (straw) during the blowing and removing time. To alleviate the drudgery, pedal operated seed cleaner suitable for smallholder farmers has been designed, manufactured and tested. The test result has shown that the machine can clean up teff at the rate of 200 kg hr^{-1} with 97% efficiency. Whereas, by traditional methods, a woman can clean up 10 kg $manhr^{-1}$, which is ten times less than the capacity of the machine. Hence, this pedal operated seed cleaner can play an important role in alleviating drudgery in areas where electric motor and diesel engine is costly or not available.

Key words: Cleaning, efficiency, threshing.

Introduction

Seed cleaning, in agricultural processing operation, generally does mean the removal of dissimilar and undesirable materials such as low quality seeds, infested seeds of different species (weeds that are foreign to the samples) etc, from the desired grains. This activity can be done by screening, blowing and hand picking methods. The conventional method of threshing, which is being practiced by farmers, is mainly done by the use of animal treading and beating by stick on level ground. Grain threshed by these methods usually contain chaff, pieces of straw, sand, soil, animal waste, dust and sometimes insects.

Cleaning seeds is often one of the most tedious and challenging agricultural tasks facing the farmers every year in Ethiopia. Sowing clean seeds is advantageous to reduce cultivation costs and give increased yields. The price received from grains/seeds can often be substantially increased by a relatively insignificant expenditure of cleaning methods. During storing seeds, rubbish and damage seeds can be susceptible to infections. So, only good quality/viable seeds should occupy the store, but damage or non viable seeds should not be put in the store to prevent the spread of storage pests. Foreign materials get into cereals during transportation, harvesting and handling times. These unwanted materials should be removed from grains and their products for good market values. The quality of flour for bread and macaroni is highly affected by the degree of cleanliness of seeds that go to the product (Hall, 1972). The traditional practices of seed cleaning are by using local equipment such as *sefed, wonifit* (sieve) and *Mankia* (wide basket) to blow the chaff by wind. This classic method of winnowing involves placing seeds in a wide basket and tossing the seeds and chaff into the air. Winnowing by this method is extremely difficult, and the results are not satisfactory. The most vexing part of the process is that wind is always changing in velocity and direction. The method of cleaning is so laborious, time and energy consuming and there is also high loss of grains/seeds during blowing.

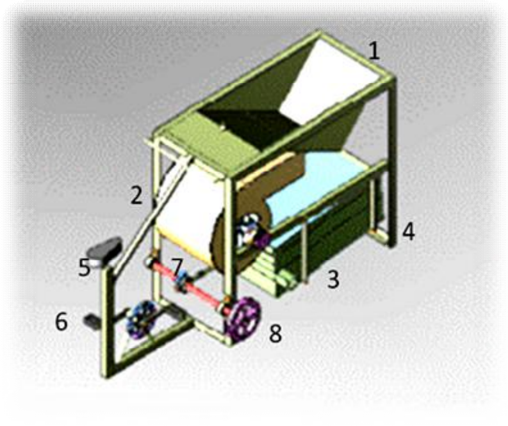
Uhl and Lamp (1966) observe that chaff-like materials were removed from cereals like wheat, rye and soybeans at air velocities of 3.05 m/s which are less than their terminal velocities. Igbeka (1984) has done a test on a cereal cleaner to determine the optimum tilt angle of sieve and found that this angle should be between 4^0 and 5^0 when operating speed is between 300 and 350 r.p.m. Gordn (1986) noted that a person can generate a power of about 0.25 hp by pedalling, which is four times more than by hand cranking. Pedal power enables a person to drive device driven by hand cranking but with less effort and fatigue. Pedal power also enables generation of more power to work at faster rate and even to operate devices requiring much power than that can be delivered by hand cranking. Application of pedal power is possible when the power level required is below a quarter of horsepower (that is below about 200 watts).

To alleviate grain cleaning related problems and drudgery, different kinds of seed cleaning machines were developed by research institutions working in agricultural machinery. One of such machines is a pedal operated seed cleaner developed by Central Institute of Agricultural Engineering based at Bohpal, India. So the aim of this work was to redesign and manufacture this pedal-driven seed cleaner and to evaluate its performance at local conditions.

Material and methods

Pedal-operated seed cleaner

A pedal-operated seed cleaner (Figure 1) is made from angle iron and iron sheet parts. It mainly consist of grain hopper with a slide gate mechanism, sieve box and blower unit. The eccentric mechanism on main shaft is driven by pedal-shaft through sprocket-chain drive and provides reciprocating motion to the cleaning box. The pulley on blower shaft receives the power from main shaft pulley by V-belt. Air draft is created by the blower, which is directed to a free falling grain from the hopper and thus separates the grain from the chaff or light impurities.



1. Hopper
2. Blower
3. Shaking sieve
4. Frame
5. Seat
6. Pedal
7. Eccentric
8. Pulley

Figure 1. Pedal-operated seed cleaner and its parts.

The machine separates impurities from the grain on the basis of size and weight (specific gravity) difference. The feed control mechanism is adjusted so that the grains fall in the form of thin sheet in the cleaning box. The sieves in the cleaning box are selected to suit the grains to be cleaned and are mounted in the cleaning box at their positions. The cleaning box, holding reciprocating sieves, separates grain in grades according to size and removes the heavier and larger impurities from the top sieve.

A mass of grains from the hopper are directed to the upper sieve by gravity and controlled by flow metering device. The lighter foreign materials like chaff, leaves and other impurities are first blown off by air blast, while the heavier straws, stalk and grains slide over the top sieve and fall off as overflow. Separation of grain with the two sieves is achieved by difference in size in which undersized particles and weed seeds pass through sieve to the bottom delivery chute for collection in the rejected container while larger impurities are retained over the top screen and discharged through the outlet located at the end. The cleaned grain are retained over the bottom screen and delivered outside through grain outlet. The dust and small particles which are less than the grain in size will pass through the lower sieve and discharged to the outside through dust outlet.

Machine specification

The specification of the seed cleaner as manufactured for testing was as follows:

a. Overall dimension
   Length (cm) = 120, Width (cm) = 60 , Height (cm) = 100
b. Power requirement - one person
c. Power transmission- Sprocket and chain drive
d. Fun type- Centrifugal 4 (straight) blades
e. Number of sieves- two
f. Connecting rode length (cm) - 50
g. Eccentric radius (cm) - 1

Centrifugal blower

A centrifugal blower is shown in Figure 2. It consists of blower wheel and housing, which are made of iron sheet and shaft. The air enters parallel to the axis but exits perpendicular to the axis, creating a higher pressure more suitable for a sieving. The configuration of the housing considerably affects the performance of a centrifugal blower and this is as important as the blower wheel. The angle developed scroll surface and blower wheel periphery is called the diffuser angle, wheel diameter and diffuser angle determined the shape and dimension of scroll (Sahay and Singh, 1994).

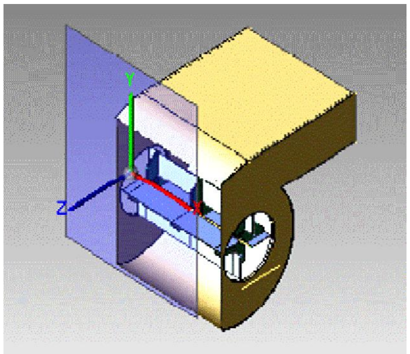


Figure 2. Centrifugal blower.

Screen mechanism

The two screens (Figure 3) were fixed inside screen casing which is suspended by hangers in such a manner that they have horizontal oscillatory and slightly vertical motions. The hanger angle was fixed at 5^0 and both sieves were fixed at 15^0. Since the stroke length of the screen affects the separation of efficiency, it is made to be adjusted by changing the eccentric size, according the crop type. The material for test, which is left, was spread uniformly over the full width of the screen surface and the thickness of the bed was kept to be not more than four times the size of the screen aperture (Sahay and Singh, 1994).

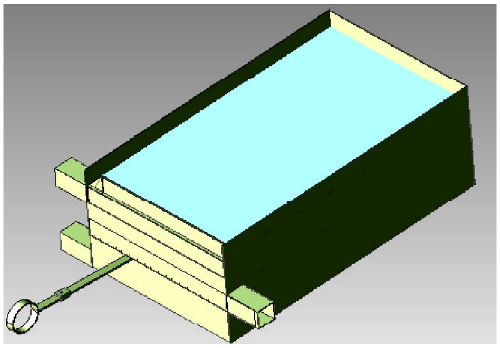


Figure 3. Sieve box.

Machine testing

Two women, an average weight of 60 kg, are randomly selected to perform the experiment. One woman is to clean seed using traditional methods, *Sefed* and *wonifit*, and another woman is to clean seed by pedal operated seed cleaner. The size of the screen opening was selected depending upon the size and shape of the grain to be handled. The teff seed used for the experiment was bought from the market. The cleaning mechanism was first adjusted to the type of seed *(teff)* and tested at three different grain flow rates, 84, 118, and 209 kg hr^{-1}.

For each test run , 5 kg of *teff* was added to the hopper using one variety of crop and three feeding rates with three replications using 60 RPM pedalling speed. During test period three samples of cleaned grain, chaff and dust have been taken at their respective outlets. These samples were further cleaned by hand, and weighed by sensitive balance. During working on the machine, two persons were required: one to operate the machine and another to load and unload the grain.

The machine was tested for its ability to separate whole grain, chaff, stalks and tiny stones. There were four collection points for the test materials, namely:

1. Air passage away from the machine for light chaff, glumes and stalks.
2. Sieve end near to the fan, for heavy materials (over tailings).
3. Container for undersize impurities.
4. Container for whole clean grain.

Cleaning capacity (CC) refers to the quantity of seeds cleaned per unit time. CC was determined by:

$$CC = \frac{W}{T} \times 60$$

Where, CC = Cleaning capacity (kg/hr), W = Clean seed at clean seed outlet (kg), T = Cleaning time (min).

Cleaning Efficiency (η) -The cleaning efficiency of the grain cleaner was determined by:

$$\eta = \frac{(D_{bc} - F_{ac})}{D_{bc}} \times 100$$

Where, η = Cleaning efficiency (%), D_{bc} = The mass of grain and impurities in the sample before cleaning (kg), F_{ac} = The mass of foreign matter left in the sample after cleaning (kg)

The test flow rates, 84,118 and 209 kg/hr, were obtained by adjusting a slide-gate mechanism. The grain and impurities collected from the four containers are separated manually and weighed, then for each feed rate, cleaning capacity and cleaning efficiency were calculated.

Results and discussion

Table 1 shows the result of the grain cleaner tested at three different grain flows. The flow rate 84,118 and 209 kg/hr were obtained by adjusting a slide-gate mechanism. The grain and impurities collected from the four containers were separated manually and weighed, then for each feed rate, cleaning capacity and cleaning efficiency were calculated.

Table 2 shows the performance of manual cleaning using traditional seed cleaning procedures. From the *test* result, it can be seen that the machine can clean *teff* in the ranges of 80-190 kg/hr with an efficiency of 80-97%, respectively. On the other hand, by traditional method, a woman can clean 9-10 kg/man hr which are ten times less than the capacity that can be achieved by using the cleaning machine.

The tables also show that the cleaning capacity of the machine increases from 79.67 to 189 kg/hr as feed rate increased from 84 to 210 kg/hr, respectively. But, the cleaning efficiency barely reduced from 97.46 to 96.97% which is very small change to be any concern at all. Grain loss figures are also more optimal at higher feed, high capacity ranges than at reduced rate.

Table 1. Test result of winnowing by machine.

Test	Hopper outlet (mm)	Time taken (min)	Quantity of seed (kg)	Feed rate (Kg/h)	Samples from different out let			Cleaning efficiency (%)	Cleaning capacity (Kg/h)	Grain loss (%)
					Outlet	Clean seed	Impurity			
T1	2.0 mm	3:57	5	84.03	Chaff	75.56	57.6	97.46	79.67	3.42
					Grain	4706.4	18.6			
					Dust	-	3.0			
					Blown	91.5	47.4			
T2	2.5	2:54	5	118.11	Chaff	24.6	60.9	97.02	110.79	2.33
					Grain	4690.3	28.9			
					Dust	-	2.7			
					Blown	87.6	54.6			
T3,	3.0mm	1:43	5	209.79	Chaff	32.6	69.2	96.95	189.0	2.14
					Grain	4505.6	30.9			
					Dust	-	6.1			
					Blown	66.3	38.5			

Table 2. Test result of manual winnowing.

No	Quantity of seed (kg)	Number of persons	Time taken (min)	Total Time (min)	Samples		Cleaning efficiency (%)	Winnowing capacity (Kg/man h)	Grain loss (%)
					Clean seed (kg)	Impurity (kg)			
1	6	2	18:00	0:36:00	5.415	0.190	100	9.28	---
2	6	2	15:28	0:30:56	5.264	0.235	100	10.21	----

Conclusion

From this experiment it can be concluded that cleaning seed at household level is one of the demanding operations in terms of human labor requirement and this labor need can be reduced by 10 folds using this simple manually operated cleaning device, pedal-operated cleaner. Besides, since women are always the main actors highly involved in grain cleaning operation, besides family responsibility and other agricultural tasks, the pedal operated seed cleaner can play an important role in alleviating their seed cleaning related problems and drudgery in areas where electric motor and diesel engine are costly or not available.

References

Abd El-Tawwab, I.M., Baiomy, M.A. and El-Khawaga, S. 2007. Design and fabrication of a local rice separating machine. J. Agric. Sci. Mansoura Univ., 32 (7):5355-5368.

Gordon, D.W. 1986. Understanding pedal power. Arlington, Virginia: Volunteers in Technical Assistance (VITA).

Hall, C.W. 1972. Processing Equipment for Agricultural Products. AVI publishing company Inc. Wesport conneticut.

Igbeka, J.C. 1984. Agricultural mechanisation Asia, Africa and Latin America 15(2):67-70.

Sahay, K.M. and Singh, K.K. 2003. Unit Operation of Agricultural Processing. VIKAS Publishing House Pvt Ltd New Delhi.

Uhl, J.B. and Lamp,T. 1966. American Society of Agricultural Engineering . pp.244-246

Performance evaluation and demonstration of direct solar potato dryer

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Abstract

The study was conducted to evaluate the performance of two models of direct solar potato dryers and to demonstrate the best drier to farmers in major potato producing areas in the Amhara region. Type 1 (wooden box) dryer and Type 2 (tent) dryer models were evaluated. Both were compared with open sun drying methods. Temperature, relative humidity, and rate of moisture removal as expressed by loss-in-weight were recorded and analyzed. Results showed that on average there was a 10-20 ^{0}C temperature difference between ambient condition and the drying chambers. Besides, the weight of sliced potato which was initially 0.9 kg was reduced to about 0.19 kg within two days of drying. There was an overall reduction in drying time by 2-3 hours compared to open sun drying. This result, however, was not perceived to be large enough under existing testing condition. But, considering other benefits of the driers like protecting the material against contaminants, dust, and insects and maintaining better quality product, this result is acceptable. Of the two driers, Type 2 dryer was found better in creating more conducive drying environment with higher temperature and lower relative humidity. Moreover, considering manufacturing costs and simplicity in design and construction, type 2 dryer is still better than Type 1 dryer. Demonstration and practical training on the use of solar dryers and methods of food preparation out of the dried potato slices was provided for a group of farmers. This dryer is suitable for drying small quantities (10-15 kg) of granular materials and is recommended for use at household level.

Key words: Potato, solar drier.

Introduction

Drying as a means of preserving agricultural products has been practiced since ancient times. It is one of the postharvest operations for biological materials as quality of these materials is influenced by drying. Crops such as fruits, vegetables and cereals can be well preserved after removing free water by means of drying. Moreover, the main purpose of drying agricultural product is to store for longer periods, minimize storage and packaging spaces and reduce weight to handle and transport. Open sun drying with the application of traditional knowledge is still widely practiced throughout the world and largely unchanged since ancient times. This method employs spreading the crop on the ground and turning regularly until the product is sufficiently dried. However, it has inherent limitations in that it requires large amount of space and extended drying time. The crop will also be damaged because of the hostile weather conditions, will be contaminated with foreign materials, and will be degraded by overheating. Besides, products will be subjected to series insect and fungal infestation and also might be susceptible to re-absorption of moisture. In such conditions, solar operated crop dryers appear to be viable alternative to the traditional open sun drying where quicker and controlled drying process can be attained and crops can be well protected during drying.

Solar thermal technology is a technology that is rapidly gaining acceptance as an energy saving measure in agriculture application. It is preferred to other alternative sources of energy such as wind, because it is more abundant, inexhaustible, and non-polluting (Akinola and Fapetu, 2006). In many parts of the world there is a growing awareness that renewable energy has an important role to play in extending technology to farmers in developing countries to increase their productivity (Waewsak *et al.*, 2006). But the performance of solar dehydration process can be affected by many variables such as amount of sun light, relative humidity, air movement and type of crop to be dried. In this regard, different types of dryers have been developed and used to dry agricultural products to improve shelf life (Esper and Muhlbauer, 1996). Most of the dryers in use to date utilize electric power which is expensive and unavailable for smallholder farmers in Ethiopia. Simple natural convection dryers can suit better to dry fruits and vegetables in remote areas of the country.

Potato is one of the most widely grown tuber crops in Amahara region. Recent survey results reveal that more than 71,325 ha of land in Amhara region were covered by potato in the year 2001/02. It accounts 90% of the total land coverage by root and tuber crops and about 68% of the volume of root crop production. Out of this produce, about 70% was used for household consumption (CSA, 2003). In spite of its wide adaptation, it is perishable which often results in high postharvest losses. Drying potato using simple natural convection dryer may be a viable option to reduce postharvest loss and assist farmers to prepare a variety of potato based food products. The objective of this study was, therefore, to determine the performance of two models of direct solar dryers in drying potato and thereby demonstrate better performing dryer to potato producing farmers in Amhara region.

Materials and methods

Description and construction of the direct solar dryers

The exact manufacturing drawing of the solar dryers was prepared using reveres engineering. Two types of direct solar dryers were manufactured for evaluation at Bahir Dar Agricultural Mechanization and Food Science Research Centre.

Figure 1 (left and middle) shows the essential features of the Type 1 solar box dryer. The drying chamber is made of a simple wooden box with its outer dimension of 1.81 m X 0.83 m X 0.82 m. The upper part of the dryer is covered with a single layer of 4 mm thick glazing transparent glass sheet; with a surface area of 1.72 m by 0.86 m. But the effective area of the glazing collector is 1.17 m. The solar collector (mirror) is oriented facing South and tilted at 21.27^{o} to the horizontal so as to receive maximum solar radiation during the desired season of use. The best stationary orientation is due South in the Northern hemisphere and due North in Southern hemisphere. This is approximately 10^{o} more than the local geographical latitude (Bahir Dar is located at 11.37^{o}N).

The drying chamber has partition in the middle where each partition has three shelves and a total of six sliding trays are inserted for placing the dried products. Each tray is 10 mm deep with wire mesh in the bottom and its effective area was 0.44 m^2. The relative positions of these trays are: the bottom tray (T3), the middle tray (T2) and the top tray (T1) which are located at 32 cm, 21 cm and 10 cm, respectively above the interior bottom floor of the dryer.

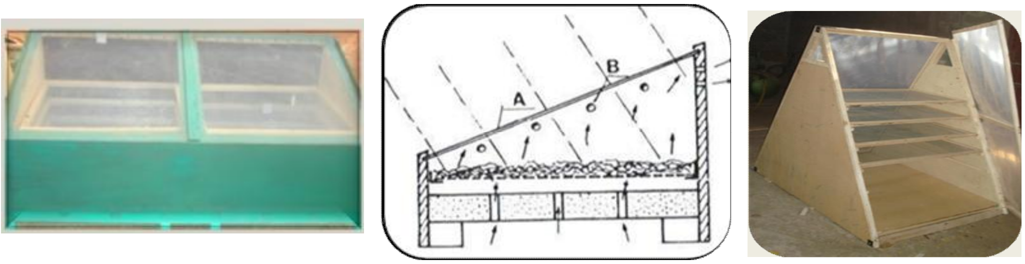

Figure 1. Complete and sectional view of Type 1 solar dryer (left and middle) and Type 2 dryer (right) .

The drying trays inside the drying box are constructed from a double layer of fine chicken wire mesh with a fairly open structure to allow drying air to pass through the drying stuff. The solar dryer has a total of 80 air inlet and outlet vents at the bottom with a diameter of 12 mm. Inlet vents located at the bottom and outlet vents provided towards the upper end at the back and at both sides of the cabinet to facilitate and control the convection flow of air through the dryer. Access door to the drying chamber is also provided at the back of the cabinet. The material used for the construction of the direct absorption dryer is wood, chipboard, 4 mm mirror and sawdust between 5 cm thick walls as insulating materials. These materials are easily available at the local market. Its weight was 75 kg and production cost was about ETB 2075.

The right side photographic view in Figure 1 depicts the Type 2 solar dryer. This dryer has 1.70 m X 1.48 m X 1.10 m overall dimensions. The front and back sides of the dryer are covered with a transparent plastic sheet; the effective area of the collector glazing is 3.28 m^2. The dryer has four shelves with sliding trays where the products to be dried are placed. Each tray is 10 mm deep with wire mesh in the bottom and their effective area for tray 1, 2, 3, and 4 are 0.59 m^2, 0.74 m^2, 0.89 m^2, and1.05 m^2, respectively. The relative positions of these trays are: the bottom tray (T4) located at 48 cm, the next tray (T3) located at 62 cm, the middle tray (T2) located at 77 cm and the top tray (T1) located 90 cm above the internal bottom floor of the dryer. The drying trays are placed inside the drying box which is constructed from a double layer of fine chicken wire mesh with a fairly open structure to allow drying air to pass through the material to be dried.

This dryer has one rectangular shape air inlet and two triangular shaped outlet windows. The inlets have a total area of 0.048 m^2 while the outlets have an area of 0.055 m^2. Inlet vents are located under the edge of the door, whereas the outlet vents are located on the upper end at both sides of the cabinet to facilitate and control the convection flow of air through the dryer. Access door to the drying chamber is also provided at the front of the cabinet (Figure 1, right). The materials used for the construction of this solar dryer were wood, plywood, and plastic sheet. These materials are easily available in the local market. Its weight is 20 kg and production cost is about ETB 568.72. The design of Type 2 dryer is simple, can be disassembled easily during transporting time and its cost is low.

Dryer performance evaluation

Fresh potato of unknown variety purchased from the local market was used for the experiment. Before drying, the potatoes were washed, peeled, cut into slices of 58 mm average diameter and 28 mm average thickness. The samples were blanched for about 10 minutes in 87 ^{O}C water, and then the surface water was removed using wire mesh filter. Finally, the samples were placed on the drying tray in a single layer in each dryer. Open sun drying was used as a check.

The performance of dryers was evaluated at the Bahir Dar Agricultural Mechanization and Food Science Research Centre. Air temperature and relative humidity of both ambient and dryer environment were recorded using temperature and relative humidity sensors which were placed at different locations inside the dryer. The sensors (Model 100 WatchDog data logger of SpecWare ^{TM}) were configured to record data at 10 minute interval. The hourly weight difference of the sample was recorded for two consecutive days between 4:00 and 9:00 local time. Conventional air and sun radiation were used to dry potato slices. The test was conducted with dryer inlets and outlets fully opened.

Results and discussion

Two tests were conducted between May and Jun 2010. This paper reports the results of one of the tests. The two dryers were compared with open sun drying between 12 to 14 May 2010 without loading potato slices. The three consecutive day time average temperature value at the peak time (20:03 hr) were found to be 29.36, 44.00 and 61.93 ^{O}C for open sun, Type 1 and Type 2 dryers, respectively (Figure 2). The overall day time (12:00–24:00) average temperature was found to be 27.3, 38.0 and 48.1 ^{O}C for open sun, Type 1 and Type 2 dryers (Figure 2). Type 1 and Type 2 dryers had 10.7 to 20.8 ^{O}C higher temperature values than open sun drying, respectively. The solar dryers were well energized during day time to a temperature of 38 to 60 ^{O}C, which is suitable for drying fruits and vegetables. During night time the temperature inside the dryers lowered and was almost equal to the ambient condition. On both dryers, temperature in the upper tray was higher than the trays in the middle. The reason is that the direct sun radiation fully falls first on the top tray and then through time expands to the rest of the trays.

The day time (12:00–24:00) relative humidity for the open sun drying, Type 1 and Type 2 dryers was 36.6%, 24% and 13.1%, respectively (Figure 3). The night time relative humidity was higher than the day time values. A fairly lower value was obtained in Type 2 dryer both during day time and night time which shows that the potential of the drying air helps to remove from the potato slices.

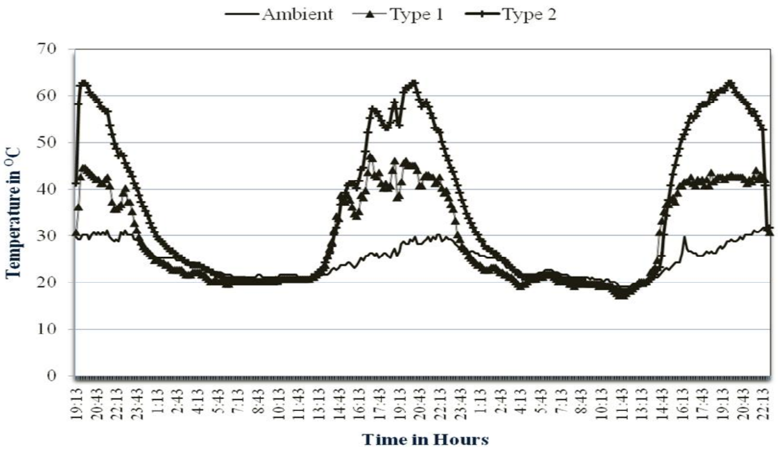

Figure 2. The inlet and outlet air temperature for Type 1 and Type 2 dryers and ambient condition. (Without loading potato slices in the dryers from 12 to 14 May 2010).

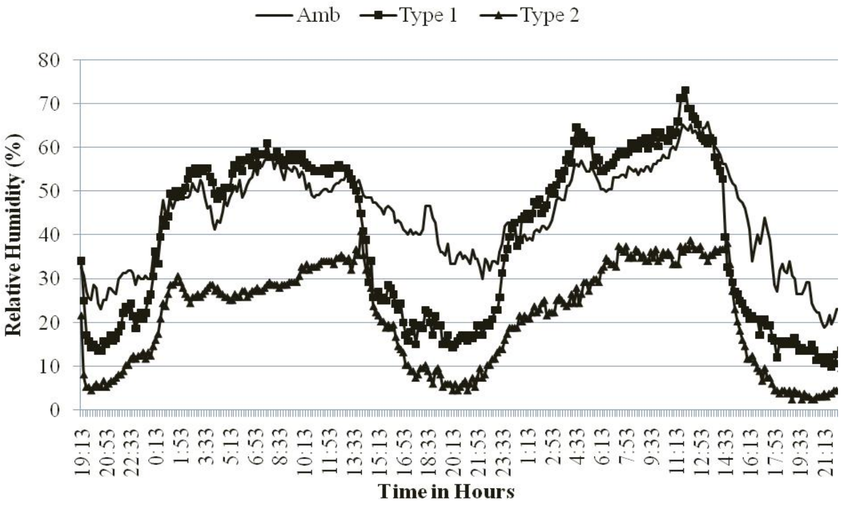

Figure 3. Relative humidity in Type 1 and Type 2 dryers and ambient condition (Without loading potato slices from 12 to14 May 2010).

The driers were also compared with open sun drying while potato slices were loaded. The results of average temperature difference between the dryer trays while fully loaded with potato slices are shown in Table 1. The results on the moisture content of potato slices showed that in Type 1 dryer the upper tray (Tray 1) exhibited the most rapid drying (Figure 4). In the first day, after 4 hours of drying the moisture content of the potato slice dropped from 78.9% to about 68.4%, 69.7%, 72.3%, and 75.7% (wet basis) for Tray 1,Tray 2, Tray 3 and open sun, respectively.

During the second day, the moisture content decreased gradually to 17.2%, 24.9%, 28.0% and 40.6% for respective tray locations. The final moisture content for the above respective trays was 8.2%, 17.0%, 18.1% and 20.8% on wet basis. These moisture contents indicated that the first tray drying time was faster than the other trays. The moisture content for potato in the open sun tray showed slow drying time requiring 2 to 3 hour to get a stable dried material.

Table 1. Average temperature (°C) record for each tray for Type 1 and type 2 solar dryers between 9 to 10 June 2010.

	Type 1 solar dryer		Type 2 solar dryer	
Driers	Time:12:00 - 24:00	Time:00:00 - 12:00	Time: 12:00-24:00	Time:00:00 - 12:00
Ambient	25.3	20.1	25.5	20.0
Tray 1	35.6	20.0	43.5	21.5
Tray 2	34.0	19.7	41.1	21.5
Tray 3	35.2	20.5	37.8	21.5
Tray 4	34.1	20.7	37.5	22.2

The results of the drying rate analysis indicated that Tray 1 expectedly had the highest drying rate during the first 3 hours (Figure 5). However, as it got dried its drying rate decreased from 1.07 up to 0.167%. The drying rate of the potato on the other trays was less than Tray 1 after hours because the drying air absorbed less moisture from the trays.

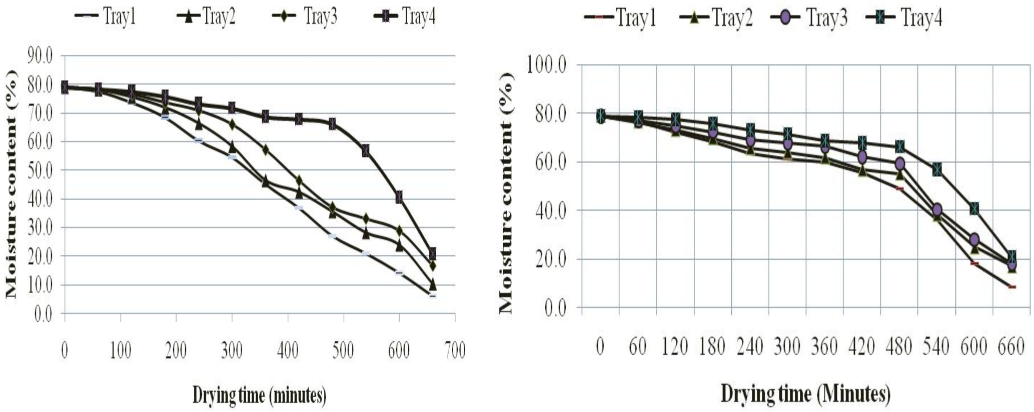

Figure 4. Moisture content of potato slices on different trays of Type 1 (left) and Type 2 (right) dryers.

Figure 5 plays the variation of air temperature with vertical distance from the bottom of the drying chamber. The major drawback of the shelf-type dryer is uneven drying. As a result of the migration of the drying front, the materials at the upper trays dried first, while the middle trays delayed in drying resulting in uneven drying.

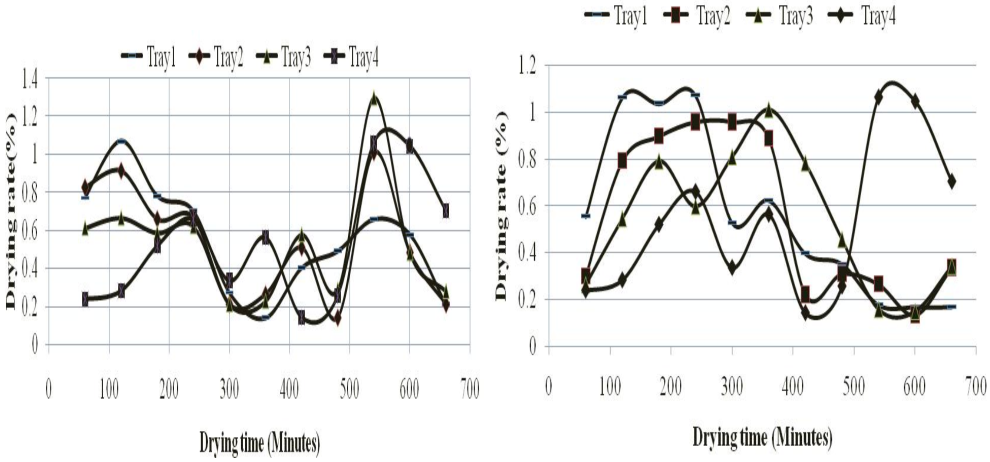

Figure 5. Drying rate curves for potato on a dry weight basis in Type 1 (left) and Type 2 (right) dryers.

Demonstration

Due to its better performance, simplicity and other parameters Type 2 dryer was selected for demonstration. Demonstration was carried out in *Adet* woreda at *Inawera* kebele. The dryer along with different methods of potato processing using dried and undried potato was demonstrated for various potato producing farmers. Both men and women households were involved during the demonstration. It was then observed that most farmers showed interest in using the dryer together with the new methods of home processing of potato. However, they strongly suggested modification for the technology. For making it easy for handling and transport the drier should be detachable.

Conclusion and recommendation

Based on the technical test results and farmers opinions during demonstration the following conclusions and recommendation are made:

- The design of Type 2 dryer is simple and its cost is low. It is suitable for drying small quantities (10-15 kg) of granular materials and is suitable for household level drying.
- Drying time reduced up to 2-3 hour compared to open sun drying, but this difference is not large enough under existing weather condition; however, the dried material is protected from contamination by dust and insects. As a result, the product quality will be high.
- Uneven draying was seen among different trays on both dryer types. The problem of shelf-type dryer on uneven drying can be alleviated by rotating the drying shelves.
- Farmers gained knowledge on processing potato where they were able to use potato slices to prepare different sorts of food.
- From the production cost, weight, transportation, and manufacturing simplicity point of view Type 2 dryer is preferable than Type 1 solar dryer. Farmers said that they can produce Type 2 dryer from local materials and using their own skill.
- The dryer temperature during night time was almost similar to ambient condition which results in lengthening the drying period. Future works to conserve day time temperature and evaluation of other types of dryers with different agricultural products needs to be addressed.

References

Akinola, A.O. and Fapetu, O.P. 2006. Exergetic Analysis of a Mixed-Mode Solar Dryer.

Esper, A. and Muhlbauer, W. 1996. Solar tunnel dryer. Plant Res. and development 44(4):16-64.

Waewsak, J., Chindaruksa, S. and Punlek, C. 2006. A mathematical modeling study of hot air drying for some agricultural products. Thammasat Int. J. Sci. Technol. 11(1):14-20.

SOIL AND WATER MANAGEMENT RESEARCH

Application of AnnAGNPS model for runoff and soil loss simulation at Anjeni watershed, Northwest Ethiopia

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Abstract

A study was conducted in 2009/2010 to evaluate the predictive capability of Annualized Agricultural Nonpoint Source (AnnAGNPS) model with respect to both event wise and annual values of runoff and soil loss on a 96 ha agricultural watershed in northwest Ethiopia. Input data used for the model including climate, runoff, soil loss, land use, and soils were generated from the Soil Conservation Research Program (SCRP) data base and previous research works. The model was calibrated and validated against observed data. Event wise runoff was over predicted by 3.1% (R^2 = 0.863) and under predicted by 21.4% (R^2 = 0.730) during calibration and validation, respectively. Sediment yield on an event basis was over predicted by 134.7% (R^2 = 0.528) and by 14.8 % (R^2 = 0.756) during calibration and validation, respectively. Annual predicted values resulted in errors of 1.99% and 11.53% for runoff and soil loss, respectively. Generally, results showed that the model performed satisfactorily in simulating both annual and event wise runoff and soil loss for the study watershed.

Key words: AnnGNPS, calibration, validation, watershed.

Introduction

The response of landscape and soil erosion processes to both natural and anthropogenic influences are a function of many independent variables that can be analyzed by monitoring the behaviour of individual landscape parameters such as vegetation, soil, and water, or holistically through watershed-scale field studies. The complexity and expensive nature of monitoring programs, however, necessitates the development and use of hydrologic models such as AnnAGNPS (Cronshey and Theurer, 1998). AnnAGNPS has been developed for evaluating the hydrologic and erosion responses of a watershed to land use practices (Yuan *et al*., 2001). An effective simulation tool can increase awareness and understanding of land use practices by land users and watershed planners and promote adoption of alternative land use practices (Yuan *et al*., 2008).

Physically-based models have the potential to simulate the runoff and erosion processes and behaviour of sediment movement accurately, with little or no calibration of the parameters used (Cronshey and Theurer, 1998). Using such models is significantly less expensive than large-scale monitoring of these processes in the field (Yuan *et al*., 2001). AnnAGNPS is one such model developed for use with little local calibration on un-gauged watersheds. This study was conducted to simulate runoff and sediment yield for Anjeni watershed (a typically agricultural watershed in Northwest Ethiopia) using the AnnAGNPS model with the objective to adapt the model for application in the Northwest Ethiopian highland environment.

Materials and methods

The study area

The study was conducted in 2009/2010 in Anjeni watershed to simulate runoff and sediment yield. Anjeni watershed is situated in Northwest Ethiopia in the Gojjam highlands (Figure 1) within an altitude range of 2407 m to 2507m above sea level between $37^0$31'30" to $37^0$32'20" E longitude and $10^0$40'10" to $10^0$41'50" N latitude. It is an agricultural watershed having a hydrologic surface area of about 96 ha. The average annual rainfall is about 1692 mm (SCRP, 2000). Mean daily temperature is 16 °C. The topography of the watershed is dominated by undulating slopes ranging in steepness from 8% to more than 30% (SCRP, 2000). Almost rectangular in shape, the watershed is north to south oriented, dissected by the Minchit perennial stream through the middle, which forms part of the Blue Nile basin. The mean annual river discharge is about 730 mm with the drainage ratio of rainfall being around 43% (Herweg and Stillhardt, 1999). The mean annual erosion rate is 54.1 tons ha^{-1} yr^{-1} (SCRP, 2000). The soils of the watershed can be described as well to excessively drained that are clay in texture and acidic in reaction (Gete Zeleke, 2000). Agriculture in the study area is characterized by a subsistence rainfed production highly oriented toward grain production and is dependent on the use of ox power for land preparation. Free grazing on communal lands is also a major component of the farming system. Tef, barley, wheat, oil crops, and pulses are the major crops grown in the study area. The study area has a unimodal rainfall regime as a result of which the condition allows only one cropping season.

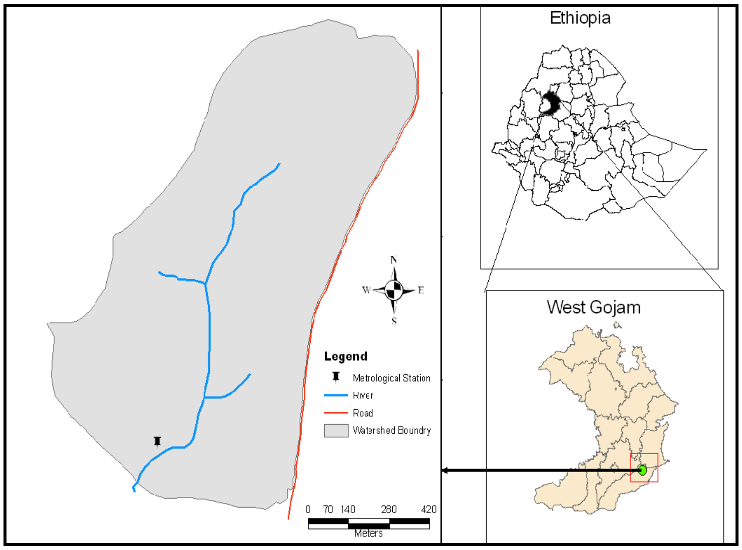

Figure 1. Location map of the study area.

Model structure

AnnAGNPS is a distributed parameter, process-based, continuous-simulation, watershed-scale model to be used as a tool to evaluate non-point source pollution from agricultural watersheds ranging in size up to 300,000 ha (Cronshey and Theurer, 1998). AnnAGNPS can simulate quantities of surface runoff and sediment yield leaving user specified computational areas within a watershed called cells and their transport through the entire watershed. Runoff estimates in AnnAGNPS are based on the SCS curve number (CN) method (USDA, SCS, 1972). Daily sheet and rill erosion is calculated in AnnAGNPS using the RUSLE equation (Renard *et al.*, 1997). Since RUSLE does not account for deposition and is only used to predict sheet and rill erosion, the Hydro-geomorphic Universal Soil Loss Equation (HUSLE) (Theurer and Clarke, 1991) was used to calculate sediment delivery to the stream system from the contributing cells. The Bagnold equation (Bagnold, 1966) is used within AnnAGNPS to determine sediment transport capacity of the stream, and sediment transport in reaches is based on Einstein deposition equation (Einstein and Chein, 1954).

Input requirements

Climate

The climate input file was created using recorded historical data from SCRP data base for the watershed. Specific data inputs required for the climate data file are maximum and minimum daily temperatures, daily precipitation, average daily dew point, cloud cover, and wind speed.

Topography

The watershed was subdivided into 100 m X 100 m grid cells as per the recommendation by Young *et al*. (1989) using GIS application from a DEM of the watershed from which flow direction and slope data were derived. Additional field checking was carried out to verify values generated by GIS and gather data on channel characteristics.

Soils

The major soil type and associated soil characteristics required by the model were determined and assigned for each AnnAGNPS cell. Required inputs include particle size fraction, bulk density, saturated hydraulic conductivity, field capacity, and wilting point.

Land use and management practices

The dominant land use in each AnnAGNPS cell was assigned to the entire AnnAGNPS cell and all associated parameter values (such as curve number) of the land use were assigned to the AnnAGNPS cell. From interviews with farmers insight was gained about management practices for each crop. A typical management cycle for annual crops in the study watershed involves a ploughing operation of one to six times to a depth of 15-20 cm and several weeding operations, depending upon the crop types. The predominant crops considered were tef, barley, niger seed, linseed, horse bean, and maize.

Selection of runoff curve number (CN) values

Initial CN values were defined for each land use and hydrologic soil type combination based on the TR-55 manual (SCS, 1986). The model itself updates the CN values according to the changes in soil moisture and cover description.

Model simulation

The simulation process using AnnAGNPS involved model sensitivity analysis, calibration and validation processes. Performance of the model was evaluated based on qualitative and quantitative assessment. The qualitative procedures consisted of visually comparing the observed and simulated values. The data sets used for model calibration and validation are presented in Tables 1 and 2.

Table 1. Observed and predicted runoff volume and sediment yield data used for AnnAGNPS calibration in Anjeni watershed.

	Observed values		Predicted values	
Event	Runoff volume (m^3)	Sediment yield (tons)	Runoff volume (m^3)	Sediment yield (tons)
6/3/1994	7258.67	187.71	9376.77	412.47
6/9/1994	3187.36	27.74	1962.77	57.45
6/24/1994	4414.96	26.32	5830.98	115.41
6/25/1994	5238.70	32.79	6154.42	108.15
6/27/1994	7369.52	75.88	6564.37	133.96
7/4/1994	7372.10	53.14	8367.90	121.30
7/27/1994	17339.29	47.42	19934.49	265.04
7/28/1994	15424.52	68.43	11594.03	122.51
8/1/1994	12049.62	41.32	12931.51	150.97
8/4/1994	13292.12	127.28	13172.50	127.83
Total	92946.86	688.03	95889.74	1615.09
Mean	9294.69	68.80	9588.97	161.51

Table 2. Observed and predicted runoff volume and sediment yield data used for AnnAGNPS validation in Anjeni watershed.

	Observed values		Predicted values	
Event	Runoff volume (m^3)	Sediment yield (tons)	Runoff volume (m^3)	Sediment yield (tons)
7/19/1994	5855.07	13.38	2837.61	27.24
8/9/1994	10776.73	54.08	8428.92	72.05
8/231994	6310.90	40.62	6718.36	35.64
8/271994	4493.24	19.88	3898.32	22.05
8/31/1994	4485.19	24.23	3195.72	17.77
Total	31921.13	152.19	25078.93	174.75
Mean	6384.23	30.44	5015.79	34.95

Results and discussion

Sensitivity analysis

Sensitivity analysis was carried out to identify the most important input parameters to the model to be subjected to calibration. It was found that SCS curve number had direct effect on runoff and sediment yield whereas LS-factor, soil K-factor, crop cover factor, crop management factor, and surface roughness factor affected only sediment yield.

Calibration

Historical daily runoff and sediment yield data from the SCRP data base were used in this simulation study. The first step in model calibration was carried out by comparing predicted and observed runoff. Only CN values were adjusted for calibration of runoff, since the sensitivity analysis showed that runoff was not affected by the other parameters. Since the first selected CN values resulted in too high runoff simulation, the CN values for each land use were lowered by the same proportion until best runoff estimates were obtained. Eventually, the model resulted in an overestimated mean daily runoff by 3.17%

with R^2 value of 0.86 (Figure 2). The over prediction , even though it is small, is mainly attributed to the fact that spatial variability still exists within a landscape that is assumed to be uniform in the modelling process. Similar results were obtained by Nigussie Haregeweyn (2000) at Agucho watershed and Eshetu Eltamo (2003) at Gununo watershed by applying the old AGNPS model.

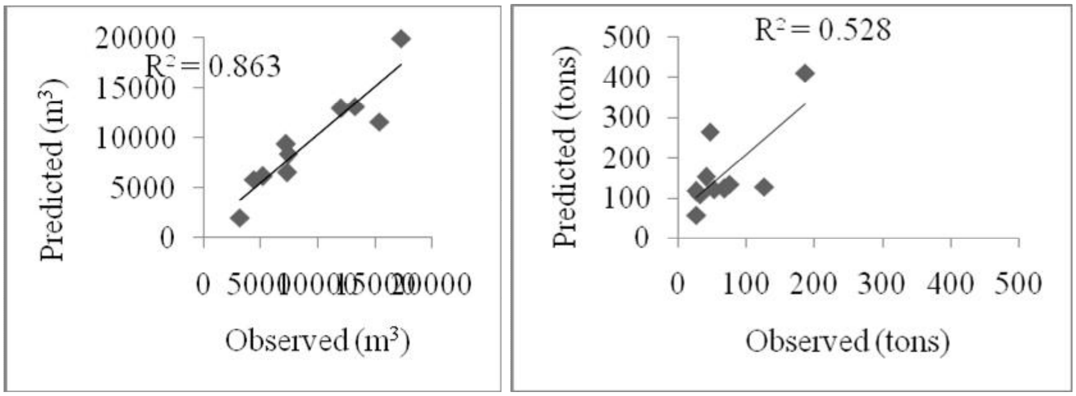

Figure 2. Calibration of AnnAGNPS model for runoff volume (left) and sediment delivery (right) at the watershed outlet of Anjeni watershed.

The second step to calibrate AnnAGNPS was done by comparing the predicted against measured sediment yield values. The parameters affecting sediment yield were adjusted within their tolerable ranges in order to bring down the very high predicted values that resulted from first model run. After such alterations, average sediment yield was over predicted by 134.74% with R^2 value of 0.528 (Figure 2). Similar trend was obtained by Shrestha *et al.* (2006) by applying AnnAGNPS in Siwalik, Nepal. These authors indicated that average event wise sediment yield was over predicted by 153% with R^2 value of 0.62. Polyakov *et al.* (2007) also applied the model in the Island of Kauai, Hawaii, and reported that AnnAGNPS overpredicted sediment yield. The use of RUSLE and associated parameters are meant to be used for making long-term estimates. This is, therefore, expected to have caused the observed errors between the measured and predicted event wise values.

Validation

During validation runoff was under predicted by 21.43% with R^2 value of 0.730 (Figure 3). The fact that it is impossible to fully account for spatial variability in the modelling process is responsible for such an error between observed and predicted values. Similar result was reported by Yuan *et al.* (2001) in which AnnAGNPS underestimated observed runoff in the Mississipi Delta.

Average sediment yield during validation was still over predicted by 14.83% with R^2 value of 0.756 (Figure 3). The decrease in the error between predicted and observed values and the increase in the R^2 value at the validation stage shows that sediment yield was predicted with a better accuracy during validation.

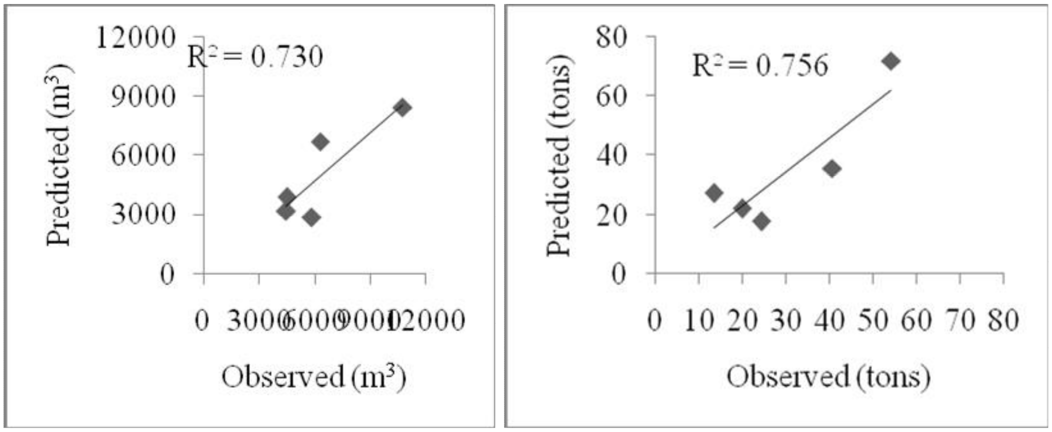

Figure 3. Validation of AnnAGNPS for runoff volume (left) and sediment yield (right) at the watershed outlet of Anjeni watershed.

Annual runoff and soil loss simulation

Being a continuous-simulation model, AnnAGNPS is capable of producing estimates of average annual runoff and erosion values. The simulation results in the study watershed showed that mean observed annual runoff (358.92 mm) and erosion rate (54.1 tons ha^{-1} yr^{-1}) values at field plot level were under predicted by 1.99% (351.79 mm) and 11.53% (47.86 tons ha^{-1} yr^{-1}), respectively. The observed values at field plot level involved only a small number of field plots that are too small in number to represent the entire watershed as the watershed is composed of diverse landforms. Therefore, the observed erosion rate values obtained from field plot data are expected to involve considerable errors, explaining the differences observed between measured and predicted annual values.

Conclusions

The AnnAGNPS hydrologic model was applied to predict surface runoff and sediment yield at Anjeni watershed. The model predicted runoff with the range of acceptable accuracy, which is reflected by the high R^2 values. This indicates that the SCS curve number method is suitable for runoff simulation in the study area. Sediment yield predictions can be considered to be in the range of moderate accuracy. However, the performance of the model to predict sediment yield can be further increased by applying appropriate watershed discretization techniques in order to properly account for spatial variability. In general, the study revealed that the AnnAGNPS model can be used in simulating both runoff and sediment yield in the study watershed and other similar areas to aid the design and planning of different management strategies for soil and water conservation.

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References

Cronshey, R.G. and F.D. Theurer (1998). AnnAGNPS: Non-point Source Pollution Model. In Proceedings of First Federal Interagency Hydrologic Modeling Conference. Las Vegas, NV, P. 1-16.

Polyakov, V., A. Fares, D. Kubo, J. Jacobi, C. Smith (2007). Evaluation of a non-point source pollution model, AnnAGNPS, in a tropical watershed. *Journal of Environmental Modeling and Software* 22:1617-1627.

Renard K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder (1997). Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). U.S. Department of Agriculture, Agriculture Handbook No. 703.

SCRP (Soil Conservation Research Program) (2000). Area of Anjeni, Gojam, Ethiopia: Long-term monitoring of the agricultural environment, 1984–1994.Centre for Development and Environment, University of Berne, Switzerland, in association with the Ministry of Agriculture, Ethiopia.

SCS (Soil Conservation Service) (1986). Urban hydrology for Small Watersheds. USDA, NRSC, Conservation Engineering Division, TR-55.

Shrestha, S. Babel S. Mukand, A. Das Gupta, F. Kazama (2006). Evaluation of Annualized Agricultural Nonpoint Source model for a watershed in the Siwalik Hills of Nepal. *Journal of Environmental Modelling and Software* 21(7):961-975.

Theurer, F.G. and C.D. Clarke (1991). Wash load component for sediment yield modeling. In Proceedings of the 5th Federal Interagency Sedimentation Conference, P. 7-1 to 7-8.

USDA (United States Department of Agriculture), SCS (1972). Hydrology. In National Engineering Handbook. Washington, D.C., P. 10.5-10.6.

Young, R.A., C.A. Onstad, D. Bosch, and W.P. Anderson (1989). AGNPS: A nonpoint-source pollution model for evaluating agricultural watersheds. *Journal of Soil & Water Conservation* 44(2):168-173.

Yuan, Y., R.L. Binger, and R.A. Rebich (2001). Evaluation of AnnAGNPS on Mississippi Delta MSEA Catchments. *Transaction of the American Society of Agricultural Engineers* 44(5):1183-1190.

Impact of land use type on soil acidity in the highlands of Ethiopia: The case of Fagetalekoma district

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Abstract

Soil acidity is one of the chemical soil degradation problems which affect soil productivity in the Ethiopian highlands. A study was conducted in 2008 with the objective of assessing the status of soil acidity in different land use types in *Fagtalekoma* district, Awi Zone in the Amhara region. The different land use types used for the study were cultivated land, backyard, grazing land and natural forest. Composite soil samples were collected along transects in each of the land use types and analyzed using standard laboratory procedures. Results indicated that cultivated land and grazing land were strongly acidic (pH<5.5), whereas natural forest and backyard land uses were moderately acidic (pH = 5.6-6.0). The strong soil acidity on cultivated lands may be due to intensive cultivation without fallow, removal of crop residues, and in appropriate use of chemical fertilizers. Soil acidity on grazing land might be aggravated by overgrazing. Significantly higher soil pH, CEC, and higher Ca and Mg contents were recorded on natural forest soils as compared to other land uses. On the other hand, significantly lower exchangeable acidity was obtained on backyard and natural forest as compared to other the two land uses. Higher organic matter and total nitrogen contents were observed on the natural forest, whereas higher available phosphorous and potassium were recorded on the backyard land use, which might be attributed to high return of biomass due to little soil disturbance and high farmyard manure input. In order to address soil acidity problem, use of manure and compost should be encouraged on cultivated lands. Reducing overgrazing by improving land management options is necessary to rehabilitate acidic grazing land soils.

Key words: Acidity, land management, land use, soil.

Introduction

The success in soil management to maintain soil quality depends on an understanding of how soils respond to agricultural practices over time. For this reason, recent interest in evaluating the quality of soil resources has been stimulated by increasing awareness that soil is a critically important component of the earth's biosphere, functioning not only in the production of food and fibre but also in the maintenance of local, regional and worldwide environmental quality (Doran and Parkin, 1994).

On the other hand, feeding the ever-increasing human population is most challenging in developing countries because of soil degradation. Soil acidity is one form of chemical degradation of soils. The main problem of acid soils is the high acidity and low amount of exchangeable calcium (Chopra and Kanwar, 1999) and it is considered to be one of the most important factors that affect the soil chemical fertility. Soil acidity affects productivity of the soil through its effect on nutrient availability and toxicity by some elements like aluminum and manganese. The four major causes for soils to become acid are rainfall and leaching, acidic parent material, organic matter decay and harvest of high yielding crops and crop residues (Johnson, 1914).

This challenge will continue as population pressure increases and degradation of soil resources is aggravated for example in the highlands of Ethiopia. Reversing this trend lies in the enhancement of sustainable development of the agricultural sector. However, the basis of sustainable agricultural development is good soil quality. The rate of soil quality degradation depends on land use systems, soil types, topography, and climatic conditions. Among these factors, inappropriate land use aggravates the degradation of soil physicochemical and biological properties (Saikhe *et al*., 1998; He *et al*., 1999). In Ethiopia, soil acidity is a problem that has not been addressed in depth. It is observed that most of these soils are found in the highlands receiving high rainfall (Paoulos, 2001). The Ethiopian highlands are one of the hotspots on the African continent with regard to food production and in the struggle to preserve the natural resource base (FAO, 2004, 2005). The Ethiopian highlands cover 95% of the cropped area and support almost 85% of the

Ethiopian population. Yields of the major cereal crops, particularly barley, are as low as 5 t ha^{-1} partly as a result of soil acidity (Paoulos, 2001).

The management of soil acidity requires precise information about the extent of the problem as well as its spatial distributions across the range of the land management practices as well as land use systems. Therefore, this study was conducted with the objectives of identifying and quantifying the extent of soil acidity in different land uses and to investigate the effect of soil acidity on plant nutrients in different land uses.

Materials and methods

The study area

Geographically the study area is located at *Gafera* and *Gullazmach kebeles* in *Fagetalekoma* district in *Awi* Zone of Amhara National Regional State (ANRS) (Figures 1 and 2). *Fagetalekoma* district is located at 11^0 04' 30"-11^0 05' latitude and 36^0 52'-36^0 54' longitudes (Figure 1). The relief type in *Fagtalekoma* consists of 38% plain, 24% mountains, and 38% others. The major soil types include Vertisols, Nitosols, and Cambisols (BoFED, 2004). Climatic conditions in Fagtalekoma district, are divided into three agro-climatic zones namely highland (*Dega*), midland (*Weynadega*) and lowland (*Kolla*). Altitude ranges from 2000-3200 m above sea level. Average annual rainfall is 2379 mm with unimodal rainy season. The rainy season for the area is from beginning of June to end of September. Temperature varies between the mean annual maximum of 25 ^{O}C and mean annual minimum of 11 ^{O}C across the elevation gradient (BoFED, 2004).

The farming system is a mixed agriculture under rain-fed farming system supplemented with traditional irrigation. Irrigation facilities are limited to few locations depending upon the availability of suitable sites for traditional irrigation. The maximum irrigation is available in one of the *kebeles* called *Nechela kebele* due to availability of perennial streams and suitably the water is diverted to nearby fields (BoARD, 2007). The major annual crops grown in the study area are barley, potato, oat, tef and noug. The natural vegetation is shrunk between *Injibara* and *Chagni* and around the Churches only as they are not damaged due to religious considerations. The *woreda* occupied total areas of 34,207 ha of which, 78% is cultivated land in the flats, 12% is forests, woodland and bushes; and 9% is grazing lands in steep slopes. From the total, 0.96% is for other purpose and 0.14% is out off use (BoARD, 2007).

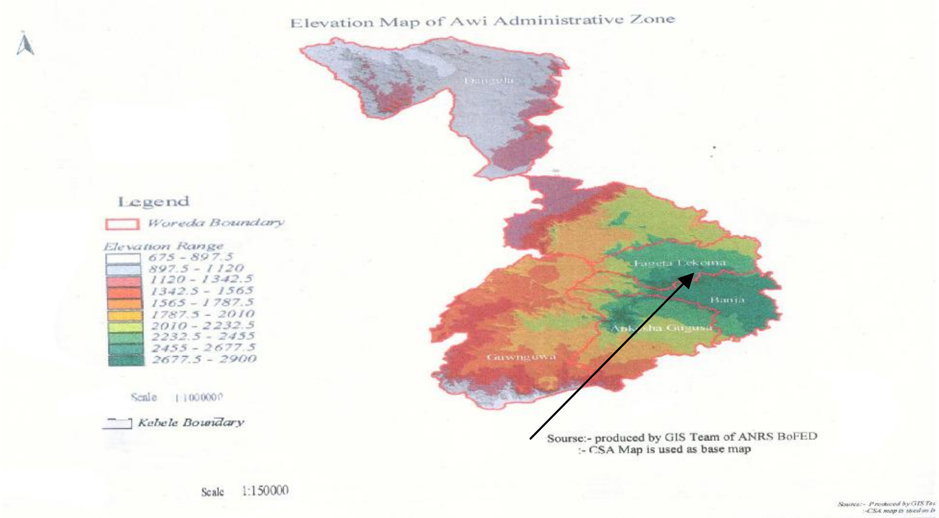

Figure 1. Elevation map of *Awi* Administrative Zone (Source: BoFED, 2004).

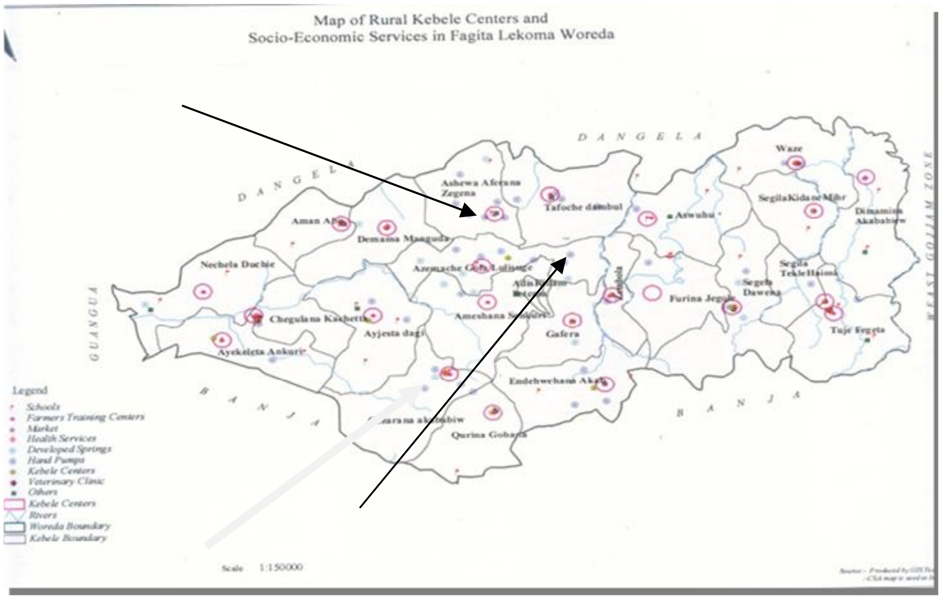

Figure 2. Map of rural *Keble* centres and socio-economic services in *Fagtalekoma* district (Source: BoFED, 2004).

Experimental procedures

Selection of kebeles, land use types and soil sampling

Before the start of the study reconnaissance survey was conducted in 2008 during off season and two sample *kebeles* and land use types were selected using purposive sampling technique. During surveying, the general geography of the area was identified. The criteria used to select the sample *kebeles* were: presence of high incidence of soil acidity problem as per the information from the district office of agriculture and presence of different land use types and its representativeness. Based on these criteria two *kebeles* (*Gullazmach* and *Gaffer*) were selected. Then, four land use types (cultivated, backyard, grazing land and natural forest) were systematically selected within each *kebele* on the basis of similarity in soil type, slope and altitude. Land use types that were bordering each other with in the respective land use types were selected for soil sampling.

According to farmers', cultivated and backyard land use systems were under intensive cultivation for more than 30 years. Besides, backyard plots got special treatment from application of farmyard manure and compost. Grazing lands were under grazing for at least the past 30 years. The cultivated land use type has received Urea and DAP fertilizers in most of the past years under barley and tef cropping systems. The forest land use type had no recorded cropping history.

To collect soil samples, transects were laid out in a 100 m x 100 m land to determine the plot in each land use systems. Along the transect walk 20 m x 20 m plot with three replications was used for soil sampling. In each plot soil samples were collected at the four corners and the centre of the plot from the depth of 0-20 cm with soil auger in March 2008. The five samples from each plot were mixed to form one composite sample. Totally, 24 composite samples were collected from the two *kebeles* and four land use systems per *kebele*.

Laboratory analysis

The soil samples collected from each land use type were air dried and passed through 2-mm sieve to determine the soil physical and chemical parameters. Soil samples for organic matter, total N, and available P determination were ground to pass 0.5-mm size sieve. Soil texture was determined with hydrometer (McDonald *et al*., 1994). The pH of the soil was measured potentiometrically with a digital pH meter in the supernatant suspension of 1:2.5 soils: liquid ratio where the liquid were water and 1M KCl solution (Pam and Brian, 2007). Exchangeable bases were extracted with 1M ammonium acetate at pH 7 and cation exchange capacity (CEC) was determined with 1M ammonium acetate (Abbott, 1989). Exchangeable acidity was determined by saturating the soil samples with 1N KCl solution and titrating with NaOH (Abbott, 1989). Organic matter, total N, and available P contents were determined using Wakley and Black (Skjemstad *et al*., 2000), Kjeldahl (Jackson, 1958) and Olsen (Olsen *et al*., 1954) methods, respectively. Soil sample analysis was done in Jun 2008.

Data analysis

Statistical analyses were performed to test the influence of land use type on soil parameters in general and soil acidity in particular using one-way analysis of variance (ANOVA). Mean comparisons were made using the least significant difference (LSD) test at $P<0.01$ and 0.05. ANOVA was done using SAS statistical software.

Results and discussion

Soil acidity in different land use systems

Soil pH ranged from 5.13-5.24 on cultivated land to 5.73-6.14 on forest land using water, while it ranged from 3.8-4.07 on cultivated land to 4.59-4.93 on forest land using KCl in *Gullazmach* and *Gaffera kebeles,* respectively. In all the different land use types soil pH measured in water was higher by about 1.05-1.33 units than the respective pH values measured in KCl solution (Table 1). The low soil pH with KCl determination indicates the presence of substantial quantity of exchangeable hydrogen and aluminium ions. According to Mekaru and Uehara (1972) and Anon (1993), high soil acidity with KCl solution determination shows the presence of high potential acidity and weatherable minerals. There are different parameters that can indicate the status of soil acidity. Among these parameters pH indicates active (solution) acidity. There was great difference in soil acidity indicator parameters between the two *kebeles*.

Soil pH (active acidity) was significantly ($p<0.01$) affected by the different land use types where in both *kebeles* the highest and the lowest pH (using H_2O solution) were recorded for the forest and cultivated land use types, respectively (Table 1). Higher soil acidity in cultivated land showed that intensive cultivation, removal of crop residues and continuous use of acid forming inorganic fertilizers on acid soils might have aggravated soil acidity (Table 1). Similarly, over grazing might be responsible for leaching of basic cations that can lead to acidity of the area in grazing land use types. These results were in agreement with the reports of many research findings (Baligar *et al*., 1997; Blamey *et al*., 1997; Wakene and Heluf, 2006).

Table 1. Soil acidity indicator parameters in different land uses at *Gullazmach and Gaffera kebeles* in 2008.

	Gullazmach kebele					*Gaffera kebele*				
Land use	pH (H_2O)	pH (KCl)	ΔpH	EA ($cmol_c\ kg^{-1}$)	AS (%)	pH (H_2O)	pH (KCl)	ΔpH	EA ($cmol_c\ kg^{-1}$)	AS (%)
Cultivate	5.24 ^{c}	4.07^{b}	1.18	3.02^{a}	29.7	5.13^{b}	3.80^{b}	1.33	4.56^{a}	32.35^{a}
Grazing	5 .41^{bc}	4.30^{ab}	1.10	3.20^{a}	20.8^{a}	5.64^{a}	4.57^{a}	1.09	1.54^{b}	10.87^{b}
Backyard	5.59 ^{b}	4.54^{ab}	1.05	0 .56^{c}	3.49^{b}	5.72^{a}	4.58^{a}	1.14	1.20^{bc}	9.11^{b}
Forest	6.14 ^{a}	4.93^{a}	1.21	0 .41^{c}	1.07^{b}	5.73^{a}	4.59^{a}	1.14	0.71^{c}	2.66^{c}
CV (%)	1.67	5.02		7.52	43.4	2.57	3.01		15.81	1

Means followed by the same letter are not significantly different at $P<0.05$. EA = Exchangeable acidity, AS = Acid saturation percentage (exchangeable acidity/ECEC).

From the results, pH (H_2O) of cultivated land at both *kebeles* and grazing land at *Gullazmach* kebele were strongly acidic according to USDA (1999) (Table 1). Grazing land and natural forest in *Gaffera kebele* and backyard land at both *kebeles* were in moderate category. But the natural forest land in *Gullazmach kebele* was slightly acidic (Table 1). Factors such as climate (temperature, rainfall and precipitation), seasonal variations of dry and rainy season, topography and morphological factors may be responsible for the increment of acidity. Further investigation should be carried out to identify the major and minor factors in acid soil formation in this area. The natural soil acidity in cultivated land of both *kebeles* and grazing land use types of *Gullazmach kebele* is aggravated by poor soil and range management.

There was a highly significant ($p<0.01$) discrepancy between land use types on exchangeable acidity as well as acid saturation percentage in both *kebeles* (Table 1). The two parameters are very good indicators of extent of potential or reserve acidity of the soil. Exchangeable acidity indicates the presence of excess Al and H^+ ion on the soil colloid as compared to total cation exchange capacity of the soil (Table 1). This is because the basic cations are leached out of the top soil layer (Tables 2 and 3) cultivated and grazing land uses. So, in the cultivated land use type there was a significantly ($p<0.01$) high exchangeable acidity and acid saturation percentage. This needs ameliorative measures. In this land use type Al toxicity may be a problem for crop production.

Acid saturation percentage and exchangeable acidity were not significantly ($p<0.01$ and $p<0.05$) different between cultivated and grazing lands use types in *Gullazmach kebele* (Table 1). This may be due to the highly destructive overgrazing that leads depletion of basic cations in the grazing land use type in this *kebele*. On the other hand, there was significant ($p<0.05$) variation between cultivated and backyard land use types in exchangeable acidity and acid saturation percentage in the same *kebele* (Table 1). This may be explained by the fact that exchangeable basic cations are not depleted and acidic cations are not left over because of good soil management in backyard land use type as compared to cultivated land in *Gullazmach kebele*. Grazing land in *Gullazmach kebele* was almost double in exchangeable acidity and acid saturation percentage as compared to the same land use system of *Gaffera kebele* (Table 1). This might be due to the high destructive overgrazing practice and collection of cow dung for energy consumption in *Gullazmach kebele* than *Gaffera kebele*. In terms of the soil acidity indicators, natural forest and backyard land were higher than the two land uses. There was no significant ($p<0.05$ and $p<0.01$) variation between forest and backyard land use types in exchangeable acidity and acid saturation percent.

Generally, soil acidity was low in natural forest and backyard land use types compared to the other land use types in both *kebeles* (Table 1). The reason may be farmers apply compost and farmyard manure that can add organic matter to their backyard. The low soil acidity in the natural forest and backyard may be attributed to accumulation of organic matter due to little soil disturbance (in natural forest), high manure and organic waste input (in backyard) as compared to the cultivated and grazing lands and hence decrease soil acidity on this land uses.

Soil acidity and plant nutrients

Highly significant ($p<0.01$) differences were observed in exchangeable Mg and Ca content between the land use types in *Gullazmach* and *Gaffera kebele* (Tables 2 and 3). On the other hand, significantly ($p<0.01$) higher exchangeable Ca and Mg were recorded in the forest land use type in *Gullazmach kebele,* while higher exchangeable cations were recorded in the same land use types in *Gaffera kebele* except exchangeable Na (Tables 2 and 4). Significantly higher ($p<0.01$ and $p<0.05$) exchangeable K content was recorded in the backyard land use type in *Gullazmach kebele* (Table 2), but not in *Gaffera kebele* (Table 3). Significantly higher ($p<0.01$ and $p<0.05$) exchangeable Na was recorded in the grazing land use type in *Gullazmach kebele* (Table 2). In *Gaffera kebele* there were no significant ($p<0.01$ and $p<0.05$) variations between land use types in exchangeable Na content (Table 3). The cation exchange capacity was also significantly different across the land use types in both kebeles (Tables 2 and 3).

The highest exchangeable K was recorded from the surface top soil of the backyard land as compared to the cultivated and the grazing lands in *Gullazmach Kebele* (Table 3). According to Marx *et al*. (1997), the exchangeable potassium content in all the land use types is high. This is in agreement with the reports of Yihenew *et al.* (2008) who reported high K status at Yilmana densa district Nitosol and Medum K statsus at Farta district

Luvisol in North West Ethiopia. However, it was in contrary with Alemayehu (1990) who reported low K concentration for Nitisols of the then Wollega state farms, western Ethiopia.

Table 2. Concentration of exchangeable bases in cmol$_c$ kg^{-1}under different land use types in *Gullazmach kebele* in 2008.

Land use	Exch. Ca		Exch. Mg		Exch. K		Exch. Na	
	Conc.	Level	Conc.	Level	Conc.	Level	Conc.	Level
Cultivated	8.15^{b}	m	2.51^{c}	h	0.92^{b}	h	0.12^{b}	l
Grazing	7.48^{b}	m	2.58^{c}	h	1.27^{b}	h	0.25^{a}	m
Backyard	8.85^{b}	m	5.23^{b}	h	2.62^{a}	h	0.13^{ab}	l
Forest	20.46^{a}	h	15.44^{a}	h	1.45^{b}	h	0.19^{ab}	l
CV (%)	24.92		13.35		23.39		34.39	

Means followed by the same letter are not significantly different at P<0.05. Exch. = Exchangeable, Conc. = Concentration, h = High, m = Medium, l = Low.

Table 3. Concentration of exchangeable bases in cmol$_c$ kg^{-1}under different land use types in *Gaffera kebele* in 2008.

Land uses	Exch. Ca		Exch. Mg		Exch. K		Exch. Na	
	Conc.	Level	Conc.	Level	Conc.	Level	Conc.	Level
Cultivated	5.56^{C}	m	3.35^{B}	h	$0 .83^{A}$	h	0.18^{A}	l
Grazing	8.48^{B}	m	3.41^{B}	h	1.20^{A}	h	0.09^{A}	l
Backyard	7.46^{BC}	m	2.86^{B}	h	1.02^{A}	h	0.12^{A}	l
Forest	13.80^{A}	h	10.82^{A}	h	1.47^{A}	h	0.11^{A}	l
CV (%)	13.35		26.23		31.49		48.16	

Means followed by the same letter are not significantly different at P<0.05. Exch. = Exchangeable, Conc. = Concentration, h = High, m = Medium, l = Low.

On the contrary, many research results supported the presence of low exchangeable potassium, since weathering, intensive cultivation and use of acid forming inorganic fertilizers on acid soils affect the distribution of K in the soil systems and enhance its depletion in cultivated lands (Baker *et al*., 1997; Saikh *et al*., 1998).

The exchangeable Ca concentration in the top soil of the natural forest land was higher by 12 cmol$^{(+)}$ Kg^{-1} in *Gullazmach keble* and five to eight cmol$^{(+)}$ Kg^{-1} in *Gaffera keble* than that of the cultivated and the grazing lands, respectively (Tables 3 and 4). The distribution of exchangeable Ca tended to increase in the order of cultivated lands, grazing lands, backyard and forest lands, except in grazing land in *Gullazmach kebele* (Table 3). Exchangeable Ca content in both *kebeles* was medium for all land use types, except in the natural forest land use type which is high (Tables 3 and 4).

There was also significant ($p<0.01$) difference in exchangeable Mg concentration between the land use types in *Gullazmach keble* (Table 3). In all the land use systems exchangeable Mg was in the highest range (Tables 3 and 4). Although exchangeable Mg, K and Ca concentrations were high and medium, their availability may be limited due to the acidity of the soil.

The decreasing trend of exchangeable K, Ca and Mg concentration in the cultivated and grazing land use types could be due to the leaching effect due to intensive cultivation, crop residues removal and organic matter degradation. Moreover, soil erosion, overgrazing and crop harvest removal for the past decades contributed for the depletion of K, Ca and Mg in the cultivated and grazing lands. This is in agreement with the findings of different investigators who indicated that continuous cultivation and use of acid forming inorganic fertilizers depleted exchangeable Ca and Mg (Saikh *et al*., 1998; He *et al*., 1999; Aitken *et al*., 1999).

On the contrary there was no significant ($p<0.05$) difference in exchangeable Na in all the land use types in *Gaffera kebele* (Table 9). However, at *Gullazmach kebele* there was significant difference in exchangeable Na concentration between cultivated and grazing land. Exchangeable Na concentration was in low level in all the land use types of both *kebeles,* except in grazing land in *Gullazmach kebele* which was in medium level (Table 4). It could be concluded that intensive cultivation and overgrazing increased soil acidity and decreased basic cations concentration. On the other hand this study indicated that reforestation practices would help in decreasing soil acidity and increasing the concentration of exchangeable bases in the soil. In the backyards increased vegetation growth and yield of crops was observed which could be due to the contribution of organic matter maintenance in the soil to decreasing acidity levels and increasing the concentration of exchangeable bases. So to decrease soil acidity and increase exchangeable base it is advisable to apply compost, lime, organic wastes, and farmyard manure and practicing plantation of forests on the boarder of cultivated as well as grazing lands.

Soil organic matter, total nitrogen and soil acidity

There was highly significant ($p<0.01$) difference in total nitrogen and organic matter (OM) content between the natural forest and the other land use types (Table 4). The organic matter content of forest land use types was found to be four times than the cultivated land use types at *Gullazmach kebele*. However, there was no significant difference between the cultivated, grazing and backyard land use types in the same *kebele* (Table 4). Total nitrogen content followed the same pattern (Table 4). In *Gaffera kebele*, however, the highest OM content of 10.88% was recorded in the forest land followed by grazing land (Table 5). These values were significantly ($p<0.01$) different compared to the cultivated and backyard soils. Total nitrogen content of forest land was found to be 0.52% which is significantly ($p< 0.01$) higher than all the other land use types (Table 5).

Table 4. Soil organic matter, total nitrogen, available phosphorous and available potassium contents of the soil under different land use types in *Gullazmach kebele* in 2008.

Land use	OM (%)		TN (%)		Available P		Available K	
	Conc.	Level	Conc.	Level	Conc.	Level	Conc.	Level
Cultivated	3.52^{B}	l	0.18^{B}	l	10.65^{B}	l	119.57^{B}	h
Grazing	4.70^{B}	l	0.33^{B}	m	5.75^{B}	l	147.12^{B}	h
Backyard	5.52^{B}	l	0.37^{AB}	m	28.87^{A}	l	482.39^{A}	h
Forest	14.73^{A}	m	0.60^{A}	h	13.94^{B}	l	246.10^{B}	h
CV (%)	20.56		33.1		24.85		23.76	

Means followed by the same letter are not significantly different at $P<0.05$. OM = Organic matter, TN = Total nitrogen, Conc. = Concentration, l = Low, m = Medium, h = High.

Organic matter content (OM) was low in all land use types at *Gullazmach kebele*, except forest land which has high OM content. While at *Gaffera keble* organic matter content was medium in grazing and backyard land use types and high in forest land use type. In both *kebeles*, total nitrogen concentration was high in the forest land use type and medium in the grazing and backyard land use types, but low in the cultivated land use types (Tables 4 and 5). Soil organic matter and total nitrogen contents have direct relation to soil acidity. This implies that in the study area intensive cultivation and total removal of crop residues had significantly depleted soil OM and total nitrogen that led to soil acidity problem. Continuous tillage operation without fallow and collection of crop residues for fuel consumption in the cultivated land may be responsible for the significantly lower organic matter and total nitrogen content. Tillage loosens the soil, improves its aeration, which hastens microbial break down of soil organic matter through respiration. It also increases decomposing of organic matter that may fasten soil acidity. It also increases susceptibility of the soil particles to detachment and removal by water during the erosion process (Roose and Barthes, 2001).

Table 5. Soil organic matter, total nitrogen, available phosphorous and available potassium contents of the soil under different land use types in *Gaffera kebele* in 2008.

Land use	OM (%)		TN (%)		Available P (ppm)		Available K (ppm)	
	Conc.	Level	Conc.	Level	Conc.	Level	Conc.	Level
Cultivated	1.42^{B}	l	0.15^{B}	l	6.61^{B}	l	161.39^{A}	h
Grazing	6.61^{AB}	m	0.30^{B}	m	6.27^{B}	l	206.87^{A}	h
Backyard	5.13^{B}	m	0.27^{B}	m	17.12^{A}	l	85.60^{B}	m
Forest	10.88^{A}	h	0.52^{A}	h	5.30^{B}	l	261.26^{A}	h
CV (%)	27.0		28.9		34.9		31.3	

Means followed by the same letter are not significantly different at P<0.05. OM = Organic matter, TN = Total nitrogen, Conc. = Concentration, l = Low, m = Medium, h = High.

The high concentration of organic matter and total nitrogen under the natural forest land could be attributed to accumulation of organic matter due to little soil disturbance as compared to the cultivated and grazing land and hence decreases soil acidity. Reduced erosion is expected to occur in natural forests, because the canopy formed by the trees, shrubs and under-storey vegetation shields the soil from the erosive energy of raindrops and thereby protecting the soil from splash erosion and surface or sheet erosion, this will again further reduce soil acidity through reducing leaching of basic cations. Water infiltration in the soil is enhanced by both preferential flow along trees roots and accumulation of absorbent humus on the soil surface, thereby significantly reducing the volume, velocity, and erosive and leaching capacity of surface runoff (Jiang *et al*., 1996). However, destructive free grazing practices in grazing land use types and continuous cultivation without fallow in cultivated land use types were responsible for poor physicochemical properties of the soil.

Therefore, poor organic matter and total nitrogen content might be due to poor nutrient management in cultivated land and over grazing in grazing land types. This finding was in agreement with Mullar - Harvey *et al*. (1985) who report that less biomass return results in less soil OM and total nitrogen content in the cultivated and grazing lands. Shariff *et al*. (1994) also reported that the most evident impact of grazing in the rangeland ecosystem is removal of the major part of above ground biomass by livestock. Therefore, the input of aboveground litter to the soil decreases. Any reduction in litter inputs may have important consequences for soil nutrient conservation and cycling.

According to Williams (2003), **t**he OM content in all the land use types at both *kebles* was below optimum which is 11-20%, except the forest land use types. The OM content for the forest land use type was in the optimum range which was 14.73 and 10.88% for *Gullazmach* and *Gaffera kebles*, respectively. The other land use types had low OM content (1.1-6.61%) as compared to the OM content requirement of most crops. According to Williams (2003), the lower OM content category is 0-10%. High decomposition rate of OM aggravates acidification of the soil in cultivated land use types, but decomposition of OM was low in natural forest (Tables 4 and 5).

Available phosphorous, potassium and soil acidity

There was significantly ($p<0.01$ and $p<0.05$) higher variation between backyard and other land use systems in available P and K concentrations (Tables 4 and 5). Significantly ($p<0.01$ and $p<0.05$) higher available P was recorded in backyard land use at both *kebeles*. There was also variation in available P and K concentrations between the two *kebeles* (Tables 4 and 5). Available P concentration decreased in the order of backyard (28.87 ppm), natural forest (13. 94 ppm), cultivated (10.65 ppm), and grazing (5.75 ppm) in *Gullazmach kebele*. There was no significant difference in available P in the other land use types. The higher concentration of these nutrients in the backyard land use may be due to the deposition of organic wastes and farmyard manure and the carry over effects of continuous P fertilizer application. Availability of phosphorous and potassium may be affected due to soil acidity in cultivated and grazing lands. At *Gullazmac*h and *Gaffera Keble*s the pH results were 5.24 and 5.13, respectively which may contribute to the lower availability of phosphorous nutrient (10.65 and 6.61 ppm) in the cultivated land use types. This result was in agreement with the finding of Orzolek (2002) which said that at pH of 5.0-5.5 phosphorus and potassium are less available to plants and may result in nutrient imbalances in the plant.

The natural forest which was low in soil acidity was also relatively low in available phosphorous as compared to backyard land use types in both *kebeles*. In *Gullazmach kebele* in the grazing land use type, where there is no external source of phosphorous, the concentration of available phosphorous was low. The low available P concentration in the grazing and natural forest land use types could be because there was no any application of chemical and organic fertilizer in these land uses. The other reason for the low available P concentration in the cultivated, grazing and forest land use types could be due to the inherently low soil P and/or the presence of P in unavailable form (Tables 4 and 5). This result is also in line with the findings of Ransmussen and Douglas (1992) and Whitebread *et al*. (1998). Available P was in the low concentration in all the land use types, except in backyard land use in *Gullazmach kebele* (Tables 4 and 5).

There was significant ($p<0.01$) variation in available K between the land use types (Tables 4 and 5). High available K concentration was observed in the backyard land use type in *Gullazmach Kebele,* but it was significantly lower in *Gaffera kebele* (Tables 4 and 5). The other land use types had statistically similar available K concentrations (Tables 4 and 5). Available K concentration for all the land use types was high, except for the backyard land use type in Gaffera kebele (Tables 4 and 5). This indicates that potassium nutrition is not a problem in that specific area.

Conclusion and recommendation

This study assessed soil acidity status in different land use systems. The results revealed that soils in all of the land use systems were generally acidic (pH<7) in the study area. Nearly all of the soil acidity indicators under the cultivated and grazing lands were very poor as compared to the other land use systems. This might be due to the continuous intensive cultivation, overgrazing, and removal of crop residue and cow dung.

Cultivated and grazing lands were also poor in macronutrients. This indicates that available nutrients might be depleted due to soil erosion, harvest of crops and crop residues and leaching which can be aggravated by repeated tillage without fallow. On the other hand, the high acidity in the cultivated and grazing land might affect the availability of these nutrients. Therefore, reducing intensive cultivation, integrated use of inorganic and organic fertilizers and lime application could replenish the degraded soil quality for sustainable agricultural production and productivity in the study area. Over grazing also causes chemical degradation of lands, therefore, controlled grazing or cut and carry system should be practiced to alleviate soil acidity problems in such land use systems.

References

Abbott, T. S. (Ed.). 1989. BCRI soil testing methods and interpretation. NSW Agriculture and Fisheries, Rydalmere, NSW.

Aitken, RL. Moody, PW. and Mckinley, PG. 1990. Lime requirement of acidic Queensland soils. Relationships between soil properties and pH buffer capacity, Australian journal of soil research 28(5) 695-701, also available at http://www.publish.csiro.au/paper/SR9900695.htmfebruary, February, 2008.

Alemayehu Tafesse. 1990. Soil and irrigation management in the state farms. pp. 47-52 In: Proceeding of first natural resource conservation conference. Natural Resource Degradation: A Challenge to Ethiopia. Institute of Agricultural Research (IAR), 7-8 Feb 1989. Addis Ababa, Ethiopia.

Anon. 1993. Soil Chemical Analysis. Part I, Vol. 1. Improvement of soil services for Agricultural development (Eth./87/010). Ministry of Natural Resources Development and Environmental Protection. UNDP, FAO, Addis Ababa, Ethiopia.

Baker, M.R., C. nys, and J.F. Picard. 1997. The effect of liming and gypsum applications on a sessile oak (Quercus petraea) stand at Larcroix-Scaille (French ardennes). I. Site characteristics, soil chemistry and aerial biomass. Plant and Soil 150: 99-108.

Baligar, V.C., G.V.E. Pitta, E.E.G. Gamma, R.E. Schafter, A.F. Filho and R.B. Clark. 1997. Soil acidity effects on nutrient use efficiency in exotic maize genotypes. Plant and Soil 192:9-13.

Blamey, F.C., Z. Ostate, K. Boczynski and G.L. Kerven. 1997. Ligand effects on aluminum sorption by calcium pectate. Plant Soil 192:269-275.

BoARD. 2007. FAgtalokoma woreda Agriculture and rural development Office annual report.

BoFED. 2004. Produced by GIS Team of ANRS, CSA map is used as Input.

Chopra S.L. and Kanwar J.S. 1999. Analytical agricultural chemistry. Pp 271.

Doran, J.W. and T.B. Parkin. 1994. Defining and assessing soil quality. Pp. 1-21. In: J.W. Joran, D.C. Coleman, D.F. Bezdicek and B.A. Stewart (eds.). Defining soil quality or sustainable environment, SSSA Special Publ. No. 35, Madison, Wisconsin, USA.

He, Z.L., A.K. Alva, D.V. Calvert, Y.C. Li and D.J. Banks. 1999. Effects of N fertilization of grapefruit trees on soil acidification and nutrient availability in a Riviera Fine Sand. Plant Soil 206: 11-19.

Jackson, M.L. 1958. Soil Chemical Analysis. Prentice Hall, Inc., Engle Wood Cliffs. New Jersey. 183-204p.

Jiang, Z., Wang, Z. & Liu, Z. 1996. Quantitative study on spatial variation of soil erosion in a small watershed in the loess hilly region. Journal of Soil Erosion and Soil and Water Conservation, 2: 1-9, (in Chinese, with English abstract).

Johnson G.V. 1914. Cause and Effects of Soil Acidity. Oklahoma Cooperative.

Marx, E.S., Hart, J. and Steven, R.G. 1997. Soil Test Interpretation Guide. Extension and station communications, Oregon state universities, 1478. Also available at extension. Oregon state .edu/catalog/pdf/ec/ec1478.pdf on August 2008.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. (1994). Australian Soil and Land Survey Field Handbook.' (Inkata Press: Melbourne.).

McWilliams, D. 2003. Interpreting Soil Tests for Efficient Plant Growth and Water Use. Guide A-141. Cooperative Extension Service College of Agriculture and Home Economics, New Mexico state university also available at http://www.cahe.nmsu.edu/pubs/_a/A-141.pdf on July 2008.

Mekaru, T. and G. Uehara. 1972. Anion adsorption in ferraginous tropical soils. Soil Sci. Soc. Am Proce 36:296-300.

Mullar-Harvey, I., Juo, A.S.R., Wilde, A. 1985. Soil C, N and P after forest clearance: mineralization rates and spatial variability. Journal of Soil Science 36:585-591.

Olsen, S.R,. C.V. Cole, F.S. Watanabe and L.A. Dean. 1954. Estimation of available P in soils by extraction with sodium bicarbonate. USDA circular 939. 1-19p.

Orzolek, M.D. 2002. Organic Matter Application Can You Apply Too Much? Virginia Vegetable, Small Fruit and Specialty Crops; Volume 1, Issue 9, Department of Horticulture.

Pam Hazelton and Brian Murphy. 2007. Interpreting Soil Test Results; What Do All the Numbers Mean? University of Technology, Sydney (UTS), Department of Infrastructure, Natural Resources & Planning: CSIRO PUBLISHING pages 59-63.

Poulose Dubale. 2001. Northeast African Studies, Vol. 8, No. 1 (New Series), pp. 27-52.

Rasmussen, P.E. and C.L. Douglas. 1992. The influence of tillage and cropping intensity on cereal response to N, sulfur and P. Fert. Res 31:15-19.

Roose and Barthes. 2001. Organic matter management for soil conservation and productivity restoration in Africa. A contribution from francophone research. Nutrient cycling in agro ecosystem 61:159-170.

Saikhe, H., C. Varadachari and K. Ghosh. 1998. Effects of deforestation and cultivation on soil CEC and contents of exchangeable bases. A case study in Simplipal National Park, India. Plant and Soil 204:67-75.

Shariff, A.R., Biondini, M.E., C.E. Grygiel. 1994. Grazing intensity effects on litter decomposition and soil nitrogen mineralization. J. Range Management 47:444–449.

Skjemstad, J. O., Spouncer, L. R., and Beech, T. A. 2000. Carbon conversion factors for historical carbon data. National Carbon Accounting System Technical Report No.15, Australian Greenhouse Office, Canberra.

United States Department of Agriculture and Natural Resources Conservation Service Soil Quality Institute (USDA). 2001. Guidelines for Soil Quality Assessment in conservation Planning.

Wakene Negassa and Hiluf Gebrekidan. 2006. The Impact of Different Land Use Systems on Soil Quality of Western Ethiopian Alfisols. Also available at http://www.tropentag.de/2004/abstracts/full/265.pdf on September, 2007.

Whitebread, A.M., R.D.B. Lefroy and G.J. Blair. 1998. A survey of the impact of cropping on soil physical and chemical properties in Northwestern New south wales. Aust. J. Soil Res. 36:669-681.

Yihenew G.Selassie (ed.). 2008. Proceedings of the 2nd Annual Regional Conference on Completed Natural Resources Management Research Activities, 18-19 September 2007, ARARI, Bahir Dar, Ethiopia.

Evaluation of regulated deficit irrigation on the yield of Potato at Adet

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Abstract

Regulated deficit irrigation (RDI) aims to optimize water use efficiency and the crop yield from a unit of water applied. In this study, three deficit irrigation water levels (20%, 40% and 60%) were applied at different potato growth stages independently namely: i) initial stage which includes the time from sowing to 10% ground cover, ii) crop development stage which is from 10% to 70% ground cover, iii) mid-season stage including flowering and yield formation, and iv) late season stage including rippening and harvest. The objective of this study was to improve water productivity with application of deficit irrigation so as to enhance crop production and save water for various uses. Field work was conducted at Adet Agricultural Research Centre for two years (2009 and 2010). The experiment was laid down in a randomized complete block design with three replications. Irrigation water was applied using furrow irrigation method. Data collected from Field experiment was analysed using SAS statistical software. The results of the combined analysis of the two year data showed that deficit irrigation did not significantly affect most biological parameters. Despite this, 60% deficit irrigation (375 mm net irrigation) at crop development stage (day 25 to day 55) gave highest marketable yield (16 ton ha^{-1}) and total yield (21ton ha^{-1}) and dry matter content (22%) which is within the acceptable industrial standard (20-25%). Moreover, results of the experiments revealed that 51 mm (510 m^3 ha^{-1}) of irrigation water, which is about 12% of the total net irrigation, could be safely saved without significant potato yield loss at Adet.

Keywords: Deficit, furrow, irrigation, potato.

Introduction

Efficient use of irrigation water enhances production and thus the income of the people and the country as well. Frequent occurrence of drought requires a proactive and rational water management approach, which could be helpful to both managers and farmers. Related to water restriction, a recent study shows that a decrease of 10% in water supply would result a reduction of about 2% net agricultural product (El Amam, 2001). Under high and very high demand conditions, the gross margin per unit of water applied decreases for the potato and the tomato crops but increases for the wheat crop. So, considering an average year, the adoption of a deficit irrigation scheme is feasible for the potato and tomato crops, while for the wheat crop it is not economically advantageous to use deficit irrigation, this is the reason why the crop is usually grown in rain fed conditions (El Amam, 2001).

In times when irrigation water is limiting, the farmer may not have enough water to irrigate all the crop fields. In this case, the farmer may decide to spread the available water over a large area, although it is less than the optimal amount. Here, it is good to know i) the crops which suffer most from water shortage and ii) the growth stages during which the various crops suffer most from water shortage (Awulachew *et al.*, 2009). If various crops are grown on a given field, it is advisable to give priority to irrigate the most drought sensitive crops.

The total growing season of a given crop is usually divided into four stages. These are i) initial stage which includes the time from sowing to 10% ground cover; ii) crop development stage which is from 10% to 70% ground cover; iii) mid-season stage including flowering and grain setting or yield formation; and iv) late season stage including rippening and harvest. In general, it is stated that out of the four growth stages, the mid season stage is the most sensitive to water shortages. This is mainly because it is the period of the highest crop water needs. Hence, if water shortage occurs during this stage, the negative effect on yield will be pronounced.

To see the effect of limited water application on yield and production, consideration must be given to the effect of the limited water application during the individual growth periods of the crops (FAO, 1979). If crops under consideration are less sensitive to water deficit and can be grown with acceptable yields but without meeting full water requirements, scheduling of supply is based on minimizing water deficits in most sensitive growth periods. During periods of unpredictable water shortages, within season adjustment of water scheduling must be made in relation to the difference in yield response to water deficits on the crops and their individual growth periods. In terms of water management this means water allocation of limited supply should be directed towards meeting full water requirements of these sensitive stages rather than spreading the available limited supply to the crop equally over the total growing period.

Maintaining a reduced soil moisture deficit keeps vegetative growth under control while photosynthesis remains unaltered. A reduced moisture deficit therefore has been stated as the most agronomic desirable soil moisture level. Excessive water stress should be avoided, as it reduces photosynthetic activity which will affect both vegetative and reproductive growth. Regulated deficit irrigation (RDI) may be implemented during part of the growing season by regulating moisture within a desired deficit range. RDI aims to optimize water use efficiency and therefore the yield returned per unit of water applied. Any minor yield loss which may result from the implementation of a mild moisture deficit/stress under RDI is compensated by the benefits of saved water to irrigate additional areas. The most desirable benefits associated with implementing a RDI strategy are: i) the reduction in excessive vegetative growth; ii) maintenance of soil moisture in the most agronomic desirable range; and iii) an increase in water use efficiency (FAO, 2002). The objective of this study was, therefore, to improve water productivity with application of deficit irrigation so as to enhance crop production and save water for various uses.

Materials and methods

The experiment was conducted at Adet research station 43 km from Bahir Dar during 2009 and 2010. Adet is located at 11^0 17’ N latitude and 37^0 43’ longitude at an altitude of 2240 m above mean sea level. The mean daily maximum temperature ranges from 22.5^0C (July and August) to 29.4 ^{0}C (March) and the mean daily minimum temperature ranges from 5.4 ^{0}C (January) to 12.1 0C in August. The soil is characterized by pH of about 5.41, organic matter content of 2.2%, bulk density of about 1.39 and its texture is basically clay.

To calculate the irrigation water requirement of potato for Adet metrological and other necessary data were collected from the National Meteorological Agency and other reliable sources. Potential evapotranspiration of the area was calculated for the recent ten years and the resulting value was fitted to 80% probable value (Table 1).

Table 1. Potential evapo-transpiration values (mm day^{-1}) for Adet research station.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1996	3.62	4.52	4.69	4.67	3.9	3.73	3.24	3.05	3.67	4.03	3.42	3.42
1997	3.62	4.39	4.51	4.80	4.35	3.60	3.16	3.30	3.97	3.62	3.51	3.57
1998	3.86	4.43	4.64	5.25	4.57	4.08	2.70	2.77	3.44	3.68	3.54	3.57
1999	3.56	4.5	5.01	5.12	4.56	3.95	3.00	3.17	3.56	3.43	3.68	3.41
2000	3.74	4.21	4.89	4.10	4.56	4.07	3.15	2.82	3.49	3.36	3.39	3.30
2001	3.59	4.09	4.23	4.83	4.37	3.22	2.95	2.90	3.67	3.66	3.39	3.34
2002	3.32	4.17	4.36	5.04	4.83	3.94	3.45	3.19	3.57	3.76	3.54	3.46
2003	3.72	4.2	4.56	5.19	5	3.79	2.84	2.80	3.24	3.89	3.56	3.43
2004	3.64	4.21	4.77	4.49	5.04	3.62	3.23	3.04	3.39	3.66	3.40	3.31
2005	3.42	4.18	4.39	4.55	4.62	3.91	2.69	3.22	3.57	3.67	3.37	3.16
Mean	3.61	4.29	4.61	4.80	4.58	3.79	3.04	3.03	3.56	3.68	3.48	3.40
Fitted (@80%)	3.72	4.36	4.79	5.08	4.83	3.99	3.23	3.17	3.70	3.80	3.56	3.49

Based on ten years meteorological data of the area and fitted potential ET_0, crop water requirement and the respective irrigation schedules were worked out for potato using CROPWAT model (Tables 2 and 3). It was determined under the conditions of field efficiency of 70% and irrigating at critical depletion level to refill the soil moisture to the level of field capacity. The irrigation schedule for potato in Table 3 was determined on the basis of predetermined seven days irrigation interval and 0.5% yield loss level.

Three deficit water levels (20%, 40% and 60%) were applied at four potato growth stages namely: i) initial stage (IS) which includes the time from sowing to 10% ground cover, ii) crop development stage (CDS) which is from 10% to 70% ground cover, iii) mid-season stage (MSS) including flowering and yield formation, and iv) late season stage (LSS) including rippening and harvest. A satellite plot which is fully irrigated (0% deficit) was also included in the experiment.

Table 2. Crop water requirement and irrigation requirement of potato at Adet research station.

Month	Decade	Growth Stage	Kc	ET crop (mm/day)	ET crop (mm/dec)	Eff. rain (mm/dec)	Irr. req. (mm/day)	Irr. req. (mm/dec)
Dec	3	Initial	0.5	1.79	3.6	0.2	1.68	3.4
Jan	1	Initial	0.5	1.82	18.2	2.4	1.59	15.9
Jan	2	Initial	0.5	1.86	18.6	2.6	1.6	16.0
Jan	3	Initial/Dev.	0.59	2.32	25.5	2	2.13	23.4
Feb	1	Dev.	0.78	3.26	32.6	0.6	3.2	32.0
Feb	2	Dev.	1.0	4.39	43.9	0	4.39	43.9
Feb	3	Dev/Mid	1.13	5.12	40.9	2	4.86	38.9
Mar	1	Mid	1.15	5.37	53.7	5.8	4.79	47.9
Mar	2	Mid	1.15	5.52	55.2	8.2	4.7	47.0
Mar	3	Mid	1.15	5.63	62	10.7	4.66	51.3
Apr	1	Mid/Late	1.14	5.68	56.8	12.8	4.4	44.0
Apr	2	Late	1.06	5.39	53.9	15.1	3.88	38.8
Apr	3	Late	0.92	4.62	46.2	19.4	2.68	26.8
May	1	Late	0.8	3.94	31.5	19.3	1.53	12.2
Total					542.6	101.1		441.4

ET = Evapotranspiration, Kc = Crop coefficient, Eff. rain = Effective rain, Irr. Req. = Irrigation requirement, Initial = Initial growth stage, Dev. = Development growth stage, Mid = Mid growth stage, Late = Late growth stage.

Table 3. Irrigation schedule of potato at Adet research station.

Date	Day	Growth Stage	Rainfall (mm)	Depletion (%)	Kc frac	ETa (%)	Net irr. (mm)	Deficit (mm)	Loss (mm)	Gross irr. (mm)	Flow (l/s/ha)
5-Jan	7	Initial	0	24	1	100	11.5	0	0	16.4	0.27
12-Jan	14	Initial	0	22	1	100	11.6	0	0	16.6	0.27
19-Jan	21	Initial	0	20	1	100	11.7	0	0	16.7	0.28
26-Jan	28	Dev.	0	23	1	100	14.7	0	0	21.0	0.35
2-Feb	35	Dev.	0	26	1	100	18.1	0	0	25.9	0.43
9-Feb	42	Dev.	0	30	1	100	22.5	0	0	32.2	0.53
16-Feb	49	Dev.	0	37	0.96	99	29.4	0	0	42.1	0.70
23-Feb	56	Mid	1.0	38	0.97	100	31.7	0	0	45.3	0.75
2-Mar	63	Mid	0	41	0.92	99	34.8	0	0	49.8	0.82
9-Mar	70	Mid	0	41	0.93	99	34.2	0	0	48.9	0.81
16-Mar	77	Mid	0	40	0.94	99	33.9	0	0	48.4	0.80
23-Mar	84	Mid	5.7	39	0.96	99	32.8	0	0	46.9	0.78
30-Mar	91	Mid	0	40	0.95	99	33.5	0	0	47.8	0.79
6-Apr	98	Mid	0	39	0.96	99	32.7	0	0	46.8	0.77
13-Apr	105	Late	8.0	37	1	100	30.8	0	0	44.0	0.73
20-Apr	112	Late	0	35	1	100	29.7	0	0	42.4	0.7o
27-Apr	119	Late	10.9	14	1	100	12.2	0	0	17.4	0.29
4-May	126	Late	0	19	1	100	15.7	0	0	22.4	0.37
9-May	End	Late	0	9	1	0					
Total							441.5			631	

Initial = Initial growth stage, Dev. = Development growth stage, Mid = Mid growth stage, Late = Late growth stage, Kc = crop coefficient, ETa = actual evapotranspiration, Net irr.= net irrigation, Gross irr. = gross irrigation.

Treatments were arranged in randomized complete block design with three replications with a plot size of 3 m X 6 m each. Land preparation and planting were carried out early in December and at the end of December, respectively. Eighty potato seeds were planted along the ridge at 30 cm spacing and 75 cm between ridges in each plot. Fertilizer was applied at the rate of 69 kg P_2O_5 ha^{-1} and urea was split applied at the rate of 81 kg N ha^{-1} at planting and flowering stages.

Depending on the CROPWAT results, the irrigation schedule for each treatment setup was worked out (Table 4). Irrigation water was applied using furrow irrigation method and irrigation water was applied on weekly basis. The required amount of irrigation water for each treatment was applied to each furrow using a siphon. Geo-membrane was used as a lining material for the furrows to avoid lateral seepage of irrigation water to the adjacent plots. On average, three irrigations for establishment and fourteen irrigations afterwards were made throughout the potato growing season. Agronomic data such as number of tuber, tuber weight, total and marketable yield, unmarketable yield, dry matter content and water use efficiency were collected. The collected data were then subjected to statistical analysis using SAS software.

Results and discussion

Using the past ten years meteorological data, the daily maximum and minimum potential evapotranspiration rates were found to be 5.08 mm and 3.17 mm which occur during April and August, respectively. The average daily potential evapotranspiration was 3.98 mm. The seasonal crop evapotranspiration was then estimated to be 543 mm for Adet. Considering effective rainfall, the Cropwat model estimated 441 mm and 631 mm net and gross irrigation water requirements, respectively for potato at Adet.

Table 4. Amount of gross irrigation applied in liters for 18m^2 plot area at each potato growth stage in the season.

Date	Gross Irr. (lit)	Growth Stage	20% @ IS	40% @ IS	60% @ IS	20% @ CDS	40% @ CDS	60% @ CDS	20% @ MSS	40% @ MSS	60% @ MSS	20% @ LSS	40% @ LSS	60% @ LSS
5-Jan	295	IS	236	177	118	295	295	295	295	295	295	295	295	295
12-Jan	299	IS	239	179	120	299	299	299	299	299	299	299	299	299
19-Jan	301	IS	240	180	120	301	301	301	301	301	301	301	301	301
26-Jan	378	CDS	378	378	378	302	227	151	378	378	378	378	378	378
2-Feb	466	CDS	466	466	466	373	280	186	466	466	466	466	466	466
9-Feb	580	CDS	580	580	580	464	348	232	580	580	580	580	580	580
16-Feb	758	CDS	758	758	758	606	455	303	758	758	758	758	758	758
23-Feb	815	MSS	815	815	815	815	815	815	652	489	326	815	815	815
2-Mar	896	MSS	896	896	896	896	896	896	717	538	359	896	896	896
9-Mar	880	MSS	880	880	880	880	880	880	704	528	352	880	880	880
16-Mar	871	MSS	871	871	871	871	871	871	697	523	348	871	871	871
23-Mar	844	MSS	844	844	844	844	844	844	675	507	338	844	844	844
30-Mar	860	MSS	860	860	860	860	860	860	688	516	344	860	860	860
6-Apr	842	MSS	842	842	842	842	842	842	674	505	337	842	842	842
13-Apr	792	LSS	792	792	792	792	792	792	792	792	792	634	475	317
20-Apr	763	LSS	763	763	763	763	763	763	763	763	763	611	458	305
27-Apr	313	LSS	313	313	313	313	313	313	313	313	313	251	188	125
4-May	403	LSS	403	403	403	403	403	403	403	403	403	323	242	161
9-May		LSS										0	0	0
Total	11358		11179	11000	10821	10922	10485	10049	10156	8954	7752	10904	10449	9995

The agronomic results showed that the number of tubers per plant, average tuber weight, marketable yield, total yield, unmarketable yield and dry matter content were not affected significantly by deficit irrigation (Table 5). Generally, it was observed that the highest marketable yield, highest tuber number, and the highest total yield occurred with deficit application at crop development stage which gives an impression that deficit application at crop development stage is feasible (Table 5). On the contrary, the satellite plot (which is fully irrigated at all stages in the season) gave only 15.09 t/ha marketable yield and water productivity of 3.54. This relatively low yield may be attributed to the fact that potato yield and quality are susceptible to excess soil water as well. Excess soil water from frequent or intensive irrigation or rainfall during any growth stage leaches nitrate nitrogen below the plant root zone, potentially resulting in nitrogen-deficient plants, reduced fertilizer use efficiency. Saturation of the soil profile for more than 8-12hours can cause root damage due to a lack of oxygen required for normal respiration. Excess soil water at planting promotes seed piece decay and delays emergence due to decreased soil temperature (King and Stark, 1997).

Conclusion and recommendations

Most biological parameters respond non-significantly for the application of deficit irrigation application at different crop growth stages for both years. Hence, conclusion is made by critically looking into marketable yield, non-marketable yield, total yield, dry matter content and water use efficiency of potato. Accordingly, the combined analysis result of the two year data showed that, 60% deficit irrigation application at crop development stage (day 25 to day55) gave maximum marketable and total yield of 16.44 and 21.0 ton ha^{-1} respectively and dry matter content (22%) which is within the acceptable industrial standard (20-25%).

Table 5. Effect of deficit irrigation on yield and yield components of potato at Adet (2009 and 2010 combined).

Treatments	No. of tubers/plant	Av. tuber weight (g)	Marketable yield (t/ha)	Total yield (t/ha)	Unmarketable yield (t/ha)	Dry matter (%)	Water productivity (kg/m3)	Water saved (mm)
20% @ IS	8.6	62.4	15.11	19.85	4.74	22.3	3.61	7
40% @ IS	8.6	59.2	12.1	18.96	6.86	22.3	2.94	14
60% @ IS	8.4	57.8	12.34	18.17	5.83	21.6	3.05	21
20% @ CDS	9.1	53.2	13.76	18.45	4.69	22.1	3.36	17
40 % @CDS	8.7	58.6	15.12	19.15	4.03	20.6	3.86	34
60% @ CDS	9.9	55.6	16.44	21.02	4.58	22	4.38	51
20% @ MSS	9	62.9	14.37	19.95	5.58	22.2	3.79	47
40% @ MSS	8.5	62.5	15.13	19.97	4.84	22.3	4.54	93
60% @ MSS	8.7	56.3	12.57	18.68	6.11	22	4.4	140
20% @ LSS	8.6	58.8	14.76	20.42	5.66	20	3.58	14
40% @ LSS	7.4	65.6	12.89	17.05	4.16	22.3	3.25	22
60% @ LSS	8.5	58	15.32	19.13	3.81	22.5	4.01	37
LSD (5%)	NS	NS	NS	NS	NS	NS		
CV (%)	20.5	19.6	16.8	12.6	19	8.2		

Crops are more sensitive to water deficit during emergency, flowering and early yield formation than crop development and late stage (Doorenbos and Kassam, 1979). Hence, the result of this study goes in line with the above fact. Studies made at Colorado state university also indicated the critical period for potato is the time from tuber formation to harvest. Management allowable deficit (MAD%) for potato is found to be 40-60 % at early vegetative period, 30-40% at tuber bulking period and 65% at ripening period (Al-Kaisi and Broner, 2009). It can be seen that by applying 60% deficit irrigation at crop development stage, the crop used only 375 mm net irrigation water whereas full application with no deficit at all potato growth stage took net irrigation amount of 426 mm during the whole growing season. This implies that 51 mm irrigation water which is about 12% of the total net irrigation could be saved without significant potato yield loss at Adet. This is equivalent to saving 510 m^3 of irrigation water from a hectare of potato field. Therefore, application of 60% deficit irrigation at crop development stage (days 25 to 55) could be used to produce potato in Adet and areas having similar agro-ecology.

References

King, B.A. and Stark, J.C. 1997. Potato irrigation management. University of Idaho, Aberdeen Research & Extension Center.

Doorenbos, J. and Kassam, A.H. 1979. Yield response to water. Irrigation and drainage paper No. 33. FAO, Rome, Italy.

El Amam, H., Zairi, A., Pereira, L.S., Machado, T., Aslatni, A. and Rodrigves, P. 2001. Deficit irrigation of cereals and horticultural crops.

Food and Agriculture Organization of the United Nations (FAO). 2002. Deficit Irrigation Practices. Water report 22, Rome, Itly.

Al-Kaisi, M.M. and Broner, I. 2009. Crop Water Use and Growth Stages. Collorado State University Extension, Fact Sheet No. 4.715.

Sileshi Bekele Awulachew, Lemperiere P. and Tafa Tulu. 2009. Training material on agricultural water management. IWMI (international water management institute), Addis Ababa, Ethiopia, ILRI (International Livestock Research Institute), Nirobi,Kenya and Adama University, Adama, Ethiopia.

Assessment on the socioeconomic aspect of area enclosure in North Shewa Zone: The case of Kewote and Basona Worena districts

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Abstract

The general objective for undertaking this research was to identify the contribution of area enclosure for household income and assess socioeconomic factors that contribute for better use and management of area enclosure. The study was done in two districts of North Shewa zone, Kewote and Basona Worena. Both probability and non-probability sampling techniques were employed in the study. Accordingly, two kebeles (Yelen and Karajejeba) from Kewote and one kebele (Gudoberhet) from Basona Worena districts were selected purposively and samples of 95 farmers participating in area enclosure were selected randomly. Primary data were collected using structured questionnaires. Focus group discussions were also held to supplement data collected using questionnaires. Data were analyzed using descriptive statistics and econometric model using STATA version 8 software. The cost-benefit analysis result showed that besides its ecological benefit, area enclosure has a net benefit of ETB 3272.33 ha^{-1} per year per household. Farmers on average have incurred a cost of ETB 1399 ha^{-1} per year. The regression result indicated that education status of the household head, number of male family members, grazing land problem and experience in participation of area enclosure use and management affected income from area enclosure positively and significantly. But sorghum production affected income from area enclosure negatively.

Key words: Cost-benefit, ecological benefit, enclosure.

Introduction

The establishment of area enclosures (AE) has been one of the strategies for rehabilitating degraded hillsides within a catchment. The inception of area enclosure in Ethiopia dates back to the early 1980s, which coincides with the beginning of large-scale land rehabilitation and soil and water conservation programs in the country (Betru *et al.*, 2005). Area enclosure in the Ethiopian context is defined as a degraded land that has been excluded from human and livestock interference for rehabilitation (Tefera *et al.,* 2005). In principle, human and animal interference is restricted in the AE to encourage natural regeneration. In practice, however, cattle are allowed to free graze in several of the AE. Cutting grass and collection of fuel wood and bee keeping is also practiced. In some areas besides enclosing the area soil and water conservation structures are also implemented. The AE and community woodlots were established by the government primarily for ecological regeneration and biodiversity conservation. The concept of economic benefits was not often explicitly addressed in the early years of their establishment. But, since few years there is a huge interest from participants in using AE and community woodlots as source of income.

It is believed that the socioeconomic situation of specific area affects the sustainable and effective management of resources. Even though there are limited works done on the socioeconomic aspects of AE in different areas of the country, there is no similar work done in the study areas. Therefore this study was conducted with the overall objective of examining the contribution of AE for household income and assessing the socioeconomic factors that contribute to the better management of AE. The finding of this research will complement the study done by the Forestry and Agro-forestry program of Debre Birhan Agricultural Research Centre (DBARC) about area enclosure, since the research was limited only to the ecological aspects of AE.

Methodology

Study area

The study was conducted in Kewote and Basona Worena districts of North Shewa zone. Out of the total area coverage in North Shewa zone (15954 km^2) Kewote and Basona Worena districts share 715.85 and 1301.78 km^2, respectively. The total population is 118,333 and 120,879, respectively (CSA, 2007). Kewote district is mostly lowland, while Basona Worena is generally highland. The share of the different land use patterns in North Shewa is about 11.5% farmland, 10.8% grassland, 21.5% natural forest, 17.1% plantation forest, and 39.1% others. The land covered by AE in North Shewa zone is 15,265 ha out of which 1,500 ha and 1,805 ha are in Kewote and Basona Worena districts, respectively (NSZoA, 2007).

Sampling procedure and data analysis

A combination of probability and non-probability sampling techniques were employed. A multistage sampling method was implemented to identify sample farmers. Initially, Basona Worena and Kewote districts were selected purposively on the basis of their area enclosure coverage and representing the highland and lowland areas in the zone. Then, two kebeles (Yelen and Karajejeba) form Kewote and one kebele (Gudoberhet) from Basona Worena districts were selected purposively again based on the coverage and long year experience in area enclosure. Finally, 65 farmers from Kewote and 30 farmers from Basona Worena (a toal of 95 sample farmers) who participated in AE were selected using random sampling procedure. Primary data were collected using questionnaires that were pre-tested and modified accordingly in 2007/2008. Secondary data were collected from the central statistical authority and respective district agriculture and rural development offices. Focal group discussions were also held to strengthen the quantitative data collected. The data were analyzed using descriptive statistics and econometric method using STATA Version 8 software.

Econometric model specification

Generally, the following multiple linear regression model was used following Gujarati (2004):

$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + E_i$

Where, i=1, 2, 3………n, and n= total number of respondent farmers

Y = Dependent variable, income from AE in Ethiopian Birr per year

k = Number of explanatory variables

X = Explanatory variables

β s are coefficients of the explanatory variables, and

E_i is residual term

Before running the model all the hypothesized explanatory variables were tested for the existence of multicollinearity and Hetroskedasticity problem using Variance Inflation Factor (VIF) and Breusch-Pagan/Cook-Weisberg tests, respectively. The dependent and explanatory variables employed and the hypothetical relationships are indicated in Table 1.

Table 1. Variable definition and hypothetical relationship.

Variables	Code	Hypothetical relationship
Income from AE in ETB year^{-1} (Dependent)	IncomeAE	---
Education level of the household head	Educhh	+
Number of male members of the household head	Malfamsz	+
Production of teff (Quintal = 100 kg)	Pteff	-
Production of Sorghum (Quintal = 100 kg)	Psorghum	-
Grazing land problem (1 = yes, 0 = No)	Grazlndpro	+
Distance of AE from home (minute by foot)	Farenclos	-
Feeling of ownership (1 = yes , 0 = No)	Felurs	+
Extension service (1 = yes , 0 = No)	Extserev	+
Experience in AE (years)	Whenenclo	+

Cost benefit analysis

The cost benefit analysis simply took both benefits and costs that could be estimated in monetary terms. In the benefit side both the grass used for home and sold grass was considered. Costs associated with management and use of area enclosure were considered. The total cost for guard was estimated by dividing the total salary paid for a year by the total members/participants of AE. Other costs are estimated by using the market values for labor (wage rate) both for hired and family labor.

Results and discussion

General household and farm characteristics

Out of the total sample households the majority (87%) were male headed. The average age of the household head in the study areas is 43 years. Total landholding per household head varies from 1 to 11.5 *timad* (1 *timad* = 0.25 ha), with an average holding of 4.82 *timad*. The average family size is five where three of them are male. Households own oxen in the ranges of zero to four oxen per household, with an average of one ox (Table 2).

Table 2. Household (HH) characteristics in Kewote and Basona Worena districts.

Variable description	N	Minimum	Maximum	Mean	Std. Dev
Age of the household head	89	18	86	43.2	14.82
Number of male family members	92	0	7	2.76	1.57
Total number of family members	92	1	11	5.10	2.14
Total landholding per HH (*timad*)	90	1	11.5	4.82	2.40
Total farmland per HH (*timad*)	85	0.5	8	3.68	1.81
Total number of oxen per household	89	0	4	1.44	0.90

Note: One *timad* is 0.25 hectare.

Area enclosure use and management

It is expected that area enclosure will have its own implication on availability of grazing land. The study result confirmed that farmers face grazing land problem due to enclosure and other associated reasons. Out of the total respondents about 81.4% reported grazing land shortage (Table 3). However, on the other hand enclosing the area has enhanced the productivity of the land, especially of grass, which in turn could solve feed shortage in the area.

The other basic problem in managing common property is lack of sense of ownership. In terms of ownership, from the total sample households about 83% of the respondents gave area enclosure an equivalent weight to their private land (Table 3). Factors that improved sense of ownership are: farmers are using and managing the resource by themselves, farmers are getting short term benefit out of AE (in case of Kewote), and some farmers formed a cooperative and got ownership license. Majority (nearly 80%) of the respondents have had contact with extension agents and take lessons/advices about area enclosure management. Similar study conducted by Tefera *et al.* (2005) also confirmed positive sense of ownership by farmers where 93% of the respondents showed positive attitude to AE and indicated that the value of the land had increased due to enclosures.

Table 3. Perceptions of household on factors associated with area enclosure in Kewote and Basona Worena districts.

Variable description		N	Percent
Grazing land problem prevalence	No	16	18.6
	Yes	70	81.4
Consideration of enclosed land as private cultivated land	No	14	16.7
	Yes	70	83.3
Communication with extension agents	No	18	20.5
	Yes	70	79.5

Even though there is an experience of tree plantation in the enclosed area, there is no success as compared to the number of seedlings planted, especially at Kewote district. At Gudoberhet kebele basically Eucalyptus was planted and there is no adaptation problem, but lack of follow up contributes much for its failure.

Area enclosure in Kewote district was started in 2001 by the Debre Birhan Agricultural Research Centre on the demonstration site of Karajejeba kebele. Since then, different stakeholders have replicated AE at various kebeles such as Karajejeba, Yelen, Kore, Wureba, and Charie kebeles of the district. In these areas enclosure was implemented at different periods; in 2004 in *Mereye*, in 2005 in *Wureba*, and in 2006 in *Kore* (Kewote WOA, 2009). AE in Basona Worena district at Gudoberhet kebele was started relatively late. It was started in 2007 with 75 farmers who have land in one area (Basona Worena DOA, 2009). Farmers in that area get organized, enclose the area and plant trees. This was done by the help of district and kebele level agricultural experts together with NGOs in the area. At Kewote district the hills that farmers enclosed were communal owned, but at Basona Worena they take their own share of land, out of which it was communal before the area is enclosed. However, in Basona Worena woreda aswel, development activities and management is done in cooperation. In both cases the basic reason for enclosure is to get economical advantage and to safeguard the area from erosion. In both districts, farmers hire guards and pay a monthly salary ranging from ETB 120 to 150 for each guard.

Several stakeholders were involved in the use and management of AE both at Kewote and Basona Worena (Table 4). The responsibility of the kebele goes up to penalizing those who act out of the agreed bylaws. The practices in the two districts vary slightly; unlike in Basona Worena, farmers at Kewote are getting short term benefit from selling grass out of the AE. At Karajejeba kebele of Kewote there is also an experience that involved farmers organized themselves and received ownership license, which created strong sense of ownership.

Table 4. Role of different stakeholders in the use and management of area enclosure at Kewet and Basona Worena districts.

Stakeholders	District	Task/responsibility	Remark
Research	Kewote	Research was done and demonstrated to familiarize the community at Karajejeba kebele	DBARC
	Basona Worena	Taking the initiation and giving training for farmers.	Forestry Research Centre
Agricultural offices	Kewote and Basona Worena	Follow up and giving technical assistance and providing seedlings.	Kebele and woreda experts
NGOs	Kewote	Adopt the success in Karajejeba in Yelen kebele by taking the initiation and giving training for farmers.	'Mulu wongeale church'
	Basona Worena	Giving training and financial assistance for farmers.	SUNARMA, CCF
Community/ Kebeles	Kewote and Basona Worena	Form bylaw and do for its practicality	
Farmers	Kewote and Basona Worena	Get organized and do all necessary tasks in group and individually.	

Problems and opportunities of AE

Major reasons for failure and success of area enclosures

Reason for failure (problems)

- AE are often adjacent to other kebeles or regions and this has became source of conflict, less accountability.
- Some farmers, especially those who have land beneath the hills are not involved in AE and this has created some gap in controlling and managing it.
- AE were implemented on land were used to be grazing lands, hence create grazing land shortage.
- There is a fear that government will encroach to their area, from their former experience in the Derg regime.

Reasons for success (opportunities)

- A due attention was given by some NGOs. Hence, there was training and financial support at the beginning stage.
- AE is source of additional income with a little investment; hence everyone is accountable and responsible since he/she takes his/her share.
- Farmers participating in AE have their own strong bylaws for managing and utilizing the area.
- Farmers have practically seen that the area has been conserved from erosion and got rehabilitated.

Cost benefit analysis of AE

The cost benefit analysis results showed that besides its ecological benefit, which was not considered in this analysis, AE generated a net benefit of ETB 3272.33 ha^{-1} year^{-1} household^{-1} (Table 5). Basically farmers use grass from the enclosure (especially in Kewote woreda) for their own consumption or for sell. Farmers invested money to guard and manage and finally harvest the product from the AE. Accordingly, on average a farmer invested ETB 1399 ha^{-1} year^{-1} (Table 5). The result of this study is in line with the one done in Hauzien district, Tigray region. According to this study, enclosures without terracing and enrichment plantation had net present value (NPV) of ETB 6745 ha^{-1} (Dereje, 2001).

Table 5. Cost benefit analysis of an individual farmer participating in AE use and management in Kewote district.

Items	Description	Value (ETB ha^{-1} $year^{-1}$)
Benefit	Sale of grass	399.33
	Grass for home consumption	4272.00
	Total benefit per year	4671.33
Cost	Salary for guard	67.94
	Plantation (digging and planting)	47.66
	Harvesting and transportation	512.51
	Household labor value	333.90
	Terrace construction	384.49
	Others	52.50
	Total cost per year	1399.00
Net		**3272.33**

Note: The price for home consumption is estimated by the market value of the grass at time of harvest. The cost for family labor was calculated by changing the hours spent on AE to man-days since the farmers do these activities when they are free from their major agricultural activities and not full day.

Farmers use both family and hired labor for the different activities done in managing and utilizing the area enclosure. The study prevailed that the major share of the total labor is invested for harvesting and transportation grass followed by plantation (Table 6). Generally, a family will invest more than 33 man-days per ha per year for area enclosure use and management (Table 6).

Table 6. Labor used for the use and management of a hectare of AE.

Activities	Man day ha^{-1} $year^{-1}$
Plantation (digging and planting)	11.47
Harvesting and transportation	29.85
Terrace construction	26.40
Others	4.96
Total labor used for AE	33.39

Factors affecting income from area enclosure

A total of 67 respondents from Kewote district have been taken for the analysis. Basona Worena district was not taken into consideration for this analysis since the experience in these two areas is different. At Basona Worena district the existing situation does not yet allow participants to get income/return out of the area enclosure, because their expectation is to get income from sell of trees which demand relatively longer time.

Income from area enclosure (basically from sell of grass) can be affected by many socioeconomic factors. The dependent variable in the regression analysis is total income from area enclosure. It is calculated by the summation of revenue from sold grass and the opportunity cost of grass used for home consumption. Since there are rules and regulations on how and to what extent participants can use products of the enclosure, income from AE will be taken as a proxy variable for efficient and sustainable management of the resource. A total of nine variables were considered in the regression analysis, out of which five of them were found to be significant (Table 7). The R^2 value of 0.796 is interpreted as; 80% of the variation in income from area enclosure is explained by the variables in the model.

Table 7. Result of a regression analysis on factors affecting income from area enclosure.

Variables	Coefficient	Std. error	t	P>|t|	VIF[1]
Educhh	1922.78	689.69	2.79	0.014**	1.30
Malfamsz	1025.81	286.33	3.58	0.003***	2.33
Pteff	155.64	95.83	1.62	0.125	1.22
Psorghum	-320.32	79.95	-4.01	0.001***	2.93
Grazlndpro	1660.90	937.90	1.77	0.097*	1.56
Farenclos	-41.23	35.01	-1.18	0.257	1.80
Felurs	-193.84	882.16	-0.22	0.829	1.16
Extserev	-3013.69	1835.99	-1.64	0.122	1.44
Whenenclo	643.81	364.64	1.77	0.098*	1.55
Constant	-2528.48	2149.75	-1.18	0.258*	-

Remark: R^2 = 79.63% and N = 67; * significant at 10%, ** significant at 5% and *** significant at 1%.

The VIF values in Table 7 indicated that there is no significant multicollinearity problem among explanatory variables. The Breusch-Pagan test (which assumes Ho: Constant variance)

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[1] VIF is the variation inflation factor that is used to test for multicollinearity problem in the model.

result also confirmed as the model is free from Hetroskedasticity problem with 1% level of significance.

Education status of the household head (*Educhh*) affected gross income from AE positively and significantly (Table 7). The variable was a dummy variable with choices of literate or illiterate. The regression result confirmed that literate households earned ETB 1922 year^{-1} better than illiterate once. Education can also be seen as a proxy variable for level of awareness. Literate farmers do have better exposure to learn and easily understand new information and technology. Management of natural resources in general and AE in particular demands huge labor force. Major tasks of management and use of the AE are basically done by male. In line with this argument the number of male members of household (*Malfamsz*) significantly and positively affected the income from AE (Table 7). Hence, an increase in male family members will increase income from AE by ETB 1025.81 year^{-1} (Table 7).

In a situation where there is fixed amount of inputs, activities that use similar inputs will compete for the same resource. Agricultural production and management and use of AE compete for labor and other resources. Hence, 100 kg increase in the production of sorghum (*Psorghum*), which is the major crop in the study area, induced ETB 320 year^{-1} reduction on the income from AE (Table 7). Moreover, the result of the current study prevailed that those who have grazing land problem (*Grazlndpro*) got better benefit from AE than those who do not have grazing land problem. This indicates that farmers with shortage of grazing land are more committed to manage the AE and harvest the product (grass) on the appropriate time, which in turn help them to earn ETB 1661 year^{-1} better than those who have no grazing land problem (Table 7). The last but not least continuous variable that affected income from AE positively and significantly is experience in AE practice. It was measured in years, from which the household began to participate in AE use and management. The model output confirmed that farmers with more experience were effective in the use and management of AE. Hence, one more years of experience in AE use and management could increase the income from AE by ETB 643.81 year^{-1} (Table 7).

Conclusion and recommendations

Like other community resources, use and management of AE needs active participation of different stakeholders for common action. The experiences in the two districts showed that there is participation of stakeholders at different stages. There are success stories in many areas, but there is also failure in some areas. This failure is basically due to conflict and lack of cooperation in managing the resource and negligence of the community. The profitability analysis proved that investment in AE is profitable. On average every household got a net profit of ETB 3272.33 ha^{-1} $year^{-1}$. Basically farmers use family labor for managing and use of the AE, and on average a household contributes nearly 33 man-days ha^{-1} $year^{-1}$.

The multiple linear regression model prevailed that around 80% of the variation in the dependent variable was explained by explanatory variables included in the model. The model result indicated that educational level of the household head positively and significantly affected income from AE. Households with more number of male members got better income from AE. The basic rational for having positive and significant relation between number of male members in the family and income from AE can be attributed to the reason that the majority of the AE use and management tasks are done by male. The only variable that affected income from AE negatively is production of sorghum. This implies that those who focus on production of crop (sorghum) earn less return from AE. The other most important variables in explaining the variation in income from AE are grazing land problem and years of experience in AE use and management. Both the variables affected income from AE significantly and positively.

The basic problem in managing common property, like area enclosure, is conflict in sharing the benefit out of it. Hence, there should be a thorough planning work in harmonizing the benefit share among kebele, districts and regions adjacent to the area enclosures. Even though enclosing an area creates pressure on availability of grazing land, the cost benefit analysis showed that it is profitable. Usually this practice is done on degraded lands (hill sides), hence it will create an opportunity to produce more grass out of it than before and also have a rewarding potential to reduce erosion. Therefore, this practice should be replicated to other similar areas too. Those who are educated have been seen to benefit more from AE. Therefore, there should be training and/or education to create awareness about area enclosure to better manage the resources in general and AE in particular.

Area enclosure plays a great role in protecting resource degradation. But, farmers will be convinced in managing AE when they get some practical benefit, hence such works should include short term benefits (like grass) to the participants. If there is no way that farmers would get short term benefit, there should be a support (technical and/or financial) from governmental and nongovernmental stakeholders at least in the early stages of formulation since benefit and better management of AE comes through experience.

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References

Basona Worena district Agriculture Office. 2009. Annual Report on agricultural activities. Unpublished document.

Betru Nedessa, Jawad Ali, and Ingrid Nyborg. 2005. Exploring Ecological and Socio-Economic Issues for the Improvement of Area Enclosure Management: A Case Study from Ethiopia. DCG Report No. 38, Ethiopia.

CSA (Central Statistics Agency). 2007. Summery and Statistics Report of 2007 Population and Housing Census. Addis Ababa, Ethiopia.

Dereje Asefa. 2001. The Socio-Economic effects and Environmental Impacts of area enclosures in Hauzien Woreda, Tigray, Northern Ethiopia. MSc thesis at Sweden University.

Kewote district Agriculture Office. 2009. Annual report on agricultural activities. Unpublished document.

NSZOA (North Shewa Zone Office of Agriculture). 2007. The 2007 annual report of NSZOA. Unpublished document.

Tefera Mengistu, Demel Teketay, Håkan Hultén and Yonas Yemshaw. 2005. The Role of Communities in Closed Area Management in Ethiopia. *Mountain Research and Development* Vol 25 No 1: 44–50.

FORESTRY RESEARCH

Floristic diversity and vegetation structure of Zege Peninsula forest, Northwest Ethiopia

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Abstract

This study was conducted in 2011/12 to investigate the vegetation composition, regeneration status, and farmers' coffee and tree management practices of Zege peninsula forest. A range of biophysical data were collected from 67 circular sample plots (53 in coffee-based and 14 in non-coffee forest patches) laid along the transect lines across. Data were analyzed for species diversity, basal area and Important Value Index. Socio-economic information was collected from 40 interviewed households. A total of 115 plant species (57 trees, 35 shrubs, 9 climbers, 13 herbs, and 1 Epiphytes) were recorded. Accordingly, the Shannon diversity index (H) of coffee based forest was 2.06 and the Evenness (E) 0.23 and that of the non-coffee forest was 3.28 and 0.43 respectively. The total basal area and density of woody species in coffee-based forest were 25.21m^2 ha^{-1} and 5930 ha^{-1} respectively, and that of the non-coffee forest were 13.49 m^2 ha^{-1} and 4659 ha^{-1} respectively. The local people preferred *Ehretia cymosa*, *Albizia schimperiana* and *Millettia ferruginea* as best coffee shade tree species in descending order. Destruction of forests to obtain wood for market and sheep free grazing were found to be the two major threats for zege peninsula forest.

Key words: Basal area, coffee, regeneration, shade, value index.

Introduction

Ethiopia is one of the tropical countries which comprise the major part of the eastern African highland mass (Tesfaye Awas, 2007) and over 50% of the African Afromontane vegetation (Tamrat Bekele, 1993) of which dry Afromontane forests make the largest part (Demel Teketay, 1996). Eastern Africa Afromontane including the Ethiopian highlands constitute vivid examples of tropical forest ecosystems that have exceptional species richness and high concentrations of endemic species. Particularly, Afromontane rainforests are known as centers of origin and genetic diversity of *Coffea arabica* and still harbor wild coffee species (Schmitt *et al*., 2010) and internationally recognized as the Eastern Afromontane biodiversity hotspot (Mittermeier *et al*., 2004).

Despite their unparalleled advantages, nowadays, most of these natural forests are fragmented, modified or changed into other land use system as a result of settlements, and extensive farming and grazing (Demel Teketay, 1992; EFAP, 1994; Demel Teketay, 2005; Schmitt *et al*., 2007). Reusing (1998) reported that 60% of the Ethiopian forest area has been modified or destroyed in the last three decades by anthropogenic factors such as new settlements, conversion to other land uses and timber extraction.

Especially, remnant forests in Northern Ethiopia are found in the form of patches in churchyards, sacred groves, and being dispersed in croplands and semiarid degraded savannas (Aerts *et al*., 2006; Bongers *et al*., 2006; Alemayehu Wassie, 2007) although the same are subjected to many mismanagement and malpractices such as clearing indigenous trees and replacing them with fast growing trees. In the southwestern Ethiopia, many of these forests have been reduced in extent and species composition due to improper coffee management. A research done by Schmitt *et al*. (2006) showed that, wild coffee forests are not only endangered by the conversion into agricultural fields and settlements but also by high intensities of coffee management. Traditional management practices range from the simple collection of mature coffee fruits to the removal of most of the original forest vegetation for the enhancement of coffee growth. Therefore, the objective of this study was to investigate the impact of coffee management practices on plant diversity and structure in comparison with non-coffee forest patch of Zege Peninsula forest.

Materials and methods

Study area

The study was conducted at Zege Peninsula forest, which is about 35km north of Bahir Dar, the capital of Amhara Regional State. It has a total area of about 1219 ha and located at 11^0 40’ and 11^O 43’ N and 37^O 19’ and 37^O 21’E with altitudinal range of 1770 -1988 above sea level. The mean annual temperature is 18.9 ^{O}C (minimum 11.0 ^{O}C and maximum 28.9 ^{O}C). The rainfall pattern is uni-modal with annual rainfall of 1660.4 mm with drier period from November to April.

The vegetation of the study site is classified as undifferentiated Afromontane forest (Aalbaek and Kide, 1993) or dry Afromontane vegetation type (Alemnew Alelign, 2002). It contains two forest patches: the first one is coffee-based forest, which is under the hand of the community which depends on coffee as income source and the second one is non-coffee based forest which is administered by the Kebele. The Zege peninsula forest comprises two Kebeles namely Yiganda and Ura Kidane Mihiret, with a total human population of 7489 (3456 female and 4033 male). Landholding ranges from 2 to 2.5 hectares per household. Lake Tana is everything for the Zege people as they use it for drinking, washing, swimming, fishing, coffee seed raising etc.

Data collection

A reconnaissance survey was made on January 9 and 10, 2011 to have an impression of the forest condition and settlement in general and the study site in particular. The actual field data collection was conducted from January 14 to March 04, 2011. Vegetation data were recorded on circular sample plots laid along the transect lines with 500 m interval in coffee-based forest patch and 200 m interval in non-coffee forest patch. Along each transect, sample plots were laid systematically at 400m interval in coffee-based forest and 150 m interval in non-coffee forest. A total of 67 plots (53 in coffee-based and 14 in non-coffee forest patch) were taken.

Each sample plot contains three circles overlaid each other with different diameter size. Number of woody seedlings, DBH< 2.5 cm, or with height less than 1m (Thang and Dung, 2009) and the ground cover percentage of herbs were recorded in a central plot with 1m radius (3.14 m^2). Woody saplings and shrubs (DBH >2.5 cm and <10 cm) were recorded in the middle circle with a radius of 3 m whereas trees and woody climbers (DBH >10 cm) in the outer circle of 10 m radius.

Scientific name of recorded species were identified with the help of plant identification manuals such as Honey Bee Flora of Ethiopia (Fichtl and Admasu, 1994) and Flora of Ethiopia and Eritrea (Edwards *et al*., 1995; Hedberg and Edwards, 1995; Edwards *et al*., 2000; Hedberg *et al*., 2006). Those which were difficult to identify using the manuals were taken to Addis Ababa University National Herbarium for further identification. Samples of 40 households were interviewed using a checklist to assess parameters such as tree and coffee management practices, coffee shade tree species preferences, off-farm livelihood sources and their main income source.

Data analysis

Shannon-Wiener diversity index, species richness and Shannon's evenness were computed to describe plant species diversity of the two forest patches (Magurran, 2004). Sorensen's similarity coefficient was used to determine the pattern of species turnover among the two forest patches (Magurran, 1988). The formulas of the parameters described above are as follows.

Shannon-Weiner Index (H')

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Where, H' = Shannon Diversity Index, *Pi* = Proportion of individuals found in the i^{th} species expressed as a proportion of total cover, S = Total number of species (1, 2, 3…..n).

Shannon evenness (E)

$$E = \frac{H'}{H'_{max.}} = \frac{\sum_{i=1}^{s} p_i \ln p_i}{\ln s}$$

Where, E = Equitability (evenness) index, H' = Shannon Diversity Index, $H'_{max\,=}$ Maximum level of diversity possible within a given population.

Sorensen's similarity Index (Ss)

$$S_S = \frac{2C}{(2C + A + B)}$$

Where, Ss = Sorensen's similarity index, A = Number of species in coffee-based forest, B = Number of species in non-coffee forest), C = Number of species common to both forest patches.

Population structure

Frequency of a species = $\frac{\text{Number of plots in which a species occurs}}{\text{Total number of plots}} \text{X } 100$

Relative frequency = $\frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \text{X } 100$

Density of species = $\frac{\text{Number of individuals of that species}}{\text{Area sampled}}$

Relative density = $\frac{\text{Density of a species}}{\text{Total density of all species}} \text{X } 100$

Basal area (m^2) = $(DBH/200)^2 \pi$ or $BA = \frac{\pi^* DBH^2}{4}$, Where π = 3.14 and DBH= diameter at breast height (cm) for woody species with DBH>2.5

Dominance = $\frac{\text{Total basal area}}{\text{Area sampled}}$

Relative dominance = $\frac{\text{Dominance of a species}}{\text{Total dominance of all species}} \text{X } 100$

Importance Value Index (IVI) = Relative density + Relative frequency + Relative dominance.

Results and discussion

Species diversity and species richness

A total of 115 plant species (57 trees, 35 shrubs, 9 climbers, 13 herbs, and one Epiphytes) were recorded in the studied plots and along the transect lines within the Zege forest. These species belong to 55 families (34 in coffee-based and 38 in non-coffee forest patches and 7 undetermined species). Fabaceae was the most species-rich family comprising 9 (8.3%) of the total plant species identified in Zege forest. A similar result has also been observed in Belete forest (Kitessa Hundera and Tsegaye Gadissa, 2008) and Hugumburda forest (Ermias Aynekulu, 2011). This might be due to agro-ecology similarity of the forests or the adaptation potential of Fabaceae families to wider agro-ecologies.

In considering the two forest patches separately, 56 plant species were recorded in the coffee-based forest patch and 69 in the non-coffee forest patch. Still Fabaceae was the most species-rich family represented by 5 species (in the coffee-based forest) and 7 species (in the non-coffee forest) followed by Euphorbiaceae with 4 species in each forest patch. The coffee-based forest patch had lower values of species richness, evenness and diversity than non-coffee forest patch (Table 1) which agrees with Tripathi and Singh (2009) where the diversity value of plantation forest with intensive management were found to be lower (H = 1.46) than in natural forest (H = 2.05). Of course, forest management highly affects diversity in favoring the selected plant species while suppressing the undesirable ones. The Sorensen's floristic similarity index ($S_S = 30.8\%$) showed that the two forest patches share very few plant species in common.

Population structure and regeneration

The diameter size distribution of all woody species in the two forest patches showed more or less inverted J-shape (Figure 1), greater numbers of individuals in the lower diameter size class. This indicates that there was excessive felling of large trees in the past to meet the demand of firewood and timber, or they were at secondary stage of forest succession (Abayneh Derero *et al*., 2003). Moreover, the large numbers of individuals in the lower diameter size class might be shrubs particularly coffee plant in the coffee-based forest. In the coffee-based forest, 65.6% and in the non-coffee forest, 66.4% of individuals were concentrated in the first lower diameter size class (2.5 cm-10 cm).

Table 1. Comparison of richness, Shannon diversity (H'), Simpson's diversity (D) and evenness (E) of woody species in coffee-based and non-coffee forest patches.

		Diversity	
Forest patches	Richness	H	E
Coffee-based forest	48	2.06	0.23
Non-coffee forest	60	3.28	0.43
Zege forest in total	74	2.76	0.64

The Sorensen's similarity index of the two forests patches = 30.8%.

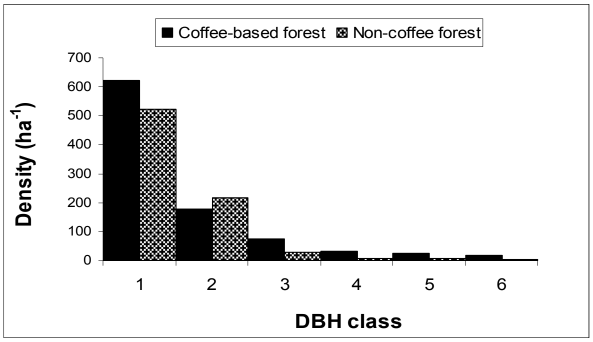

Figure 1. Diameter size distribution of all woody plants within coffee-based and non-coffee forest patches. DBH class: 1 = 2.5-10 cm, 2 = 10-20 cm, 3 = 20-30 cm, 4= 30-40 cm, 5 = 40-50 cm, 6 = >50 cm.

However, 17 (38.6 %) species in the coffee-based forest such as *Bersama abyssinica* and *Ficus thonningii* were not represented by seedling stage. Other 10 species (22.7%) for example *Dracaena steudneri* and *Ficus vasta* were without sapling stage. The rest 7 (15.9%) e.g. *Combertum molle* and *Phytolacca dodecandra* were still losing their tree stage. In the non-coffee forest patch, 9 (15.8%) species, for example *Millettia ferruginea* and *Ficus vasta* were without seedling, whereas 17 (39.8%) and 33 (57.8%) species were without sapling and tree stages respectively. *Ficus vasta* with 183.1 cm and *Celtis africana with* 111.5 cm were the first and the second highest DBH size in the coffee-based forest patch. Similarly, in the non-coffee forest patch, *Ficus vasta* was with the highest DBH size (165.6 cm) while *Cupressus lusitanica (*51.0 cm), was the second. Figure 2 displays the structure of some of the above mentioned tree species.

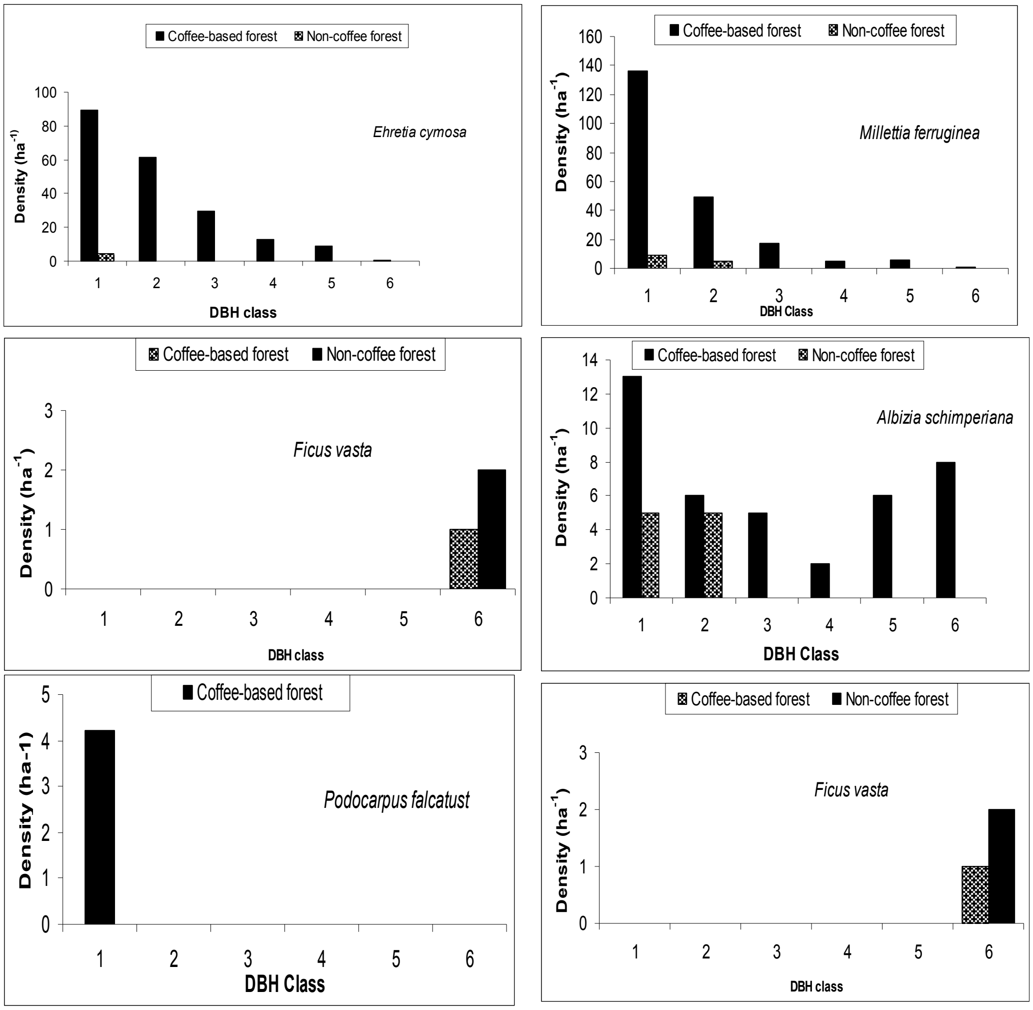

Figure 2. Diameter size of selected woody species in the coffee-based and non-coffee forest patches. DBH class: 1 = 2.5-10 cm, 2 = 10-20 cm, 3 = 20-30 cm, 4 = 30-40 cm, 5 = 40-50 cm, 6 = >50 cm.

The height class distribution of woody species revealed that 54.6% of individual trees in the coffee-based forest were found at the lowest height class (1-5 m) and only 0.3% of individuals were recorded at the highest height class (>30 m) (Figure 3). In the coffee-based forest, *Ficus vasta* was the tallest tree with 34m height and followed by *Celtis africana* with 32 m. Similarly, in the non-coffee forest patch, *Ficus vasta* was the tallest tree with 30 m height and *Cupressus lusitanica* with 25 m.

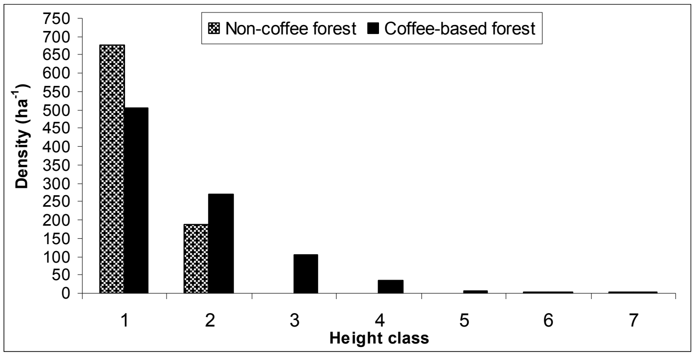

Figure 3. Height distribution of woody species in the coffee-based and non-coffee forest patches. Height class: 1 = 1-5 m, 2 = 6-10 m, 3 = 11-15 m, 4 = 16-20 m, 5 = 22-25 m, 6 = >26 m.

Importance value index (IVI)

Importance value index is a measure of the relative importance of a species in an area (Van Andel, 2003) or an important parameter that reveals the ecological significance of species in a given ecosystem (Lamprecht, 1989). Species with high IVI values are considered more important than those with low IVI value. The IVI values can also be used to prioritize species for conservation, and species with high IVI value need less conservation efforts, whereas, those having low IVI value need high conservation effort. Accordingly, the importance value indices of woody plant species were analyzed (Table 2). *Coffea arbica* had the highest IVI of 54.86 (18.3%) in the coffee-based forest followed by *Millettia ferruginea* with 41.44 (13.9%) and *Ehretia cymosa* with 36.33 (12.1%). In the non-coffee forest *Ficus vasta* with IVI of 36.60 (12.3%) was the first followed by *Rhus glutinosa* with 24.63 (8.25%).

Basal area and density

The total basal area of all the woody species in the Zege forest with DBH >2.5cm was 22.76 m^2 ha^{-1} due to the presence of some large sized trees in the forest (Figure 4). The basal area of all the woody species with DBH>2.5 cm in the coffee-based and non-coffee forest patches was 25.21 m^2 ha^{-1} and 13.49 m^2 ha^{-1} respectively. *Ehretia cymosa with* 5.10 m^2 ha^{-1} attained the largest proportion of the total woody species basal area in the coffee-based forest followed by *Albizia shimperiana* with 4.19 m^2 ha^{-1}. In the non-coffee forest, *Ficus vasta* had the highest basal of 4.89 m^2 ha^{-1} followed by *Rhus glutinosa* with 1.77 m^2 $ha^{-1.}$

Table 2. Importance value index (IVI) of the woody plant species in the coffe-based and non-coffee forests.

Forest patches	Botanical names	RF	RD	RDO	IVI
Coffee-based	*Coffea arabica*	8.99	44.83	1.53	54.86
	Millettia ferruginea	1.08	18.50	14.06	41.44
	Ehretia cymosa	0.18	5.55	21.64	36.33
	Albizia shimperiana	0.90	1.41	17.76	26.54
	Croton macrostachyus	6.29	1.87	5.98	14.24
	Diospyros abyssinica	6.29	0.42	1.48	14.16
	Ritchiea albersii	7.01	3.28	0.56	10.84
	Vangueria volkensii	5.94	3.13	1.71	10.68
	Celtis africana	4.68	1.33	4.23	10.23
	Solanum gigantum	5.40	3.34	0.19	8.91
	Cordia africana	3.06	0.43	3.68	7.17
	Ficus vasta	0.36	0.01	6.71	6.90
	Sub-total	50.18	84.1	79.53	242.3
	Total (including other 36 species)	100.00	100.00	100.00	300.00
Non-coffee based	*Ficus vasta*	0.45	0.05	36.11	36.60
	Rhus glutinosa	5.38	4.44	14.81	24.63
	Stereospermum kunthianum	4.48	9.11	9.46	23.05
	Buddleja polystachya	4.48	14.95	0.07	19.50
	Cordia africana	4.04	2.57	7.66	14.26
	Vernonia amygdalina	5.38	4.53	2.66	12.58
	Grewia ferruginea	3.14	7.20	1.03	11.37
	Clausena anista	3.59	6.21	0.00	9.80
	Dulesa (local name)	2.69	0.93	5.98	9.60
	Croton macrostachyus	3.59	2.15	3.15	8.88
	Vangueria volkensi	4.04	3.74	0.49	8.26
	Bersama abyssinica	1.79	4.39	0.88	7.07
	Sub total	43.05	60.27	82.3	185.6
	Total (including other 48 species)	100.00	100.00	100.00	300.00

RF = Relative frequency; RD = Relative density; RDO = Relative dominance.

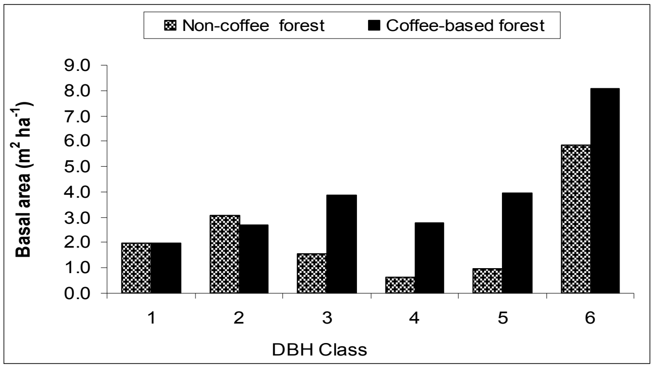

Figure 4. Basal area across diameter classes of all woody species in coffee-based and non-coffee forest patches. DBH class: 1 = 2.5-10 cm, 2 = 10-20 cm, 3 = 20-30 cm, 4 = 30-40cm, 5 = 40-50 cm, 6 = >50cm.

The density of all the woody species in the coffee-based forest with 5930 ha^{-1} was higher than the non-coffee forest with 4659 ha^{-1} (Table 3). In both forest patches saplings with DBH>2.5cm and < 10cm obtained the highest proportion and followed by seedlings with DBH<2.5 cm. Coffea *arabica* with 2659 ha^{-1}, *Millettia ferruginea* with 1097 ha^{-1}, *Diospyros abyssinica* with 380 ha^{-1} and *Ehretia cymosa* with 329 ha^{-1} were the first four species with highest stem density in the coffee-based forest. In the non-coffee forest, *Rhus glutinosa, Solanum gigantum* and *Vernonia amygdalina* were with the highest density of 27 ha^{-1} each.

Table 3. Density (ha^{-1}) of woody species in both the coffee-based and non-coffee forests of the Zege forest.

Growth stages	Coffee-based forest	Non-coffee forest
Seedlings (DBH <2.5 cm and height <1 m)	2424	1824
Sapling (Understorey and shrubs, 2.5 cm >DBH<10 cm)	3031	2473
Trees (DBH >10 cm)	475	362
Total	5930	4659

Farmers' coffee shade preferences and their management practices

Most of the trees and shrubs in the Zege forest regenerated naturally, except coffee and very few fruit trees although the forest is in the hands of the community. An interview made to assess farmers' coffee shade tree preference showed that 82.9% of the respondents preferred *Ehretia cymosa*, *Albizia schimperiana*, *Millettia ferruginea and Celtis africana* in order of importance. Of course, farmers have their own justifications in selecting these species, for example *E. cymosa* is evergreen with medium canopy density so that it gives year round and fair shade, *A. schimperiana* and *M. ferruginea* though deciduous they regenerate at peak dry season to provide shade for coffee. Similar studies carried out in Costa Rica also showed that farmers' follow the same principles of preference (Albertin and Nair, 2004).

Factors affecting forest condition

Wood extraction for fuel wood and timber was found to be the major threat of Zege peninsula forest followed by sheep free grazing. The 111.2 stump ha^{-1} density in the coffee-based forest showed that there was high human interference than the non-coffee forest with 36.4 stump ha^{-1} (Table 4). Moreover, coffee and fruit production is highly challenged by drought and wild animals, respectively.

Table 4. Stump density ha^{-1} of woody species in the two forest patches at Zege.

Species	Coffee-based forest	Non-coffee forest
Millettia ferruginea	35	-
Ehretia cymosa	25	-
Celtis Africana	19	-
Diospyros abyssinica	16	-
Croton macrostachyus	12	-
Ritchiea albersii	11	-
Rothmannia urcelliformis	8	-
Cordia Africana	8	-
Vanguria volkensi	6	-
Albizia schimperiana	5	-
Coffea Arabica	5	-
Eucalyptus camaldulensis	2	-
Rhamnus prinoides	1	-
Unidentified	17	-
Stereospermum kunthianum	-	3
Vernonia amygdalina	-	2
Bersama abyssinica	-	2
Cordia Africana	-	1
Unidentified	-	8
Total stem stamp recorded	170	16

Conclusions and recommendations

Zege Peninsula forest has a healthy population structure of inverted J-shape. However, economically important indigenous species like *Prunus africana, Podocarpus falcatus and Ficus vasta* were highly affected. The traditional coffee forest management has negatively affected woody species diversity by only favoring certain species that are used for coffee shade. In Zege Peninsula forest, there was no proper management to improve coffee production and to install sustainable forest management in place except some routine practices of slashing, coppicing etc. The decline of coffee production and subsequent shift to intensive wood extractions, free sheep grazing in the forest and vertebrate pests are the major factors that adversely affect the Zege Peninsula forest.

Generally, Zege forest offers great economic and social values for the rural communities. Therefore, to reduce the present pressure on the forest and to manage the forest on a sustainable basis, the following recommendations are suggested: Enrichment planting should be done particularly in the open spaces of the non-coffee forest patch for sustainable fuel wood and timber production. Designing irrigation and water harvesting techniques, diversifying livelihood through honey production, organizing existing fishing practices, jewelry selling and tourist guiding should be encouraged as off-farm activities. Fruit production should be promoted and preventive measures against vertebrate pests and fruit disease need to be design.

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References

Aalbaek, A. and Kide T. (1995). Seed zones in Ethiopia and Eritrea. Prepared for National Tree seed Project, UNSO/ETH/88/X02. Addis Abeba, Ethiopia.

Abayneh Derero, Tamrat Bekele and Bert-Ake, N. (2003). Population structure and regeneration of woody species in a broad-leaved Afromontane rain forest, South-West Ethiopia. *Ethiopian Journal of Natural Resource* 5(2): 255-280.

Albertin, A. and Nair, P. K. R. (2004). Farmers' perspectives on the role of shade trees in coffee production systems: An assessment from the Nicoya Peninsula, Costa Rica. *Human Ecology*, Vol. 32, No. 4.

Alemayehu Wassie (2007). Ethiopian church forests opportunities and challenges for restoration. PhD thesis, Wageningen University, Wageningen, The Netherlands.

Alemnew Alelign (2002). Diversity and socio-economic importance of woody plants in Peninsula of Zege, Northwestern Ethiopia. *Implication for their sustainable utilization*. MSc thesis of Wondo Genet College of Forestry, Ethiopia.

Bongers, F, Alemayehu Wassie, Sterck F.J., Tesfaye Bekele and Demel Teketay (2006). Ecological restoration and church forests in northern Ethiopia. *J.of the drylands* 1(1): 35-44.

Demel Teketay (2005). Seed and regeneration ecology in dry Afromontane forests of Ethiopia: Forest disturbances and succession. *Tropical Ecology* 46(1): 45-64.

Demel Teketay (2005). Seed and regeneration ecology in dry Afromontane forests of Ethiopia: Seed production-population structure. *Tropical ecology* 46(1): 29:44.

Demel Teketay (1992). Human impact on a natural montane forest in southeastern Ethiopia. *Mountain Research and Development* 12: 393-400.

Demel Teketay. (1996). Seed ecology and regeneration in dry Afromontane forests of Ethiopia. PhD Dissertation, Swedish University of Agricultural Sciences, Umeä.

Edwards, S., Mesfin, T. and Hedberg, I. (1995). Flora of Ethiopia and Eritrea, Vol. 2(2). The National Herbarium, Addis Ababa.

Edwards, S., Mesfin, T., Sebsebe, D. and Hedberg, I. (2000). Flora of Ethiopia and Eritrea, Vol. 2(1). The National Herbarium, Addis Ababa.

EFAP. (1994). Ethiopian Forestry Action Program. Final Report, Vol. II – The Challenge for Development. Transitional Government of Ethiopia, Ministry of Natural Resources Development and Environmental Protection, Addis Ababa.

Ermias Aynekulu. (2011). Forest diversity in fragmented landscapes of northern Ethiopia and implications for conservation. PhD Dissertation, Bonn.

Fichtl, R. and Admasu Adi. (1994). Honeybee flora of Ethiopia. Weikersheim, Margraf, 1994.

Hedberg, I., Ensermu, K., Edwards, S, Sebsebe, D., and Persson, E. (2006). Flora of Ethiopia and Eritrea, Vol. 5. The National Herbarium, Addis Ababa.

Hedberg, I. and Edwards, S. (1995). Flora of Ethiopia and Eritrea, Vol. 7. The Na-tional Herbarium, Addis Ababa.

Kitessa Hundera and Tsegaye Gadissa. (2008). Vegetation composition and structure of the Belete forest, Jimma Zone, South Western Ethiopia. *Ethiopian Journal of Biological Science* 7(1): 1-15.

Lamprecht, H. (1989). Silviculture in the tropics: tropical forest ecosystems and their tree species-possibilities and methods for their Long-term utilization. Eschborn, Federal Republic of Germany.

Magurran, A.E. (2004). Measuring Ecological Diversity. Blackwell Science Ltd., Malden.

Magurran, A. E. (1988). Ecological diversity and its measurement. Chapman and Hall, London.

Mittermeier, R. A., Gil, P. R. And Hoffman M. (2004). Hotspots revisited: Earth's biologically richest and most threatened terrestrial eco-regions. Conservation International, Washington, DC.

Reusing, M. (1998). Monitoring of natural high forests in Ethiopia. Ministry of Agriculture and GTZ, Addis Ababa.

Schmitt, C. B., Manfred, D., Demissew Sebsebe, Friis, I., and Boehmer, H.J. (2010). Floristic diversity in fragmented Afromontane rainforests: altitudinal variation and conservation importance. *Applied vegetation science* 13: 291–304.

Schmitt, C.B., Pistorius, T. and Winkil, G. (2007). Global network of forest protected areas under the CBD: Opportunities and challenges. Schmitt C.B., Pistorius T. and Winkil G., (eds). Proceedings of an international expert workshop held in Freiburg, Germany, May 9-11, 2007.

Schmitt, C.B. (2006). Montane rainforest with wild Coffea arabica in the Bonga region (SW Ethiopia): plant diversity, wild coffee management and implications for conservation. PhD Dissertation, Ecology and Development Series No. 47, Cuvillier Verlag Göttingen.

Tamrat Bekele. (1993). Vegetation ecology of remnant Afromontane forests of the Central Plateau of Shewa, Ethiopia. *Acta Phytogeographica Suecica* 79: 1-59.

Tesfaye Awas. (2007). Plant diversity in Western Ethiopia: Ecology, Ethnobotany and conservation. PhD Dissertation, University of Oslo, Norway.

Thang, T. N. and Dung, N. T. (2009). Community forest status and incentive structures for effective forest management in Nam Dong District, Thua Thien Hue province. In Linkages of forest protection, economic growth and poverty reduction-Issue and approaches in Vietnam. Hanoi, Vietnam.

Tripathi, K.P. and Singh, B. (2009). Species diversity and vegetation structure across various strata in natural and plantation forests in Katerniaghat Wildlife Sanctuary, North India. *Tropical Ecology* 50(1): 191-200.

Van Andel, T.R. (2003). The distance of measures in physiological sampling. *Ecology* 47:451-460.

Determining the optimum tapping schedule for a better survival and frankincense yield of matured *Boswellia papyrifera* trees in the dry land of North Gondar

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Abstract

This study was carried out to determine the optimum tapping schedule against survival and frankincense yield of matured *Boswellia papyrifera* trees. The experiment was conducted in Metema woreda, Masha Kebele of North Gondar zone. Trees having 10-20 and >20 cm diameters were randomly selected. For each diameter class, twenty five trees taken and labeled. These trees were then allocated to five different tapping schedules (resting categories) i.e., tapped in each year, tapped one year and rest for one year, tapped for two years and rest for one year, tapped for three years and rest for one year and the remaining are left without tapping. Trees tapped for one year and trees rested for one year regularly after one tapping year were found to provide 80% and 100% survival rate for small trees and large trees, respectively. Significant differences were also observed between treatments on effect of resting on frankincense yield. The yield of frankincense that have been collected from tapping of matured small and large sized *Boswellia papyrifera* was found to be cal.77.6 to 535.3 gm/tree/year, respectively. This figure ranges from cal. 77.6 to 282.5 gm/tree/year and 151.9 to 535 gm/tree/year for small and large sized trees, respectively. These figures indicated that frankincense yield production is highly influenced by the tree size of the stand thus the higher yield has been obtained from the larger sized matured *Boswellia papyrifera* trees as compared to the small sized matured tress.

Key words: Metema, rest, season, survival, yield.

Introduction

Ethiopian natural vegetation resources comprise several tree and shrub species of potential importance. For instance, the Acacia-Commiphera woodlands which are located in the dry land sections of the country are dominated by Acacia, Boswellia, and Commiphera and are well known for their economically valuable products, largely oleo-gum resins such as gum arabic, frankincense, myrrh, and karaya (Abeje, 2002 ; Mulugeta *et al*., 2003; Wubalem *et al*., 2004).

The potential area covered by natural gum and resin-bearing species is believed to be very high in Ethiopia. Preliminary mapping and assessments showed that the resource is found in eight regions covering an area of about 2.9 million ha (Girmay, 2000). Tigray and Amhara National Regional State (ANRS) constitute the leading natural gum and resin bearing forest resource base, 32.9% and 23.8%, respectively. Vast areas of land, ca. 51% in Ethiopia are arid to semiarid (NCSS, 1993) with marginal or no agricultural potentials. Including the dry sub-humid area, the total dry landmass of the country amounts to 860,000 km^2 (*ca*. 71%). Nevertheless, many of the indigenous trees and shrubs in these vast arid and semi-arid lowlands have actual and economically potential products of principally oleo gum resins such as gum acacia (gum arabic and gum talha), frankincense, myrrh, hinna, and gum karaya (Mulugeta Lemenih *et al*., in press).

Boswellia papyrifera is an indigenous gum producing multipurpose perennial tree species that grows in drier parts of Africa from Nigeria in the West to Eritrea and Ethiopia in the East. In ANRS, the woodlands dominated by *B.papyrifera* stands are identified in nine zones covering 34 woredas and 151 kebeles. It is found abundantly in Metema, Quara and Armachiho woredas of North Gondar Zone (NGZ). Boswellia has an immense ecological and economic significance. It is found to be highly suitable for future reforestation establishments or restoration efforts in moisture deficit arid and semi-arid areas (Kindeya *et al*., 2005). This species produces frankincense, an oleo-gum resin valued for its industrial, folk medicine, cultural and religious uses (Girmay, 2000). It has wide demand in domestic and international markets.

At present, *B.papyrifera* is threatened as the result of several interrelated factors. Increasing population pressure has resulted in the conversion of woodlands to agricultural land while unregulated grazing by which young seedlings are either eaten or trampled by livestock is hindering the natural regeneration. Another factor causing the decline of *B.papyrifera* is overexploitation manifested in the form of unplanned, unwise and unsustainable tapping system. Among these factors, tapping has been reported to affect sexual reproduction and natural regeneration. The fragile relationship between the extraction of wood exudates and tree regeneration in natural populations was first demonstrated quantitatively by Rijkers *et al*. (2006). The negative effect of over-tapping for wood exudates, such as premature tree death and enhanced risk of insect and fungus infections has also been demonstrated by field observation. Trees are used to be tapped every year in the dry season. The frankincense tapers are paid based on the amount of gum collected. This easily can lead to over tapping. Intensive tapping is thought to have resulted in the death of many trees, especially during the period of drought. Furthermore, there are indications that over-tapping may lead to poor flower and seed production and hence poor regeneration. All these factors deceasing Boswellia stand at alarming rate in the study area. Therefore, proper planning, for the development, conservation and sustainable utilization of this potential resource is urgently required. Hence, the main objective of this study was identifying the optimum resting time for a better survival and frankincense yield of matured *B.papyrifera* trees. More specifically to determine the annual yield of frankincense that can be harvested from a tree per year and recommend the best season for high frankincense yielding.

Materials and methods

Site description

Metema woreda is located about 900 km northwest of Addis Ababa and about 180 km West of Gondar town. Metema woreda has an international boundary of more than 60 km long distance between Ethiopia and Sudan. It is found North of Quara and Alefa, West of Chilga, South of Tach Armachiho woredas and East of Sudan border (Figure 1). It is one of the 18 woreda in North Gondar Zone. According to the 2004 woreda plan, there are 15,675 rural households (excluding the newly resettled households) and about 4,991 urban households.

According to this estimate, the total population of the woreda is 91,216 people. Out of the total, 3918 are rural and 1497 are urban women households. The original residents of the area are Gumuz. Until recently, they practice slash and burn and hunting wild animals. They produce sorghum as the staple crop and it is the major food crop in the area. Since the settlement programmes of the last and current governments, the area is populated and the natives became small in number. They are concentrated in few areas and live close to each other. They are found in only three PAs (Kumer Aftit, Tumet and Shinfa).

Figure 1. The location of the study site of Metema (Tefera *et al.,* 2011).

The altitude of Metema ranges from as low as 810 to 990 m. a.s.l while the minimum annual temperature ranges between 22 ^{O}C and 28 ^{O}C. Daily temperature becomes very high during the months of March to May, where it may get to as high as 43 ^{O}C. Nearly all of the land in the woreda is in the lowlands except some mountain tops which fall outside. According to the available data, the mean annual rainfall for the area ranges from about 850 to around 1100 mm. These values are not in agreement with what has been reported by the OoA. Based on this data, about 90% of the woreda receives mean annual rainfall of between 850 and 1000 mm. Metema has a unimodal rainfall. The rainy months extend from June to the end of September. However, most of the rainfall is received during the months of July and August. Rainfall during these months is erratic, combined with the poor workability of most of the soils, farm operations are also affected. The soils in the area are predominantly black and some are soils with vertic properties.

Establishment method

Homogeneous site was delineated for the selection of trees. Trees which have similar tapping history and be tapped one year before the experiment were selected. Within each area, trees having 10-20 and >20 cm diameters were randomly selected. For each diameter class, twenty five trees were labeled. These trees were then allocated for five different tapping resting categories (n = 5 per tapping resting categories) i.e., tapped in each year, tapped one year and rest for one year, tapped for two years and rest for one year, tapped for three years and rest for one year and the remaining are left without being taped. Following the traditional/local practices each category was taped according to the time allocated for each trial i.e., 1, 2, 3 and

4 years. The gum obtained from each tree was then collected and compared to see the impact of resting on the yield of gum.

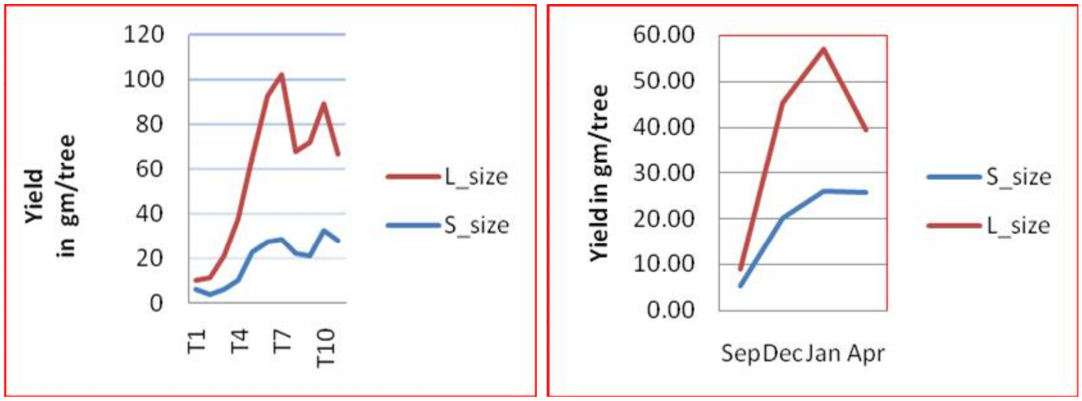
Data analysis

Analysis of variance was performed to assess variations among treatments. Least significant difference was used for mean separation when significant differences were found.

Result and discussion

High frankincense yielding season

It has been possible to identify the high yielding time. Since frankincense production is the response of physiological responses of the trees to stress, it is important to identify the best time for the trees to response actively in order to maximize frankincense yield from tapping of the trees. Accordingly, this study identified that the trees have been more responsive to tapping when they were tapped from tapping period of four (T4) (Figure 2) up to ten (T10) according to the local taping practice of the farmers in the study area. When it is explained in months of the year, from the beginning of December to the mid of April (Figure 3) is the peak period to tap high yield from the matured *B.papyrifera* trees. At this time it has been possible to collect the maximum yield from the trees. Thus, this indicated that trees have to be tapped effectively at this time in order to collect maximum yield of frankincense.



Note: L_ size = Large size, S_ size = Small size

Figure 2. Frankincense yield variation according to local tapping practice period (left) and Frankincense yield variation in months of the year (right).

Effect of resting on the survival of tapped B.papyrifera trees.

Survival of trees tapped each year without resting

From Table 1 it is clearly indicated that as the trees are tapped continuously without resting will have negative effect on the survival of the tapped trees. Therefore, it is easily understood that resting of Boswellia trees is a must in order to protect the trees from death.

Table 1. Survival of Boswellia trees tapped without resting.

	Survival rate (%)			
Treatments	1999	2000	2001	2002
Small Sized trees	100	100	40	20
Large Sized trees	100	100	80	60

Survival *of trees tapped one year with one year resting*

Among tapped trees, ten of them from small (5 trees) and large (5 trees) sized trees have been assigned to be tapped for one year and rested for one year and then tapped to see the effect of one year tapping and one year resting on the survival of matured *B.papyrifera* tress. The results of this tapping schedule indicated that tapping of trees for one year and resting for one year will provide better survival or provide less mortality to the tapped tress (Table 2).

Table 2. Survival of Boswellia trees tapped for one year with one year resting.

Treatments	Survival rate (%)			
	1999	2000	2001	2002
Small Sized trees	100	100	100	80
Large Sized trees	100	100	100	100

Survival of trees tapped for two years with one year resting

Of tapped trees, ten of them from small (5 trees) and large (5 trees) sized trees have been assigned to be tapped for two years and rest for one year and then tapped. The results of this tapping schedule indicated that tapping of trees for two continuous years and resting for one year regularly resulted in high mortality of tapped trees as compared to those trees tapped for one year and rested for one year (Table 3).

Table 3. Survival of Boswellia trees tapped for two year with one year resting.

Treatments	Survival rate (%)			
	1999	2000	2001	2002
Small Sized trees	100	100	60	20
Large Sized trees	100	100	80	60

Trees tapped for three years with one year resting

Of tapped trees, ten of them from small (5 trees) and large (5 trees) sized trees have been assigned to be tapped for three years continuously and left to rest for one year. The result of this tapping category indicated that there was high mortality of the trees next to the continuously tapped trees category (Table 4).

Table 4. Survival of Boswellia trees tapped for three years with one year resting.

Treatments	Survival rate (%)			
	1999	2000	2001	2002
Small Sized trees	100	100	60	20
Large Sized trees	100	100	80	40

Effect of resting period on frankincense yield

There were significant differences between treatments i.e., large trees tapped for one year and rested for one year, large trees tapped for three years and rested for one year, and small trees tapped for three years and rested for one year (Table 5). High mean yield was recorded for the large diameter trees tapped for one year and rested for one year followed by large trees tapped for three years and rested for one year. But trees having small diameter and which were tapped every year have lower yield followed by small trees tapped for two years and rested for one year and large trees tapped every year.

Table 5. Effect of tapping and resting frequencies on the frankincense yield of Boswellia trees.

Treatment	Frankincense yield (g/tree)
Large trees tapped for one year and rested for one year	535.3a
Large trees tapped for three years and rested for one year	404.8b
Large trees tapped for two years and rested for one year	307.1c
Small trees tapped for one year and rested for one year	282.5c
Small trees tapped for three years and rested for one year	164.8d
Large trees tapped every year	151.9de
Small trees tapped for two years and rested for one year	147.9de
Small trees tapped every year	77.6e

Based on the result, trees that has been collected from tapping of matured small and large sized *B.papyrifera* trees, the frankincense production potential of the study area is found to be *cal.*77.6 to 535.3 g/tree/year, respectively. This figure ranges from *cal.* 77.6 to 282.5 g/tree/year and 151.9 to 535 g/tree/year for small and large sized trees, respectively. These figures indicated that frankincense yield production is highly influenced by the tree size thus the higher yield has been obtained from the larger sized matured *B.papyrifera* trees as compared to the small sized matured trees. The result of larger photosynthetic carbon acquisition capacity by bigger trees (Abeje Eshete *et al*., 2011) Generally, from the stand analysis of the Boswellia dominated woodland of Metema woreda, in a hectar of land it is possible to find *cal.* 250 to 300 matured *B.papyrifera* tress (Tatek *et al*., 2006). Therefore, it is likely to harvest frankincense yield on the average of *cal.* 45.1 kg/ha/year in the range between *cal.* 19.4 to 70.6 kg/ha/year from small sized matured trees and average yield of *cal.* 85.89 kg/ha/year in the range between *cal.* 37.96 to 133.82 kg/tree/year from large sized trees depending on the site condition and density of the tree.

Conclusion and recommendation

From this study, it can be concluded that tapping period of four up to ten gave more yield than the local taping practice. It also indicated that tapping period seven was the highest yielding period with about 0.1 kg/tree and 0.032 kg/tree for large and small matured Boswellia trees, respectively. From the beginning of December to the mid of April, it was the peak taping period to get maximum yield of frankincense from the matured *B.papyrifera* trees in the study area. This clearly indicated that if trees are tapped continuously without resting such an act will have a negative effect on the survival of the tapped trees. Therefore, it was easily understood that resting of Boswellia trees is a must in order to protect the trees from death. Trees tapped for one year and rested for one year regularly after one tapping year could provide better survival or less mortality to the tapped tress. The tapping category indicated that there was a high mortality to the tapped trees next to the continuously tapped trees category. From trees having large diameter trees tapped for one year and rested for one year gave high mean yield with 0.535 kg/tree/year and followed by 0.404 kg/tree/year for large trees tapped for three years and rested for one year. Trees having small diameter and tapped every year have lower yield followed by small trees tapped for two years and and rested for one year and large trees tapped every year.

References

Abeje Eshete. 2002. Regeneration status, soil seed banks and socio-economic importance of B. papyrifera in two Woredas of Northern Gonder Zone, Northern Ethiopia. M.Sc thesis, Swedish University of Agricultural Sciences, Sweden.

Abeje Eshete, Sterck, F. and Bongers, F. 2011. Frankincense production from *Boswellia Papyriferera.* Dissertation.

Girmay Fitwi. 2000. The status of gum arabic and resins in Ethiopia. Report of the Meeting of the Network for Natural Gum and Resins in Africa (NGARA) 29th-31st May, Nairobi, Kenya. pp. 14-22.

Kindeya Gebrehiwot, B. Muys, M. Haile and R. Mitloehner. 2005. The use of plant water relations to characterize tree species and sites in the drylands of northern Ethiopia. Journal of Arid Environments 60(4) 581-592.

Mulugeta Lemeneh and Demel Teketay. 2003. Frankincense and myrrh resources of Ethiopia: I Distribution, production, opportunities for dryland development and research needs. Sinet: Ethiop. J. Sci., 26(1):63–72.

NCSS (National Conservation Strategy Secretariat). 1993. National Conservation Strategy, Vol.1: National Policy on the Resources Base, its Utilization and Planning for Sustainability. NCSS, Addis Ababa, Ethiopia.

Tatek Dejenie, Abrham Abiyu and Kibruyisfa Sisay. 2006. Study on propagation techniques and population structure of *Boswellia papyrifera* (Del.) Hochst in North Gondar Zone.

Wubalem Tadesse, Sisay Feleke and Teshome Eshete. 2004. Comparative study of traditional and new tapping method on frankincense yield of Boswellia papyrifera. Ethiopian Journal of Natural Resources 6, 287–299.

Assessment of forest cover change and its environmental impacts: The case of Gumara-Maksegnit watershed of North Gondar Zone, Ethiopia

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Abstract

This study evaluated changes in forest cover in the Gumara-Maksegnit watershed, northwestern part of Ethiopia. The trend of forest cover both in time and space was investigated from 1986 to 2007 using remote sensing images and Geographical Information System (GIS). Two sets of satellite images; Landsat (1986 and 1999) and SPOT (2007) were acquired and supervised classification was used to categorize the land cover types. The overall accuracy and the Kappa value of classification were 91% and 86%, respectively. Change detection was undertaken to know the dynamic trend of forest cover in the area. The findings showed a decreasing trend in the area of forest cover over the last 21 years. In all the periods considered, the area under forest declined by 1056.25 ha (18.92%) from the base year (1986). The annual clearance of forest cover in the first years (1986-1999), in the second years (1999-2007), and over all the periods (1986-2007) were 48.04 ha, 95.69 ha, and 50.3 ha respectively. Agricultural expansion was the major driving force behind the changes. As a result of deforestation, the local people are mainly facing loss of important tree/shrub species (biodiversity) and drying of rivers and streams in the area.

Key words: Change, forest, GIS, Landsat, SPOT, remote sensing, supervised classification.

Introduction

Ethiopia has large number of species of flora and fauna in general and forest resources in particular with a significant rate of endemism. Ethiopian forest cover once was 40% of the country's land area and with the inclusion of the savanna woodlands (EEPFE, 2008). FAO (2006) estimated 11.9% of the country's land mass is covered with forests (0.13 million Km^2) and is at an alarming rate of deforestation (at 1.1% annually).

Reduction in forest cover results in soil erosion, reduced capacity for watershed protection, reduced capacity for carbon sequestration, biodiversity threatening, deterioration and instability of ecosystems and shortage of various wood and non-wood forest products and services. Before putting something to the ground to reverse the existing degradation, the first step should be mapping the current situation of the area.

Some researches on natural resources mapping have been conducted in the Amhara Region (Solomon, 1994 and 2005; Kebrom and Hedlund, 2000; Gete and Hurni, 2001; Belay, 2002; Woldeamlak, 2002; Girmay, 2003; Selamyihun, 2004; Birru, 2007; Hussien, 2009; Menale *et al.,* 2011), but there is significant variation in the level of analysis performed and purpose and output of the studies.

It is hoped that this study will provide information for decision makers and development practitioners about the magnitude and dimensions of long term forest cover changes, its drivers and impacts in the study area and surrounding.

Problem Statement

The ecology and environment of the Gumara-Maksegnit watershed has changed due to the sharper conflict between human and nature. IFAD/EPLAUA (2007) stated that most of the forests in the watershed are destroyed except some remnants of vegetation types of scattered trees left in the farm fields, churchyards, open forest along the streams and inaccessible areas. The natural vegetation cover of the watershed has been depleted. As a result, the natural resource base has been depleted to a greater extent due to inappropriate land use, soil erosion, reduction in the vegetation cover, biodiversity loss, and associated substantial reduction in the desired services including soil and water conservation and sustainable flow of water to the downstream. These problems are related either directly or indirectly to the total reduction of vegetation/forest cover and its composition (biodiversity) of the study area. Yonas *et al.* (2010) has also reported that small-scale farmer's productivity is constrained by small and fragmented land holdings, harsh climatic conditions, and other related factors. Therefore, it is crucial to answer the following questions: What was the spatial pattern of forest cover of the watershed in the past? What is the current status forest cover? What are the main causative factors for the change of forest cover over time? And what are the socioeconomic impacts of these forest cover changes?

Material and methods

The study area

The study was conducted in the Gumara-Maksegnit watershed located at about 45 km southwest of Gondar town and 695 Km from Addis Ababa, the capital of Ethiopia. It is located between 12^0 11’ 24” and 12^0 39’ 00” latitude and 37^0 22’ 48” and 37^0 36’ 00” longitude. The watershed drains into the Gumara-Maksegnit River, which ultimately reaches to Lake Tana (Fig 1).

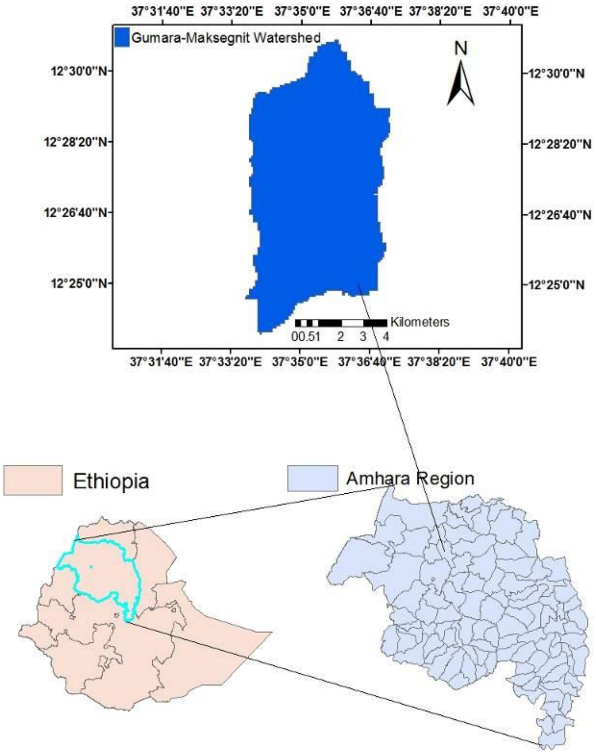

Figure 1. The study area

The study area is characterized by a unimodal rainfall distribution with mean annual rainfall of 1052 mm. The mean monthly minimum and maximum temperatures are 13.3 °C and 28.5 °C, respectively (Yonas *et al.*, 2010). The total area of the Gumara-maksegnit watershed is about 5600 ha. The topography situation of the area ranges from gentle slope to very steep slope. The altitude ranges from 1912 to 2848 m above sea level. The soils are red soil (Nitosol) 21%, black soil (Vertisol) 43%, and brown and other types (Gleysol and Leptsol) 36% of the study area. Vegetation of the study area is part of the evergreen dry afromontane forests that dominate the highlands of Ethiopia (Demel, 1996). The dominant tree species is *Olea africana*. Other large tree species are *Albizia gummifera, Ficus spp and Euphorbia species* (mainly in the natural forest). In areas of clearings and gaps, *Croton macrostachys* is the frequent species (Chaffey, 1979, ILDP, 2002 and Yonas *et al.*, 2010). The major crops include sorghum, teff, garlic, shallot, faba bean, lentil, bread wheat, chickpea, field pea, linseed, finger millet, barley and maize. Teff, sorghum and chickpea are the main staple crops in the study area (Yonas *et al.*, 2010).

Data collection and analysis

Data type and software used

Satelite images and analysis tools included in Table 1 were used to analyze the forest cover change in the watershed.

Table 1. Data type and software used.

Data types and software used	Description
Landsat	p170r055 Landsat TM 1986 and ETM+ 1999 with 28.5m spatial resolution,
SPOT	SPOT 2007 (spatial resolution =10m, (Scene ID = 4 133-325 07-10-08 08:21:42 1 I, Date = 2007-10-08 08:21:42, Instrument = HRVIR 1 and Number of spectral bands = 4)
DEM (Digital Elevation Model)	ASTER DEM (pg-BR1A0000-2007020401_003_012, 90m spatial resolution)
ERDAS	ERDAS version 9.1 used for image analysis
ArcGIS	ArcGIS version 9.3 used for image analysis
SPSS	SPSS version 16 used for socioeconomic data analysis

Socio-economic data

Questionnaires were developed and interviewes carried out to gather the necessary information. Households were selected from three kebeles (Chenchaye degola, Denzaze and

Jayera). All of the interviewees were farmers living in the watershed. In each Kebele, 30 interviewees were selected and a total of 90 respondents were interviewed. The overall content of the questionnaire mainly focused on knowledge of people in the watershed related to the trend of forest cover change and their experiences due to the changes of the forest resources. The questionnaire included personal and demographic data, crop production, vegetation data emphasizing on the forest resources, its changing trend, its associated environmental problems and solutions. Quantitative and qualitative data were co-analyzed in order to allow identification of causative factors. The analysis of the socioeconomic data was carried out using SPSS software version 16 (SPSS, 2007).

Different methods and techniques were used to measure and analyze spatial and non-spatial data. Landsat and SPOT satellite images of 1986, 1999 and 2007 were analyzed to identify forest cover change in the Gumara-Maksegnit watershed. A topographic unit such as altitude was extracted by using ASTER DEM and the aforementioned images. Field observations and/or Global Positioning System (GPS) points were collected from December to March 2011 to make reference information for image analysis and accuracy assessment. Socioeconomic data were also collected through questionnaires and informal communication to identify the pressures causing forest cover change and its impact on the environment.

Data acquisition and classification of forest cover

Field observations were performed to understand the features of different land cover (LC) classes. A total of 234 GPS points were collected. The number of GPS points for cropland, forest, and grassland were 60, 94 and 15, respectively. In addition, the remaining 65 GPS data were used for accuracy assessment. With some modifications, the land cover categorization was attained based on Hurni and Ludi (2000), Amsalu *et al.* (2007), Birru (2007), Hussien (2009) and Menale *et al.* (2011).

Forest/open shrub land: Refers to those areas covered with trees, shrub, bushes and some grasses. There exists variation in vegetation between dense shrub/bush lands with an estimated cover of >50% and open shrub/bush lands with less than 50% cover. The latter are not bare at all, but being degraded from competing use of grazing, cultivation, and deforestation as some of the degraded shrub/bush lands serve for grazing purposes (Birru, 2007). Red brown to bright red in the Landsat image (4, 3, 2 band combination) (Menale *et al.*, 2011) and SPOT image (1, 2, 3 band combination).

Cropland: Cultivated and fallow lands have a characteristic pattern, for example sharp edges between fields. Dark to grey and brown color in the Landsat image (4, 3, 2 band combination), unless the land lies fallow (Hurni and Ludi, 2000) and (Amsalu *et al.*, 2007) and SPOT image (1, 2, 3 band combination).

Grassland/Pasture /Bare land: Land under permanent and intensive grazing and bare land (land surface features devoid of vegetation) (Hussien, 2009). Homogeneous and have no pattern compared to agricultural land. Bright to white color in the Landsat image (4, 3, 2 band combination) (Hurni and Ludi, 2000) and SPOT image (1, 2, 3 band combination).

Analysis of images

Images obtained and used were Landsat TM 1986, Landsat ETM 1999 and SPOT 2007. These periods were considered based on the availability of satellite images. The projection was Universal Transverse Mercator (UTM). Before any analysis, resampling of spatial resolution of all images to 28.5 m X 28.5 m was done. Digital Elevation Model having a spatial resolution of 90 m was accessed to generate altitudinal classes. Representative Areas of Interests (AOIs) were selected as training for LC classification. The AOIs are selected based on the knowledge of the area obtained from field work, visual interpretation of the images and using GPS points. The number of sample AOIs for cropland, forest and grassland were 118, 62, and 53, respectively. A total of 233 AOIs were used for classification.

Based on the field survey data, an error matrix was generated to compare the real LC type versus the automated classification output. Overall accuracy of the classification, producer´s and user´s accuracy and kappa coefficient were calculated from the error matrix.

Forest cover change detection was done for 1986 to 1999, 1999 to 2007 and 1986 to 2007 using functions in the ERDAS Imagine software version 9.1. Four classes were assigned for the map produced after two images were overlaid to produce the change detection. The classes were no class (a place which is devoid of forests between two times under interest or cropland and grasslands), no change (a place where it is under forest in both times under study), new forest (a place where it was covered with non forest land covers during the first study period but forests emerged or replaced the previous land covers in the second time of the study period) and deforestation (places where there was a forest land in the base year, whereas lost its cover in the subsequent periods). Altitude was categorized into five classes to identify forest cover change in each level of category. Those class ranges were extracted in "if conditional modeler" by combining DEM and each year's change detection result. Then the model generated the amount of forest cover change at each level of altitudinal ranges. The altitudinal ranges were categorized into five classes with an interval of 200 m. The categories were: below 2000 m, 2000-2200 m, 2200- 2400 m, 2400-2600 m, and above 2600 m a.s.l.

Results and discussion

Land cover conditions of Gumara–Maksegnit watershed

To group land covers into different classes, classification categories were made based on reference information, structure/pattern and spectral signature. Three LC maps were produced for visual display of different LC categories for the three periods (Figure 2).

Forest cover share for the specific study years of 1986, 1999 and 2007 were 31.6%, 25.5% and 22.2%, respectively. Cropland covers 38.7%, 62.6% and 76.1% in 1986, 1999 and 2007, respectively. Grassland shared 29.7%, 11.8% and 1.8% in 1986, 1999 and 2007, respectively.

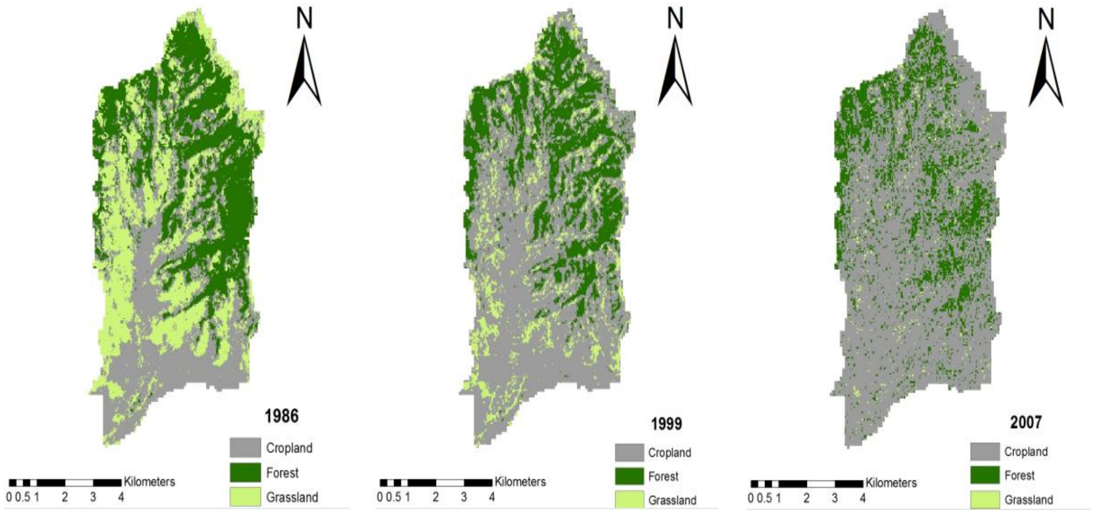

Figure 2. Land cover classification over study period.

Accuracy assessment

Sixty five GPS points were used for verification of the land cover classes generated. The general kappa index obtained is 0.86, which explains that the classification process is avoiding 86% of the errors that a completely random classification would generate. The overall accuracy of the field data versus automated classification result is 91% which is more than the acceptable range in such kind of classifications. And the producer's and user's accuracy are presented in Table 2.

Table 2. Error Matrix.

	Field data				
Classification	Forest	Agriculture	Grassland	Row total	User's accuracy
Forest	25	1	0	26	0.96
Agriculture	0	23	4	27	0.85
Grassland	0	1	11	12	0.92
Column total	25	25	15	65	
Producer's accuracy	1	0.92	0.73		

Forest cover change detection

Spatial and temporal forest cover change in the watershed was investigated. There was a decreasing trend of forest cover between the first (1986 and 1999) and the second (1999 and

2007) periods, and for the whole study period (1986 to 2007). The area under the forest cover was 1764.5 ha (31.6% of the watershed) in 1986 found declined to 1425.0 ha (25.5% of the watershed) and to 1239.19 ha (22.2% of the watershed) in 1999 and 2007, respectively. The greatest deforestation took place between 1999 and 2007. The size of forest cleared between 1999 and 2007 is 765.55 ha or 13.71% of the watershed. The annual clearance of forest covers in the first, second and the whole period were considerable and was estimated 48.0 ha, 95.7 ha and 50.3 ha, respectively. However, few newly emerged forests were also found. This is due to plantation in farmlands, farm boundaries, gullies and homesteads. The field observation revealed that most of the emerging forests are plantation covered by Eucalyptus species. Farmers have great interest for Eucalyptus because of its fast growth habit which enables to fulfil the wood demand of the farmers and as cash income generation along side with the main farm activities. Regeneration of the natural forests situated in remote and inaccessible (steep terrain) areas also contributed these increments. The change detection of forest cover was categorized as no class (land covered by crop and grassland), new forest, deforested land and forest areas that have no change in the last two decades (Table 3).

Table 3. Forest cover change (ha).

Class	1986 to 1999	1999 to 2007	1986 to 2007
No class	3534.91	3591.61	3300.90
No change	1140.40	659.47	708.20
New forest cover	284.61	567.36	518.62
Deforested	624.05	765.55	1056.25
Total	5583.98	5583.98	5583.98

Analysis of forest cover across altitudinal ranges

The natural distribution of forests is sensitive to altitude due to the physiological requirement. The distribution of land area to the different altitude classes in the watershed is shown in Table 4.

Table 4. Distribution of land areas in different altitudes (DEM of the watershed).

Altitude (m.a.s.l.)	Area (ha)	%
Below 2000	730.38	13.08
2000 – 2200	1458.88	26.13
2200 – 2400	2375.51	42.54
2400 – 2600	607.08	10.87
Above 2600	412.14	7.38
Total	5583.98	100

Between 2200 and 2400 m a.s.l. elevation category, for the first study period (1986 and 1999) the amount of deforestation was 16.0% while the amount of newly emerged forests was 10.5% (Figure 3).

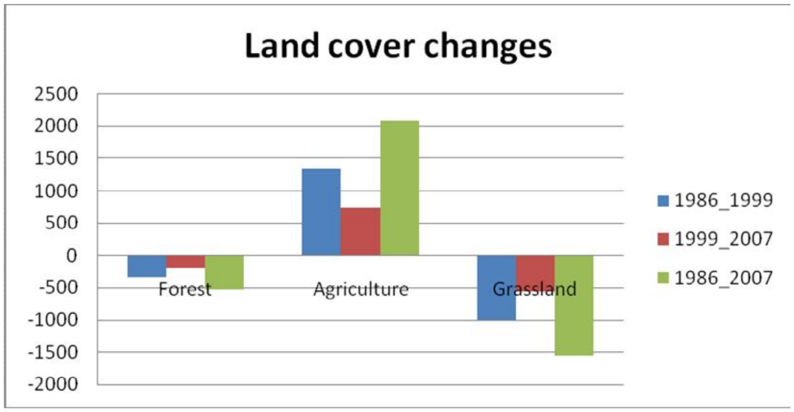

Figure 3. Land cover change

For the second period (1999 and 2007) of the study the amount of deforestation and newly emerged forests were 24.6% and 13.2%, respectively. And for the whole study period these amount are estimated to be 30.2% and 13.1%, respectively.

In all the periods, deforestation and new forests were concentrated in altitudinal range between 2000–2200 and 2200–2400 m a.s.l. This is because, in these higher altitudes agricultural and grazing (which is "no class" in the graph) activities are very limited due to its inaccessibility and physical unsuitability of the land to agricultural practice as can be seen in the result. Agricultural and grazing activities are concentrated up to 2200 m a.s.l altitude. Large areas of newly planted forests (153.6 ha first period, 240.4 ha second period and 233.6 ha whole period) were observed in between 2200–2400 m altitudinal ranges in all the studied periods. The reason behind this was that it predominates (68.67%) the watershed and as a result there is a high population intervention to this altitudinal range. The field observation also confirmed that plantations which are new forests like Eucalyptus woodlots were concentrated around homesteads and farmlands. In addition, large areas of deforestation (237.0 ha, 358.4 ha and 440.2 ha in various periods) were observed within the elevation category of 2200-2400 m a.s.l. altitudinal ranges. This is due to clearance of forests by the people starting from their surrounding up to the tolerable distances for different purpose.

Socioeconomic data

The total population of the 90 sample households was 369, of which 194 (52.57%) were male and 175 (47.43%) female. The average family size for all surveyed households was 4.1 with a range of 2 to 11. Average agricultural land holding of farmers is 1.32 ha. Only 3.25% of the interviewees have more than 2.5 ha. A large proportion of the surveyed households (91.6%) indicated that area under cultivation has decreased from time to time due to giving the resource to their children. While the remaining (8.4%) responded that there was no change. Ninety two percent of the respondents have put population growth as a first rationale for cultivation area decline in the households.

Drivers of forest cover change

The majority of interviewees (97.8%) confirmed that forest cover of the watershed has declined for the last decades. While the remaining 2.2% of them said there was no change on its extent. The major cause identified by 83.3% of respondents in the study was expansion of agricultural fields with the expense of forest lands and grasslands. The LC change detection result also showed the changes in LC types from 1986 to 2007 period. Agricultural land cover increased by 24% from 1986 to 1999, 13% from 1999 to 2007 and 37% for the whole study period with the expenses of forest and grassland land covers. Conversely, forest cover has declined 6% from 1986 to 1999, 3% during 1999 to 2007 and 9% during 1986 to 2007. The highest reduction occurred during the time between 1986 and 1999. As it has been observed during field observation, the remaining forests were due to difficulty to cultivate and inaccessibility for other use of the forests. Moreover, 11.1% and 3.3% of the respondents reported that the loose institutional setup and fuel wood collection contributed as a second and third causes of deforestation, respectively. About 98% of the farmers responded that government institutions have little or no influence despite the forest policy is in place.

Impact of forest cover change on the environment

The interviewees raised many problems that occurred as a result of deforestation in the watershed. Among the problems raised; lack of fire wood, construction timber scarcity, shortage of fodder, increased soil erosion and water flooding, drying out of springs and rivers, species extinction and productivity reduction were some of them. Sixty-nine percent of the respondents reported that the main problem in the study area occurred due to deforestation is drying of water bodies like ground water, springs and rivers. About 17% of them indicated soil erosion due to water as the main environmental problem, whereas 9% of them have raised fire wood scarcity as a major problem. Others prioritized scarcity of fodder (2.2%), lack of construction timber (2.2%) and species extinction (1.1%) as a primary problem of the watershed. The respondents identified a list of trees/shrubs species (Table 5) as disappeared due to deforestation in which the farmers had been extracting one or more benefits from these trees.

Table 5. Disappeared plant species from the Gumara-Maksegnit Watershed.

Vernonia amygdalina (Grawa)	*Psydrax schimperiana* (Seged)	Shonet
Schefflera abyssinica (Geteme)	*Delonix regia* (Kachona)	Yellew
Rhus glutinosa (Embus)	*Carissa ed ulis* (Agam)	Enkoy
Combretum molle (Abalo)	Euphorbia spp (Enketitif)	Kechem
Ziziphus spina-christi (Gaba)	Tekere	Kunbel
Syzygium guineense (Dokima)	Duduna	Dimetot
Juniperus procera (Tid)	Ayiderkie	Wonbella
Entada abyssinica (Kontir)	Afer	Chocho
Podocarpus falcatus (Zigiba)	Dingay seber	Tenbelel
Acacia albida (Girar)	Awera	Kimo

In addition to the impacts mentioned earlier, farmers in the watershed also raised productivity reduction and gully formation as other major problems due to deforestation. Ninety percent of the respondents asserted productivity reduction on their farmlands while 6% and 4% of the respondents replied as there has not been any change in productivity and increase in production through time, respectively. For the solutions farmers given to combat the problem of loss of productivity, 48% of the respondents looked for additional land through different mechanisms (e.g renting, buying, etc). Forty three percent of the respondents tried to increase the fertility of their farmland by using fertilizers as a solution for productivity reduction. Two percent of the respondents used to fallow their old farms as a solution for the productivity reduction occurred on their farmlands. The rest 7% of the respondents didn't take any action because there was no reduction of productivity.

Conclusion and recommendations

Using Landsat TM 1986 and ETM 1999 and SPOT 2007 datasets, forest cover change of the Gumara-Maksegnit watershed was analyzed. Drivers for the observed change and deforestation consequences over the environment were also identified by analyzing the knowledge of the farmers by surveying and focus group discussion.

The quantitative evidence of forest cover dynamics showed the substantial decline of forest cover since 1986. Therefore, it was the agricultural expansion which was accountable for the decline of the forest cover in the watershed. So, due to such deforestation, the local people have faced so many environmental problems such as loss of biodiversity, drying of streams and water bodies, etc. However, the leading problem was found to be the deterioration of the water bodies in the watershed.

Satellite derived topographic unit, such as altitude which is supposed to influence the growth of trees were extracted to examine the topographic unit of the study site. The mid elevation category of the watershed area is the dominating natural condition to the distribution of forest cover and agricultural land expansion in the watershed. And large areas of deforestation and newly emerging forests were observed in this altitudinal ranges.

Deforestation mainly as a result of agricultural expansion is a serious problem in the study area; it requires the decision of the government with top priority to come to an understanding with the communities to undertake afforestation, close the forest areas from animals and human beings and utilize sustainably, establish arboretum to conserve the biodiversity and prevent further expansion of cultivation lands through different mechanisms. Besides it would be important for farmers to be engaged in different off farm activities so as to reduce the pressure over forest resources. Making a local forest as a source of income generation by incorporating economically useful trees could make the resource sustainable. Further studies on policy and detailed socioeconomic issues should be undertaken to understand the human forest interaction and bringing options to reverse the current deforestation. Further study is required to quantify the reported species extinction and underlying factors responsible for the problem. Introduction of modern energy sources like kerosene as well as the introduction of fuel wood saving stoves has to be given priority consideration.

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References

Amsalu A., Stroosnijder, Leo and de Graaff, J. 2007. Long-term dynamics in land resource use and the driving forces in the Beressa watershed, highlands of Ethiopia. Journal of Environmental Management 83: 448–459.

Birru Y. 2007. Land Degradation and Options for Sustainable Land Management in the Lake Tana Basin (LTB), Amhara Region, Ethiopia. PhD thesis, Centre for Development and Environment, University of Bern, Switzerland.

Chaffey D. 1979. Northwest Ethiopia forest inventory project, Addis Ababa, Ethiopia.

Demel T. 1996. Seed Ecology and Regeneration in Dry afromontane forests of Ethiopia. Journal of Vegetation Science 6: 777-786.

EEPFE (Environmental Economics Policy Forum for Ethiopia). 2008. Policies to Increase Forest Cover in Ethiopia. Addis Ababa, Ethiopia.

FAO. 2006. Global Forest Resources Assessment 2005. Progress towards sustainable forest management. FAO FORESTRY PAPER 147. Food and Agriculture Organization of the United Nations. Rome, Italy.

Gete Z. and H. Hurni. 2001. Implications of Land Use and Land Cover dynamics for mountain resource degradation in the northwestern Ethiopian highlands. Mountain Research and Development 21(2): 184-191.

Girmay K. 2003. GIS based analysis of landuse/land cover, land degradation and population changes: A study of Boru Metero area of south Wello, Amhara Region, MA Thesis, Department of Geography, Addis Ababa University.

Hurni H. and Ludi E. 2000. Reconciling conservation with sustainable development. A participatory study inside and around the Simen Mountains National Park, Ethiopia. Center for Development and Environment (CDE), University of Bern, Switzerland.

Hussien A. 2009. Land Use and Land Cover Change, Drivers and Its Impact: A Comparative Study from Kuhar Michael and Lenche Dima Of Blue Nile and Awash Basins of Ethiopia. MSc thesis, Cornell University at Bahirdar University. Bahirdar, Ethiopia.

IFAD (International Fund for Agricultural Development)/EPLAUA (Environmental Protection, Land Adminstration and Use Authorty). 2007. Amhara National Regional State Community-based Integrated Natural Resources Management in Lake Tana

Watershed. Baseline Information On Water Resource, Watershed, Water Harvesting and Land Use. Unpublished. Project Planning Team. Bahir Dar, Ethiopia.

ILDP. 2002. Integrated Livestock Development Project. Livestock Characterization in North Gondar. Unpblished. Gondar, Ethiopia.

Kebrom T. and Hedlund L. 2000. Land cover changes between 1958 and 1986 in Kalu District, southern Wello, Ethiopia. Mountain Research and Development 20: 42-51.

Menale W., Schneider W., Assefa M. and Demel T. 2011. Spatial and Temporal Land Cover Changes in the Simen Mountains National Park, a world heritage site in Northwestern Ethiopia. Remote Sens., 3, pp.752-766.

Selamyihun K. 2004. Using Eucalyptus for soil and water conservation on the highland Vertisols of Ethiopia. Ph.D. Thesis. Wageningen University, The Netherlands.

Solomon A. 1994. Land use dynamics, soil degradation and potential for sustainable use in Metu area, Illubabor Region, Ethiopia. African Studies Series No. A 13. Ph.D. Thesis, University of Berne, Switzerland.

Solomon A. 2005. Land-use and land-cover change in headstream of Abbay watershed, Blue Nile basin M.Sc thesis. Addis Ababa University. Addis Ababa, Ethiopia.

SPSS (Statistical package for Social Science). 2007-SPSS for windows released16.0.0. Standard Version SPSS Inc, 1989-2007.

Woldeamlak B. 2002. Land cover dynamics since the 1950s in Chemoga watershed, Blue Nile basin, Ethiopia. Mountain Research and Development 22(3):263–269.

Yonas W., Teferi A., Asmamaw Y., Solomon A., Hailu K. and Ambachew G. 2010. Socio-economic survey of Gumara-maksegnit watershed. Gondar Agircultural Research Center. Unpublished. Gondar, Ethiopia.

Determination of high yielder point and wound recovery to optimize frankincense yield from *Boswellia papyrifera* trees in the lowland of North Gondar Zone

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Abstract

Boswellia papyrifera (Del.) Hochst is threatened as the result of several interrelated factors and among these factors exploitation system is considered to be the major cause for the decline of the species. Boswellia trees are used to be tapped every year in the dry season and heavy tapping is observed to damage the cambium and curtail the life span of the trees due to slow wound healing. Research intervention in the area of tapping technique helps to alleviate problems of damaging trees during tapping and to enhance incense production. This study was conducted at Metema Woreda Lemelem Terara kebele North Gondar Zone from 2002 to 2003 E.C. The objectives of this study were to investigate: i) the effect of tapping height and tree size on wound recovery, and ii) the effect of tapping height and tree size on frankincense yield. Trees were selected for the experiment based on different diameter classes. To keep the homogeneity among the experimental trees, forty five sample trees with similar tapping history were selected using stratified sampling techniques and then three diameter classes of 10-15 cm, 16-20 cm and 21-25 cm were randomly selected accordingly. For each diameter class, 15 trees were taken and labeled. Then, finally, these trees were allocated to three different tapping height categories (n = 5 per tapping height categories) i.e. tapped at 0.5m, 1m and 1.5m. Following the traditional tapping practices, each tree category were tapped in the east and west direction. Factorial RCBD designs with three level of diameter size and three level of tapping height were used. The result of the wound recovery study showed that among the treatments height showed significant difference. In this study those tapped tree at higher diameter (16-20 cm) of tapping height 0.5 m yield higher wound recovery and trees tapped at lower diameter (10-15 cm) of tapping height 1.5 m exhibited lower wound recovery. The frankincense yield collected from the tapped *B. papyrifera* trees had shown significance difference between treatments of height, diameter and year. The result revealed that trees tapped at higher diameter (21-25 cm) of tapping height of 1 m had bring higher frankincense yield whereas trees tapped at lower diameter (10-15 cm) of tapping height 1.5 m has scored the lowest frankincense yield. Therefore, when tapping is planned to be carried out, it needs to consider tapping height and the tree diameter (DBH) since these are found to be the major factors that determine the frankincense yield and the recovery of the wound.

Key words: *Boswellia papyrifera*, DBH, frankincense, tapping, wound, yield.

Introduction

The dry land woodlands of Ethiopia are endowed with diverse tree species that are known for their valuable Non-Timber Forest Products (NTFPs) of local, national and international significance. One of the well- known species in this regard is *Boswellia papyrifera* (Del.) Hochst. The species is a deciduous multipurpose tree with the potential for economic development and desertification control (Lemenih and Teketay, 2003a, 2004). It is found in the *Combretum–Terminalia-Acacia-Commiphora* (broad-leaved) deciduous woodland and wooded grassland dominant on steep rocky slopes, lava flows or sandy valleys, within the altitudinal range of 950–1800 m altitude (Vollesen, 1989; Azene Bekele *et al*., 1993; Friis 1996; Eshete *et al*., 2005; NBSAP, 2005; Lovett and Ogbazghi *et al*., 2006; Tadesse *et al*., 2007; Abiyu *et al*., 2010). Frankincense is a gum resin tapped from several species of the genus *Boswellia*, is composed of about 20 species extending from Ivory Coast to India and south to north-eastern Tanzania and Madagascar but most numerous in north-eastern tropical Africa. The resin from *B.papyrifera* (Del) Hochst., Frankincense, is traded at the local and international markets for thousands of years. These products of nature have well established uses in several multibillion dollar and multinational industries such as food, pharmacology, cosmetics, perfumery, beverage (flavours, soft drinks, liquor, and brewery), paints, adhesives, inks and various other industries, thus have large international demands. These products have also wide local uses such as food supplements, ritual/religious applications, folk medicines, and others (Lemenih and Teketay, 2003a, b and 2004).

Besides the direct financial contribution to the local and the national economy, gums and gum resins producing trees and shrubs have considerable ecological role in the dry land ecosystems. *B.papyrifera* is also considered as a valuable species that thrives successfully under the conditions where soil and climate do not offer other opportunities, thus, allowing marginal dry lands to be productively and economically utilized. This behavior of successful establishment and growth of the species under harsh climatic and soil conditions make it one of the best candidates to fight desertification, rehabilitate degraded dry lands and allow adaptation of communities in dry lands to possible climate change (Lemenih and Teketay, 2004). It is also found to be highly suitable for future reforestation establishments or restoration efforts in moisture deficit arid and semi-arid areas (Kindeya *et al*., 2005). Therefore, tree based utilization of dry land ecosystems will assist communities living there to adapt to possible climate change well than, for instance, crop farming (Adam, 2003; Mulugeta *et al.*, 2003a).

Despite its long history in commercial market, studies on the resin system and on factors that determine resin production are scarce. In recent years, these species in Ethiopia particularly in the Amhara region have been facing several challenges in which it is used to be cleared for cropland expansion, overgrazing, intensive tapping and increased frequency of forest fire. At present almost all of the gum-resin resources are collected from the wild and untended plants by the surrounding community, who use crude and haphazard method of incising the main stem by axes. Owing to lack of adequate scientific techniques of tapping and collection procedures, it has become difficult to optimize the utilization and maintain a good quality standard of this indigenous natural product. Trees are tapped every year in the dry season and intensive tapping could injure the cambium and curtails the life span of the tree on account of poor wound-healing. Due to this exploitation the potential range of forest communities with Boswellia is greatly reduced and is classified as an endangered species (NCSS, 1993; Kindeya *et al*., 2002). Thus, research efforts with respect to this species could contribute greatly to the production as well as economic and ecological utilization of these vast untapped resources for the benefits of the local, national as well as international communities. No doubt that research supports in the areas of tapping height and wound recovery for enhancement of production is very crucial. Therefore, the present study aims at investigating new tapping height and diameter class combination for optimum frankincense yield collection and wound recovery from *B.papyrifera* trees species under the case of North Gondar, Amhara National Regional State, Ethiopia.

Material and methods

Site description

Geographically Metema is located at 12°33.58'-12°41.53'N, 36°04.12'-36°18.84E at about 900km northwest of Addis Ababa and Lemlem Terara is situated at about 205 km west of Gondar town, between 36°17'-36 °48'E and 12° 39'-12° 45' N (Figure 1). It is one of the west most woredas of the Amhara Regional State. According to this estimate, the total population of the woreda is 91,216 people. Out of the total, 3918 are rural and 1497 are urban women households.

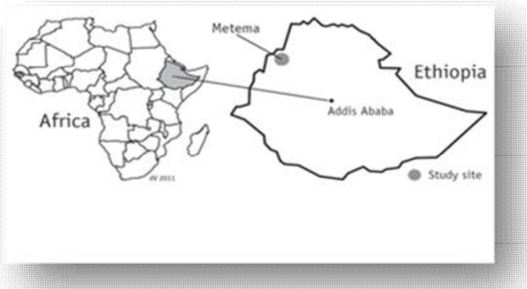

Figure 1. The location of the study site of Metema North Gondar zone of Amhara Regional state, Ethiopia (Tefera Mengistu, 2011 and Abeje Eshete, 2011).

The altitude of Metema ranges from 810 to 990 m.a.s.l. The annual rain fall ranges from 870-1390mm (between 1988 and 2007) with mean annual rain fall of 965mm and has a unimodal rainfall. The rainy season (>100 mm/month) lasts for 4 months from June till September. (Figure 2). The diurnal minimum and maximum temperature per month are 19.6 and 35.7°C respectively. Daily temperature becomes very high during the months of March to May, where it may get to as high as 43 °C (Abeje Eshete, 2011).

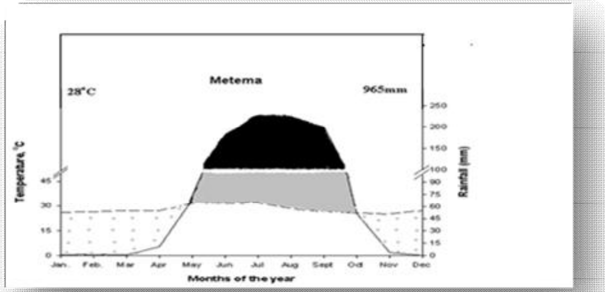

Figure 2. Climate variation over the year for the site taken from Gendewuha meteorological station(~ 25km away from the study plots) for the period from 1988 to 2007.

Note: Monthly rainfall (mm $month^{-1}$) is indicated by the solid line, mean diurnal maximum temperature per month (°C) by the dotted line, and mean diurnal minimum temperature per month by the dashed line. The annual rain fall ranged from 870 to 1390 mm (Abeje Eshete, 2011).

Nearly all of the land in the woreda is in the lowlands except some mountain tops which fall outside. The soils in the area are predominantly black and some are soils with vertic properties (Emiru Birhane.2011).The natural vegetation is categorized as *Combretum –Terminalia* woodland (NBSAP, 2005) is predominantly composed of different *Acacia spps, Balanites aegyptica, Boswellia papyrifera, Combretum spp, Stereospermum kunthianum and Terminalia brownie* (Abeje Eshete*,* 2011). Three major rivers namely Shinfa, Guang and Genda wuha drain through the woreda.

Methodology

The study was conducted in Metema Woreda, North Gondar, Ethiopia in very high population of *B.papyrfera* dominated stand at Lemlem Terrara kebele with 850 m m a.s.l. elevation. The experiment was conducted for two production season 2010-2011 and 11 round of frankincense trees tapping were under taken. Trees were selected for the experiment by considering different diameter classes. To keep homogeneity among the experimental trees, trees with similar tapping history were selected using stratified sampling techniques and then trees having three diameter classes of 10-15 cm, 16-20 cm and 21-25 cm were randomly selected. For each diameter class, 15 trees were taken and labeled. These trees then allocated to three different tapping height categories of 0.5 m, 1m and 1.5 m (Table 1).

Following the traditional/local tapping practices each tree category were tapped in the east and west direction. Then the frankincense yield and wound recovery data obtained from each trees was collected and analyzed. Factorial RCBD design with five replications was used (three level of diameter size and three level of tapping height).The tapping materials used to conduct the experiment was Mingaf, plastic bags for collecting the frankincense, sensitive balance for weighing the collected frankincense, diameter caliper for measuring the tree diameter, meter and graduated ruler to determine the tapping height category.

Table1. The number of trees tapped in each tapping height and diameter class.

Tapping height (m)	Tapping DBH (cm)	Number of trees
0.5	10-15	5
	16-20	5
	21-25	5
1	10-15	5
	16-20	5
	21-25	5
1.5	10-15	5
	16-20	5
	21-25	5

DBH = Diameter at breast height.

Data collection and analysis

The frankincense data from tapping was collected from the 45 selected sample trees for each tapping height category i.e. 0.5 m, 1 m, 1.5 m from the month September up to end of May for two productions season. The first frankincense collection round started at the second tapping round. Frankincense production per tree was determined by weighing the freshly harvested frankincense directly after collection using digital balance (0.01 g precision). Wound recovery data were collected after collecting the frankincense yield and this was usually done at the end of the rainy season (i.e. September). The data was obtained by observing the different features observed on the bark of the tapped tree and this was usually done on the tapping spot and we had tried to classify in to four size classification (0-25%, 25-50%, 50-75%, 75-10%). General Linear Model (GLM) procedures of SAS(9.0) software for data analysis was used and further to see the significant difference between treatments mean the data was exposed to LSD mean separation techniques. Data were transformed to natural logarithm to meet the assumption of normal distribution.

Results and discussion

Effect of tapping height and tree size (diameter) on wound recovery

All year round tapping were undertaken on the selected forty five sampled trees and finally before the beginning of the next tapping season wound recovery data from each tapped tree at the first year were collected for two consecutive years. Results showed that tapping height had significant effect on wond recovery (Table 2). However, tree diameter and the interaction between height and diameter did not have significant effect on wound recovery (Table 2). Trees with in the 10-15 cm diameter class and tapped at 1.5 m height and trees with in the 16-20 cm diameter class and tapped at 0.5 m height exhibited the lowest and highest wound recovery percentage, respectively which ranges from 30.5%/tree/year to 50.63%/tree/year (Table 3). This implies that bigger trees tapped at lower tapping height would have faster wound recovery than smaller trees tapped at higher tapping height.

Table 2. ANOVA for the effect of tapping height and tree diameter on wound recovery.

Source	df	Mean Square	F Value	Pr>F
Year	1	1376.833746	11.03	0.0014
Height	2	666.825466	5.34	0.0068
Diameter	2	230.321621	1.85	0.1650
Height*Diameter	4	143.236046	1.15	0.3407

Effect of tapping hieght and tree size (diameter) on frankincense yield production

The effect of tapping height and tree diameter on frankincense yield was also assessed. Results showed that there were significant differences in frankincense yield between tapping height and tapping diameter (Table 4).

Table 3. Effect of tapping height and tree diameter on wound recovery.

Height (m)	Diameter (cm)	Wound Recovery (%)	Std Dev
0.5	10-15	39.50[c]	11.89
0.5	16-20	50.63[a]	10.50
0.5	21-25	43.00[c]	14.94
1	10-15	41.00[c]	13.29
1	16-20	38.89[c]	13.87
1	21-25	46.00[a]	13.29
1.5	10-15	30.50[b]	5.99
1.5	16-20	36.11[b]	9.93
1.5	21-25	38.33[c]	10.31

Means with the same letter are not significantly different at P<0.05.

Table 4. ANOVA for the effect of tapping height and diameter on frankincense yield.

Source	df	Mean Square	F Value	Pr>F
Year	1	59865.1671	5.51	0.0216
Height	2	45128.7328	4.15	0.0195
Diameter	2	68730.1816	6.32	0.0029
Height*Diameter	4	2429.8700	0.22	0.9245

Trees with in the 21-25 cm diameter and tapped at 1 m height and trees with in the 10-15 cm diameter and tapped at 1.5 m height gave the highest and lowest frankincense yields, respectively (Table 5). The mean frankincense production potential for each tapping height category and diameter class anges from 39.72 g/tree/year to 204.28 g/tree/year.

Table 5. Effect of tapping height and tree diameter on frankincense yield.

Height (m)	Diameter (cm)	Yield (g/tree/year)	Std Dev
0.5	10-15	98.82^c	67.97
0.5	16-20	117.46^c	82.05
0.5	21-25	197.15^a	177.52
1	10-15	131.92^c	121.60
1	16-20	172.47^c	114.60
1	21-25	204.28^a	132.13
1.5	10-15	39.72^b	19.09
1.5	16-20	76.53^b	78.89
1.5	21-25	152.17^c	80.98

Means with the same letter are not significantly different at $P<0.05$.

Discussion

Tapping height and diameter size on wound recovery

In this study we evaluated the effect of tapping height and tree size (DBH) on wound recovery and frankincense yield. We hypothesized that higher wound recovery can be obtained from each higher tapping height and tree size (DBH). Accordingly, we observed that wound recovery differed between tapped trees with different diameter size and the three tapping height category. In which bigger tree size tapped at lower height of 0.5 m had higher wound recovery than that of smaller trees. Similarly, *B.papyrifera* trees tapped at higher tapping height (1.5 m) had the lowest wound recovery at any diameter size. Abeje (2002) determine the optimal DBH for tapping *in B.papyrifera* to be 10-12 cm and according to his study trees with less than 12 cm DBH may not be able to recover from their wound after tapping. The higher wound recovery result from the bigger trees can be justified as bigger tree practice higher resources acquisition capacities which intern depends on the crown size and leaf areas of trees (Abeje, 2011). According to Tefera (2011), bigger trees had more starch storing capacity than smaller tree in which attributed to attain higher wound recovery in larger trees and this also results in smaller trees suffer sooner from carbon starvation by tapping. For example, Murphy and Shiva (1977) indicated that the original thickness of *B.serrata Roxb* was regained from wound three years after tapping and further in Eritrea (Ogbazghi, 2001) explained some period (eg. 3-5 years) is necessary from wound healing in northern Ethiopia. Therefore, for *B.papyriera* trees to be tapped for the next production season the tapped tree have to recover well from wound. It is also suggested that if tapping (wounding) is undertaken on those trees with higher diameter size and avoid tapping on smaller trees. Since tapping creates multifaceted undesirable negative impacts on *B.papyrifera* trees and further intensive tapping leads to the production of non-viable seeds (Ros-Tonen *et al*., 1995; Abeje, 2002) and allows more starch to be oozed from the wound thus if tapping is applied to smaller trees consequently the tapped tree will face carbon starvation (Tefera, 2011). Particularly tapping at the lower tapping height (i.e. <1.3 m) is advised for this study.

Tapping height and diameter size on frankincense yield

The second objective of this study was evaluating the effect of tapping height and tree size (DBH) on the frankincense yield. For this we hypothesized higher tapping height and tree size (DBH) will bring higher frankincense yield. In line with our hypothesis the result revealed that trees with bigger diameter size (DBH) had shown higher frankincense yield (i.e. 204.3 g/tree/year) than that of smaller trees. On the other side, tapped trees at higher tapping height (1.5 m) gave lower frankincense yield (i.e. 39.7 g/tree/year) in which our stated hypothesis didn't meet in this case. Different scholars revealed different frankincense yield, for instance Tadesse *et al*. (2004) reported a range of 6.7-451.4 g/tree/year , Abeje and Asmamaw (unpub.) (2007) reported a frankincense yield of 207-352 g/tree/year and Girmay (2000) reported 500 g/tree/year of frankincense to be collected from *B.papyrifera* tree under normal frankincense production techniques. A similar study on the yield potential of *B.papyrifera* in the Metema area (Wubalem *et al*., 2004; Asmamaw and Abeje, 2007) revealed the potential of 67.5 kg of frankincense production from a hectare of Boswellia woodland, and Mesfin *et al*. (2007) also reported frankincense production per hectare from open and closed area in Tigray to be 254.18 kg and 169.08 kg, respectively. Generally, according to this study, tapped trees with a bigger tree (DBH) provide higher frankincense yield than smaller tree size (DBH) and in quantitative terms the value ranged from 39.7 g/tree/year to 204.3 g/tree/year and this value is not far from pervious study done on this tree species. Thus, the higher frankincense production from bigger

B.papyrifera trees observed in this study may be the result of larger photosynthesis carbon present acquisition capacity by bigger trees (Tefera, 2011) than that of smaller tree. In addition to the tapping diameter size bigger trees tapped at the lower height usually below diameter at breast height (i.e. <1.3 m) had yield higher frankincense yield than tapping done at higher height. This can be clearly justified in the following manner:- the diameter and the bark thickness of the tree usually at the lower height is thicker than at higher height and this attributed to a high accumulation of starch /carbon at the lower height than the higher one and therefore when tapping done at the lower height it will allow more resin to be oozed and the frankincense to be collected will be increased.

Conclusion and recommendation

Higher diameter will greatly favor the wound recovery rate of *B.payrifera* trees and the minimum tapping diameter size shall be limited to 16-20 cm of tapping height of lower (i.e. 0.5 m) and avoid tapping on smaller trees of any tapping height. Trees with higher diameter size (21-25 cm) with tapping height of less than diameter at breast height (i.e. <1.3 m) had brought higher frankincense yield than smaller diameter trees (i.e. 10-15 cm) size. Since carrying out tapping at higher tapping point did not produce higher frankincense yield and also wound recovery is slow. Therefore, avoid tapping on those trees with lower diameter size (10-15 cm) and higher tapping height (1.5 m). And finally to maximize the frankincense production and enhance the wound healing from individually tapped trees of adult *B.papyrifera* it is better to undertake tapping on those trees having bigger diameter size and avoiding tapping smaller trees. Further investigation on tapping intensity/number of tapping spot, tapping frequency, viability of seeds and insect/pest infestation is essential.

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References

Abeje Eshete. 2002. Regeneration Status, Soil Seed Banks and Socio-economic Importance of *Boswellia papyrifera* (Del.) Hochst. In Two Woredas of North Gonder Zone, Northern Ethiopia. MSc thesis, Swedish University of Agricultural Sciences, Skinnskatteberg, Sweden.

Abeje Eshete. 2011.The frankincense tree of Ethiopia: Ecology, productivity and population dynamics. Phd. Desertation. Wageningen University.

Abeje Eshete, Demel, T. and Hulten H., 2005. The socio-economic importance and status of population of *B. papyrefera* (DEL)Hochst. In northern Ethiopia: the case of North Gondar Zone. Forests, Trees and livelihoods. Vol. 15 pp 55-74.

Abiyu, A., Bongers, F., Eshete, A., Gebrehiwot, K., Kindu, M., Lemenih, M., Moges,Y., Ogbazghi, W. and Sterck, F. 2010. Incense woodlands in Ethiopia and Eritrea; Regeneration problems and restorations possibilities. In: Bongers, F., Tennigkeit,T. (eds.). Degraded forests in Eastern Africa: Management and restoration.Earthscan Ltd.London,Uk.

Adam, A.A. 2003. Some Aspects of Ecology and Management of *Boswellia papyrifera* (Del) Hochst. In Jebel Marra Area Darfur-Sudan. Phd Dissertation. University of Khartoum, Sudan.

Asmamaw Alem and Abeje Eshete. 2007. The effect of tapping intensity and tree diameter (size)on frankincense yield of *Boswellia papyrifera (*Del)Hochst: a key dry land species in Northern Ethiopia(Unpuplished).

Azene, Bekele-Tesemma, Birnie, A. and Tengnas, B. 1993. Useful Trees and Shrubs for Ethiopia. Identification, Propagation and Management for Agricultural and Pastoral Communities. Regional Soil Conservation Unit, SIDA, Nairobi.

Emiru Birhane. 2011.Mycorrihsal symbiosis and seedling performance of the frankincense tree (Boswellia papyrifera).Phd. Desertation. Wageningen University.

Fitwi Girmay. 2000. The status of gum arabic and resins in Ethiopia. Report of the Meeting of the Network for Natural Gum and Resins in Africa (NGARA) 29th-31st May, Nairobi, Kenya.

Kindeya G., Muys, B., Mitiku H., Mitloehner, R. 2002. *Boswellia papyrifera* (Del.) Hochst.: a tropical key species in northern Ethiopia. Paper presented at the Conference on International Agricultural Research for Development, Deutscher Tropentag 2002, Witzenhausen, October 9-11, 2002, Germany. 8 pp.

Kindeya Gebrehiwot, B. Muys, M. Haile and R. Mitloehner. 2005. The use of plant water relations to characterize tree species and sites in the drylands of northern Ethiopia. Journal of Arid Environments. Vol 60(4) 581-592.

Lovett, J.C. and Friis, I. 1996. Patterns of endemism in the woody flora of North-East and East Africa.

Ros-Tonen, M., Dijkman, W. and van Bueren, E.L. 1995. Commercial and sustainable Extraction of Non–Timber forest products Towards a policy and management oriented research strategy. The Tropenbos Foundation, Wageningen.

Mesfin Tilahun, Roland Olschewski, Christoph Kleinn, and Kindeya Gebrehiwot. 2007: Economic analysis of closing degraded Boswellia papyrifera dry forest from human interventions – a study from Tigray, Northern Ethiopia.

Mulgeta, L and Demel, T. 2003a. Frankincense and myrrh resources of Ethiopia, I. Distribution, Production, opportunities for dry land economic development and research needs. Ethiopian Journal of science SINET 26(1):63-72.

Mulgeta, L and Demel, T. 2003a. Frankincense and myrrh resources of Ethiopia, II. Medicinal and Industrial uses. SINET, Ethiopian Journal of science 26(2):161-172.

Mulugeta Lemenih and Demel Teketay. 2004. Natural Gum and Resin Resources: Opportunity to Integrate Production with Conservation of Biodiversity, Control of Desertification and Adapt to Climate Change in the Drylands of Ethiopia. Paper Presented to the First National Workshop on Conservation of Genetic Resources of Non Timber Forest Products (NTFPs) in Ethiopia, 5–6 April 2004. Addis Ababa.

Murthy,T.K. and M.p shiva. 1977. Salai Guggol from Boswellia Serrata Roxb-Its exploitation and utilization. The Indian Forester ,103(7):466-473.

NBSAP. 2005.National Biodiversity Strategy and Action Plan. Addis Ababa,Ethiopia.

NCSS (National Conservation Strategy Secretariat). 1993. National Conservation Strategy. Vol.1. National Policy on the Resources Base, its Utilization and Planning for Sustainability. Addis Ababa, Ethiopia.

Ogbazghi,W., Rijkers,T., Bongers, F. and Wessel, M. 2006b. Distribution of the Frankincense tree Boswellia papyrtifera in Eritrea:the role of environment and land use. Journal of Biogeography 33.

Tefera Mengistu. 2011 .Physiological ecology of the frankincense tree: Tapping and Carbon Balance of the Frankincense Tree (Boswellia papyrifera (Del.) Hochst. . Phd. Desertation. Wageningen University.

Vollesen, K. 1989. Burseraceae. In: Flora of Ethiopia, Volume 3, pp. 442–478, (Hedberg, I. and Edwards, S., eds). National Herbarium, Addis Ababa University, Addis Abeba and Uppsala University, Uppsala

Woldeselassie Ogbazghi. 2001. The distribution and regeneration of *Boswellia papyrifera* (del.) Hochst. in Eritrea. Tropical Resource Management Papers, No. 35. Phd. Desertation. Wageningen University. 131 pp.

Wubalem T, W,Getachew,.D.and Alia, R. 2007. Natural gum and resin bearing species of Ethiopia and their potential applications.

Wubalem Tadesse, Sisy Fleke and Teshome Eshete. 2004. Comparative study of traditional and new Tapping method on frankincense yield of Boswellia papyrifera Ethiopia journal of Natural Resource 6:287-299.

CROP RESEARCH

Genetic variability in nitrogen use efficiency of upland rice varieties in West Amhara, Ethiopia

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Abstract

Use of nitrogen efficient genotypes is an important complementary strategy in improving rice yield and reducing cost of production in subsistence farming. A field experiment was conducted at Woreta, Fogera district of South Gondar Zone, during the 2009 main cropping season. The objectives were to investigate genetic variability in nitrogen use efficiency of upland rice genotypes, to identify genotypes with best nitrogen use efficiency and to assess the nature of association between nitrogen use efficiency traits and yield and yield related traits. Twelve upland rice genotypes (6 released and 6 candidate) with two nitrogen levels (0 and 64 kg N ha^{-1}) were evaluated in a factorial randomized complete block design with three replications. Analysis of variance revealed significant differences among genotypes for yield and yield related traits and nitrogen use efficiency and its component traits. Differences were significant between nitrogen levels for the number of filled spikletes panicle^{-1}, grain yield, and biomass yield and nitrogen use efficiency component traits. Genotype×nitrogen interaction effect was not significant for all traits. The highest grain yield of 5437.7 kg ha^{-1} was obtained from NERICA-3 followed by NERICA-4 (5252.9kg ha^{-1}). Nitrogen uptake, nitrogen utilization and nitrogen use efficiency varied from 21.87 to 48.43%, 21.46 to 53.4 kg kg^{-1} N and 8.71 to 31.87 kg kg^{-1} N, respectively. Grain yield, harvest index, grain nitrogen yield, nitrogen harvest index, nitrogen uptake efficiency, nitrogen utilization efficiency and nitrogen use efficiency had high genotypic and phenotypic coefficient of variation and high broad sense heritability estimates. Grain yield showed significant and positive correlation with grain nitrogen yield, and nitrogen harvest index. Grain nitrogen concentration had significant and positive correlation with nitrogen uptake efficiency and nitrogen use efficiency. Nitrogen efficient genotypes (Superica-1, NERICA-4 and NERICA-3) could be used in production and also in breeding program to produce varieties of better nitrogen use efficiency.

Key words: Efficiency, nitrogen, rice, uptake, utilization.

Introduction

Rice, *Oryza sativa* (2n = 24), is the second most important cereal crop and staple food for more than one third of the world's population (International year of rice, 2004). It has two cultivated and more than 30 wild species with a broad geographic distribution (Watanabe, 1997). The cultivated species are *Oryza sativa L.,* which is Asian origin and *Oryza glaberrima Steud,* an African origin. Rice production in the world increasingly focuses on optimizing grain yield, reducing production costs, and minimizing pollution risks to the environment (Koutroubas and Ntanos, 2003). One of the inputs limiting rice production is nitrogen (N). However, 50–70% of the applied nitrogen (N) is not used by crop plants leading low nitrogen use efficiency (NUE) of 32% (Tilman *et al*., 2002). Nitrogen use efficiency is the ability of the plant to produce a unit of grain per kg of nitrogen applied to the soil (kg grain kg^{-1} N). It is determined by the ability of the plant to extract soil nitrogen (Nitrogen uptake efficiency, NUPE %), and by the ability to convert the absorbed nitrogen into grain yield (Nitrogen utilization efficiency, NUTE, kg grain kg^{-1} N) (Molle *et al*., 1982). The need for developing and identifying superior N efficient genotypes is evident from the low recovery of N fertilizer, associated economic and environmental concerns. Moll *et al*. (1982) recommended selecting cultivars with high NUPE and NUTE. Samone *et al*. (2006) also indicated that NUE should be considered both when developing cultivars and when making fertilizer N recommendations.

Selection in plant breeding techniques, in Ethiopia, helped to developing rice varieties that are high yielding and diseases resistant. However, genetic selection to improve rice N-use efficiency has not yet been done. Hence, there is no information on NUE variability and its relation with yield and yield related traits among rice cultivars. Moreover, in Ethiopian subsistence farming, fertilizer inputs are very expensive and mostly not affordable. Therefore, to minimize cost of production for resource poor farmers and environmental pollution and for developing sustainable rice production evaluation of rice genotypes for N use efficiency is necessary. The study aimed at investigating genetic variability in N use efficiency among upland rice genotypes, identifying genotypes with best N use efficiency and also assessing nature of association among N use efficiency and yield and yield related traits.

Methodology

The study area

The experiment was conducted at Woreta (13^{O} 19’ N and 37^{O} 03’E) located at an altitude of 1815 m above sea level in Fogera district of South Gondar Zone in 2009. Woreta receives an average annual rainfall of 1284.94 mm and the mean maximum and minimum temperatures during the main cropping season are 26.7 ^{O}C and 12.2 ^{O}C, respectively. The experimental site is characterized by a pH of 6.49, organic carbon of 3.4%, total N of 0.18%, available P of 21.2 mg kg^{-1} , CEC of 56.5 cmol(+) kg^{-1} soil and exchangeable K of 0.93 cmol(+) kg^{-1} soil.

Experimental materials and design

Twelve upland rice genotypes (six released varieties and six in pipelines) were used for this study. Genotypes were studied under two N fertilizer levels (0 and 64 kg N ha^{-1}) using a factorial randomized complete block design with three replications. Each plot had 6 rows of 20 cm apart and the gross plot area was 3.6 m^2 (1.2 m ×3 m) with harvestable plot size of 2.4 m^2 (0.8 m ×3 m). The space between blocks and plots was 1.5 m and 50 cm, respectively. The seed was drilled at the rate of 80 kg ha^{-1}. Nitrogen fertilizer, in the form of urea, was applied in three splits at planting, tillering and at panicle initiation 1/3 each. Phosphorus fertilizer in the form of TSP was uniformly applied to plots at the rate of 46 kg P_2O_5 ha^{-1} all at planting.

Data collection

Data on days to heading, days to flowering, days to maturity, plant height, panicle length, number of tillers per meter row, number of spikelets per panicle, number of filled spikelets per panicle, grain yield, thousand–kernel weight, biomass yield, harvest index, tissue N content, N harvest index and grain protein content were collected. Grain N (GNC) and straw N concentrations (SNC) were determined by Kjeldahl method: percentage of N was estimated using the formula: $\%N = \frac{(a-b)\times M \times 14}{SM} \times 100$; Where, %N = N content for grain and straw, a = Volume of HCl acid consumed in the titration of the sample, b = Volume of HCl acid consumed in the titration by the blank sample, M = molality of HCl, 14 = molecular weight of N, SM = sample mass. Then, grain protein content (GPC) in percent, grain N yield (GNY) in kg ha^{-1}, straw N yield (SNY) in kg ha^{-1}, biomass N yield (BNY) in kg ha^{-1} and N harvest index (NHI) in percent was calculated as follows: $\text{GPC} = \text{GNC} \times 5.13$, $\text{GNY} = \frac{(\text{GNC} \times \text{GY})}{100}$, $\text{SNY} = \frac{\text{SNC} \times (\text{BY} - \text{GY})}{100}$, BNY= (GNY+SNY), $\text{NHI}(\%) = \left(\frac{\text{GNY}}{\text{BNY}} \times 100\right)$; Where, GNC= grain N concentration (%), GY = grain yield (kg ha^{-1}), SNC = straw N concentration (%), BY = biomass yield (kg ha^{-1}). Then, applied N uptake efficiency (ANUPE; %), applied N utilization Efficiency (ANUTE; kg kg^{-1}N) and applied N use efficiency (ANUE; kg kg^{-1}N) were calculated as follows: $\text{ANUPE} = \left(\frac{\text{BNYf} - \text{BNY0}}{\text{Nf}}\right) \times 100$, $\text{ANUTE} = (\frac{\text{GYf} - \text{GY0}}{\text{BNYf} - \text{BNY0}})$, ANUE= $(\frac{\text{GYf} - \text{GY0}}{\text{Nf}})$ Where, BNYf = biomass N yield in N–fertilized plot (kg ha^{-1}), BNY0 = biomass N yield in non N-fertilized plot (kg ha^{-1}), Nf = N fertilizer applied (kg ha^{-1}), GYf = grain yield in N-fertilized plot (kg ha^{-1}), GY0 = grain yield in non-N fertilized plot (kg ha^{-1})

Statistical analysis

Analysis of variance (ANOVA) was performed using SAS (PROC GLM) (SAS, 2000). Mean separation was done using LSD comparison test. Variance component analysis was used to estimate coefficient of variability and broad sense heritability. Association of traits between N use efficiency traits and grain yield and yield related traits were determined following the correlation coefficient analysis using SAS software.

Variances, coefficient of variability and broad-sense heritability

The components of variance were determined following SAS system of analysis. Then, phenotypic variance (σ^2_{ph}) was obtained as: $\sigma^2_{ph} = \sigma_g^2 + \sigma^2_{gn}/n + \sigma^2_e/nr$: Where, σ_g^2 = genotypic variance, σ_{gn}^2 = G × N interaction component of variance, σ_e^2 = error variance, n = number of nitrogen levels, r = number of replications. Phenotypic (PCV) and genotypic (GCV) coefficients of variations were computed according to the method described by Hansen *et al.* (1956): $\text{PCV} = \frac{\sqrt{\text{phenotypic variance}}}{\text{population mean for the trait}} \times 100$, $\text{GCV} - \frac{\sqrt{\text{Genotypic variance}}}{\text{population mean for the trait}} \times 100$.

Heritability (H) in broad sense was estimated from the total genetic variance using the formula given by Falconer and Mackay (1996): $H(\%) = \frac{\sigma_g^2}{\sigma_{ph}^2} \times 100$; where, $\sigma_g^2 = genotypic\ variance$ and $\sigma_{ph}^2 = phenotypic\ variance$.

Results and discussion

Yield and yield related traits

Analysis of variance revealed significant differences among the genotypes for most of the traits considered ($p<0.05$) indicating presence of genetic variation among genotypes and possibility of manipulating these variations for improvement. This is in accordance with the previous reports on rice by Fageria and Barbosa Filho (2001), Sokat (2006) and Singh *et al.* (1998). The genotype by nitrogen (G×N) interaction component was not significant for all traits implying the performance of genotypes were independent of the levels of N fertilizer.

Grain yield of genotypes ranged from 2852.9 to 5437.7 kg ha^{-1} (Table 1). The highest grain yield was recorded from NERICA-3 followed by NERICA-4. These genotypes also have the highest number of filled spikelets per panicle (Table 1). This indicates that number of filled spikelets per panicle contributes for high grain yield performance. Similarly, Fageria and Baligar (1999) reported that filled spikelets per panicle and total grains per panicle were most important yield components in determining grain yield in rice genotypes, respectively. Harvest index of the genotypes varied from 15.36 to 39.64%. In the present study, harvest index seems to be important yield component as high yielding genotypes (NERICA-3, NERICA-4, IRGA370-38-1-1F-B1-1 and WAB450-11-1-1-P31-HB) had the highest harvest index (Table 1).

Table 1. Yield and yield related traits of 12 upland rice genotypes averaged across two N levels at Woreta in 2009.

Genotypes	DTH (days)	DTM (days)	PH (cm)	PL (cm)	NTMRL (No)	NETMRL (No)	NSPP (No)	NFSPP (No)	GY (kg ha^{-1})	TKW (g)	BY (kg ha^{-1})	HI (%)
NERICA-3	102.3	148.0	79.3	19.1	441.5	421.5	110.2	103.5	5437.7	25.0	16451	37.5
NERICA-4	102.7	149.8	84.5	19.1	511.3	486.3	115.3	107.2	5252.9	24.5	14224	39.6
Superica-1	107.7	160.0	91.4	18.7	409.3	353.3	101.7	78.8	4004	25.6	14104	28.6
Andassa (AD012)	118.2	170.7	99.1	20.1	389.3	328.0	100.0	73.1	3535.9	26.1	16264	20.8
Tana (AD048)	113.8	168.0	96.7	19.4	414.0	373.3	103.0	81.2	3104.3	26.2	17350	15.4
Getachew (AD01)	113.8	172.7	90.4	19.8	534.0	446.7	97.5	75.4	2852.9	24.8	12770	23.3
CNAX3031-15-2-1-1	103.0	161.0	79.6	18.1	454.7	420.7	101.7	80.1	3694.1	25.8	13606	27.7
IRGA370-38-1-1F-B1-1	101.0	154.3	75.4	17.9	426.7	371.3	91.3	72.1	5058	27.7	14938	37.8
WAB502-8-5-1	108.8	171.2	95.4	18.7	401.3	346.0	105.7	82.0	3026.9	29.5	12247	25.2
WAB450-11-1-1-P31-HB	105.5	166.0	95.2	20.2	407.3	374.7	118.0	88.5	5008.9	25.2	16323	31.1
WAB95-B-B-40-HB	106.7	165.3	97.8	19.2	430.0	383.3	100.0	76.5	4206.5	27.6	19330	24.0
WAB368-B-HI-HB	107.7	160.3	72.8	17.7	363.3	315.3	94.9	76.0	3053.8	31	12337	23.2
Mean	107.7	162.3	88.2	19.0	432.0	385.0	103.3	83.0	4019.7	26.6	14995.2	28.0
CV (%)	2.08	3.79	7.66	4.72	16.96	18.26	9.03	11.98	7.28	19.01	25.65	26.46
LSD (5%)	2.60	7.15	7.84	1.04	85.10	81.72	11.89	11.53	888.18	2.25	4470.9	8.57

DTH = Days to heading, DTM = Days to maturity, PH = Plant height, PL = Panicle length, NTMRL = Number of tillers per meter row length, NETMRL = Number of effective tillers per meter row length, NSPP = Number of spikeletes per panicle, NFSPP = Number of filled spikelets per panicle, GY = Grain yield, TKW = Thousand kernel weight, BY = Biomass yield and HI = Harvest index.

Nitrogen use efficiency and its component traits

Genotypic effects were significantly different for all N use efficiency and its component traits (<0.05) (Table 2). In the current study, wide ranges of mean values were recorded for grain N yield, straw N yield, biomass N yield and N harvest index (Table 2). Similar results were reported by Singh *et al.* (1998), Fageria *et al.* (2010) and Woldeyesus *et al*. (2004).

Higher and significant grain N concentration was obtained from NERICA-3, NERICA-4, Andassa, Tana and Getachew (Table 2). Grain protein content was the highest for NERICA-4 and lowest for CNAX3031-15-2-1-1. Genotypes showed significant differences in N harvest index with the overall mean of 49.53%. N harvest index of NERICA-3, NERICA-4, Superica-1, IRGA370-38-1-1F-B1-1 and WAB450-11-1-1-P31-HB were higher than the overall mean (Table 2). Rattunde and Frey (1986) reported that genetic variability for N harvest index exists within the small seeded genotypes and high N harvest index is associated with efficient utilization of N.

In this study, wide ranges of means were recorded for NUPE (21.87 to 48.43%), NUTE (21.46 to 53.40 kg kg^{-1} N) and NUE (8.71 to 31.87 kg kg^{-1}N) (Table 2). NERICA-3, NERICA-4, Andassa, Superica-1, WAB450-11-1-1-P31-HB and WAB95-B-B-40-HB had higher NUPE than the overall mean (Table 2). Of the tested genotypes, the highest nitrogen use efficiency was recorded for Superica-1 followed by Andassa, while NERICA-3 and NERICA-4 had relatively higher nitrogen use efficiency (Table 2).

Table 2. Nitrogen use efficiency and its component traits of 12 upland rice genotypes averaged across two N levels at Woreta in 2009.

Genotype	GNC (%)	GPC (%)	GNY (kg ha^{-1})	SNC (%)	SNY (kg ha^{-1})	BNY (kg ha^{-1})	NHI (%)	ANUPE (%)	ANUTE (kg kg^{-1}N)	ANUE (kg kg^{-1}N)
NERICA-3	1.77	9.06	96.85	0.59	65.17	162.01	62.33	34.87	49.92	22.89
NERICA-4	1.88	9.66	99.79	0.54	47.16	146.95	67.17	48.43	27.63	24.24
Superica-1	1.66	8.09	65.08	0.61	61.38	126.6	52.34	43.42	40.49	31.87
Andassa (AD012)	1.86	9.36	65.73	0.65	82.71	148.45	42.98	40.44	33.37	29.46
Tana (AD048)	1.81	9.27	56.01	0.67	90.7	146.71	36.27	31.25	23.93	17.25
Getachew (AD01)	1.78	9.11	51.36	0.66	65.34	116.7	44.15	30.16	21.46	13.98
CNAX3031-15-2-1-1	1.51	7.75	55.94	0.61	60.62	116.56	48.22	25.78	36.21	18.67
IRGA370-38-1-1F-B1-1	1.59	8.09	80.61	0.73	69.15	149.75	54.95	25.43	32.33	8.71
WAB502-8-5-1	1.64	8.39	49.85	0.59	54.26	104.1	47.68	29.53	22.79	11.95
WAB450-11-1-1-P31-HB	1.57	8.04	78.54	0.62	69.76	148.3	51.99	34.40	35.6	15.39
WAB95-B-B-40-HB	1.62	8.06	68.08	0.68	98.09	166.21	44.16	37.50	27.53	17.46
WAB368-B-HI-HB	1.51	7.78	46.1	0.69	66.5	112.6	42.08	21.87	53.4	18.97
Mean	1.68	8.55	67.83	0.64	69.23	137.08	49.53	33.61	33.72	19.24
CV (%)	10.84	11.43	19.28	18.89	32.58	21.18	17.75	27.13	30.15	28.82
LSD (5%)	0.21	1.36	15.2	0.14	26.22	33.74	10.22	18	17.21	9.39

GNC= grain N concentration, GPC= grain protein content, SNC= straw N concentration, GNY=grain N yield, SNY= straw N yield, BNY= biomass N yield, NHI= N harvest index, ANUPE= applied N uptake efficiency, ANUTE= applied N utilization efficiency, and ANUE= applied N use efficiency.

Genotypic and phenotypic coefficient of variations

Genotypic and phenotypic coefficients of variation are used to measure the variability that exists in a given population (Burton and Devane, 1953). As indicated in Table 3, genotypic coefficient of variation (GCV) was less than its corresponding estimates of phenotypic coefficient of variation (PCV) for all traits indicating significant role of environment in the expression of these traits. The difference between PCV and GCV was wide for the three N use efficiency traits, biomass N yield and number of filled spikelets per panicle. For the other traits, however, both the environment and genetic component are nearly equally important for the depiction of phenotypes (Table 3). Khan *et al*. (2009) reported on rice genotypes that PCV values were higher than GCV values for all important traits considered.

Heritability

In the present study, broad-sense heritability estimates for the 22 traits ranged from 40.37% to 99.42% (Table 3). Dabholkar (1992) generally classified heritability estimates as low (5-10%), medium (10-30%) and high (30-60). Based on this classification, almost all traits under this study exhibited high to very high heritability estimates (Table 3). Similar result was reported by Woldeyesus *et al*. (2004) on barely genotypes and by Alemayehu *et al*. (2006) on tef genotypes that broad-sense heritability estimates were higher for grain yield, grain N yield, biomass N yield and nitrogen harvest index and for N use efficiency traits.

Correlation

Improvement for a trait of interest can be achieved by selection through other traits that are more heritable and easy to select. It, therefore, requires understanding the interrelationship of the other traits among themselves and with traits of interest. In this study, significant and positive correlations were observed for grain N concentration with days to heading (r = 0.36), days to flowering (r = 0.33) and for grain protein content with days to heading and days to flowering (r = 0.340 (Table 4). On the other hand, grain N yield had significant and negative correlation with days to heading (r = -0.48) and days to maturity (r = -0.67). Grain N yield showed significant and positive correlation with grain yield (r = 0.93), biomass yield (r = 0.44) and with harvest index (r = 0.58) (Table 4). In agreement to this, Samonte *et al*. (2006) reported significant and positive correlation between grain N yield and grain yield (r = 0.49). The present study revealed that correlations between grain yield and N use efficiency traits were positive and very weak (Tables 4). However, positive and very weak correlation between grain yield and N use efficiency traits may not prevent concurrent improvement of these traits.

Table 3. Estimate of mean, range, variance components, coefficients of variation and heritability in the broad sense of various trait in 12 upland rice genotypes grown under two N levels at Woreta in 2009.

Trait	Mean± SE	Range	σ_g^2	σ^2_{ph}	GCV	PCV	H
DTH	107.67 ±1.29	101.67-118.16	27.3800	28.6904	4.86	4.98	95.43
DTM	162.28 ±3.55	148-172.67	63.4100	67.7880	4.9	5.07	93.54
PH	88.16 ±3.89	72.82-99.05	78.9100	87.6950	10.1	10.6	89.98
PL	18.98 ±0.52	17.25-20.15	0.4900	0.6833	3.7	4.4	71.71
NTMRL	431.9 ±42.28	363.33-534	1705.7000	2386.9583	9.6	11.3	71.46
NETMRL	385.04±40.60	315.33-446.67	1944.0000	2521.2733	11.5	13	77.10
NSPP	103.25±5.91	91.32-118.03	42.5000	62.8033	6.3	7.7	67.67
NFSPP	82.85 ±5.73	71.33-88.53	109.6500	130.3050	1.26	13.8	84.15
TKW	26.58 ±1.12	24.53-30.87	3.2600	3.8611	6.79	7.39	84.43
GY	4019.66 ±441.3	2852.9-5437.7	8666033.8	8716464.95	73.24	73.44	99.42
BY	14995.2± 2221.1	12247-19330	2412843.2	4792916.17	10.36	14.59	50.34
HI	27.97 ±4.26	15.36-39.64	50.5500	55.4013	25.51	26.71	91.24
GNC	1.68± 0.10	1.51-1.88	0.0124	0.0172	6.63	7.8	72.16
GPC	8.55 ±0.57	7.73-9.66	0.3892	0.4772	7.29	8.08	81.56
SNC	0.64 ±0.07	0.54-0.73	0.0011	0.0027	5.18	8.07	41.25
GNY	67.83 ±7.55	46.1-99.79	296.6370	318.3098	25.39	26.3	93.19
SNY	69.23± 13.03	47.16-98.09	155.4900	214.7335	18.01	21.17	72.41
BNY	137.01±16.76	104.1-166.21	355.8700	428.8265	3.76	15.11	82.99
NHI	49.53 ± 5.08	36.26-67.16	69.0208	77.7868	16.77	17.81	88.73
ANUPE	60.97±13.50	30.76-88.32	269.9100	543.3900	26.95	38.23	49.67
ANUTE	33.72±8.30	21.46-53.4	69.9500	173.2900	24.80	39.04	40.37
ANUE	19.14±4.53	8.71-3.87	36.6700	67.4100	31.47	42.62	54.40

SE = standard error of the mean, σ_g^2= genotypic variance, $\sigma^2_{ph=}$ phenotypic variance, GCV= genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, H = Heritability in the broad sense, DTH = Days to heading, DTM = Days to maturity, PH = Plant height, PL = Panicle length, NTMRL = Number of tillers per meter row length, NETMRL = Number of effective tillers per meter row length, NSPP = Number of spikeletes per panicle, NFSPP = Number of field spikeletes per panicle, TKW = 1000 kernel weight, GY = Grain yield, BY = Biomass yield, HI = Harvest index, GNC = Grain nitrogen concentration, GPC = Grain protein content, SNC = Straw nitrogen concentration, GNY = Grain nitrogen yield, SNY = Straw nitrogen yield, BNY = Biomass nitrogen yield, NHI = Nitrogen harvest index, ANUPE = Applied uptake efficiency ANUTE = Applied utilization efficiency, ANUE = Applied nitrogen use efficiency

Table 4. Phenotypic correlation coefficients between yield and yield related and nitrogen use efficiency and its component traits in twelve upland rice genotypes grown under two nitrogen levels at Woreta during 2009 main cropping season.

Trait	DTH	DTM	PH	PL	NTMRL	NETMRL	GY	BY	HI
GNC	0.360*	0.005	0.08	0.09	0.05	-0.005	-0.05	0.17	-0.17
SNC	0.14	0.111	0.01	0.14	0.102	0.09	-0.19	0.11	-0.23
GP	0.34*	0.02	0.06	0.09	0.12	0.08	-0.05	0.15	-0.18
SNY	0.29	0.22	0.48**	0.46**	-0.06	-0.05	0.005	0.81***	-0.61***
GNY	-0.48**	-0.670***	-0.23	-0.19	-0.03	0.03	0.93***	0.44**	0.58**
BNY	-0.13	-0.33	0.04	0.07	0.003	0.05	0.60***	0.62***	0.09
NHI	-0.61***	-0.680***	-0.52**	-0.49**	0.05	0.09	0.65***	-0.3	0.93***
ANUPE	0.36	0.09	0.24	0.09	0.21	0.16	0.09	-0.04	-0.05
ANUTE	-0.20	-0.23	-0.39*	0.22	-0.42	-0.34	0.03	0.07	-0.05
ANUE	0.20	-0.12	-0.07	-0.14	-0.21	-0.18	0.06	0.03	-0.04

*, **, and *** significant at 0.05, 0.01 and 0.001 probability levels, respectively. DTH = Days to heading, DTM = Days to maturity, PH = Plant height, PL = Panicle length, NTMRL = Number of tillers per meter row length, NETMRL = Number of effective tillers per meter row length, GY = Grain yield, BY = Biomass yield, HI = Harvest index, TKW = 1000 kernel weight, GNC = Grain nitrogen concentration, SNC = Straw nitrogen concentration, GPC = Grain protein content, SNY = Straw nitrogen yield, GNY = Grain nitrogen yield, BNY = Biomass nitrogen yield, ANUPE = Applied uptake efficiency, ANUTE = Applied utilization efficiency, ANUE = Applied nitrogen use efficiency, NHI = Nitrogen harvest index.

Conclusion and recommendation

Highly significant variations among genotypes for yield and yield related traits and for N uses efficiency traits were observed in the current study. NERICA-3 and NERICA-4 were genotypes with high mean values for grain yield, number of filled spikelets per panicle, harvest index, grain N concentration and N harvest index. Nitrogen use efficiency was highest for Superica-1, Andassa, NERICA-4, and NERICA-3. Phenotypic coefficient of variation (PCV) and genotypic coefficients of variation (GCV) values were very high for grain yield, harvest index, N use efficiency, utilization efficiency, uptake efficiency and N harvest index. Heritability estimates were very high for grain yield, days to heading, days to maturity, harvest index and grain N yield. Grain yield had significant and positive correlations with grain N yield and N harvest index.

The information generated from this study has significant insinuation in nitrogen use efficiency variability. However, the findings of this study were based on one location and one cropping season data on limited number of genotypes. Therefore, further investigations using more diverse locations and more number of genotypes is essential to generate reliable and conclusive information on genetic variability in nitrogen use efficiency of upland rice genotypes and identify nitrogen efficient genotypes for use in the breeding program or for commercial production.

References

Alemayehu, B., R. Gretzmacher and Johann Vollman. 2006. Genetic variation in nitrogen-use efficiency of tef. *Journal of Plant Nutrition and Soil Science*, 169:704-710.

Burton, G.W. and E. H. Devane. 1953. Estimating heritability in tall Fescue (*Festuca arundinacea*) from replicated clonal materials. *Agronomy Journal*, 45:487-488.

Dabholkar, A. R. 1992. Elements of biometrical genetics. Concept Publishing Company, New Delhi, India. 431p.

Fageria, N. K. and V. C. Baligar. 1999. Yield and yield components of lowland rice genotypes as influenced by timing of nitrogen fertilization. *Journal of Plant Nutrition,* 22:23-32.

Fageria, N. K., and M. P. Barbosa Filho. 2001. Nitrogen use efficiency in lowland rice genotypes. *Community of Soil Science, Plant Analysis*, 32(13&14): 2089-2089.

Fageria, N.G., O.P.D.Morais and A.B. D Santos. 2010. Nitrogen Use efficiency in Upland Rice Genotypys. *Journal of plant Nutrition*. 33: 1696-1711.

Falconer, D.S., T. F. C. Mackay. 1996. Introduction to Quantative Genetics. 4th ed., Longman Group Limited, Malaysia.

International Year of Rice. 2004. ''Rice and Us'' fact sheet. http://www.fao.Org/ag/ irc/default.htm. Accessed in April, 2008.

Khan, A. S., M.Imran and M. Ashfaq. 2009. Estimation of genetic variability and correlation for grain yield components in rice. *American-Eurasian Journal of Agriculture and Environmental Science* 6(5):585-590.

Koutroubas, S. D., and D. A. Ntanos. 2003. Genotype differences for grain yield and nitrogen utilization in indica and japonica rice under Mediterranean conditions. *Field Crops Research*, 83:251–260.

Lee, H. J., S. H.Lee and J. H.Chung. 2004. Variation of Nitrogen Use Efficiency and its Relationships with Growth Characteristics in Korean Rice Cultivars. *Proceedings of the 4th International Crop Science Congress*. Brishane, Australia, 26 Sep-1Oct.2004.

Moll, R. H., E. J. Kamprath, and W.A. Jackson.1982. Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization. *Agronomy Journal,* 74: 562-564.

Samonte, S. O. P. B., T. W. Lioyd, C. M. James, R. M. P. Shannon, M. M. C. Anna and S.L. Joveno. 2006. Nitrogen Utilization Efficiency: Relationships with Grain Yield, Grain Protein, and Yield-Related Traits in Rice. *Agronomy Journal,* 98:168-176.

SAS Institute. 2000. The SAS system for windows, V.8.1. SAS Institute, Carry, NC, USA.

Singh U., J. K. Ladha, E.G.Castillo, G.Punzalan, A.Tirol-Padre, and M. Duqueza. 1998. Genotypic variation in nitrogen use efficiency in medium and long duration rice. *Field Crops Res*earch, 58: 35-53.

Sokat Yiech. 2006. Nitrogen uptake and yield responses of rainfed rice (*Oryza sativa* L.) varieties to fertilizer N on fluvisols of Gambella region. An Msc Thesis presented to the School of Graduate Studies of Haramaya University, Ethiopia.

Watanabe, Y.1997. Phenology and geographical distribution of genus oryza. In: "Science of the rice plant". pp.29-39. Food and Agricultural policy Research Centre, Tokyo.

Woldeyesus Sinebo, R.Gretzmacher and A.Edelbauer, 2004. Genotypic variation for nitrogen use efficiency in Ethiopian barely. *Field Crops Research*, 85: 43-60.

Genotype by environment interaction and adaptability of upland rice varieties in northweatern Ethiopia

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Abstract

Rice is commonly characterized as a semi aquatic crop and well adapted to submerged anaerobic soil culture. There are also varieties adapted to dry land culture on aerobic soils like any other cereal crops. This type of rice variety is called upland rice and it is one of the main staple food crops in inter-tropical highland areas of the world. Nine upland rice genotypes were tested at three different locations in randomized complete block design with three replications in north western Ethiopia to estimate the magnitude of genotype by environment interactions and the adaptability performance of upland rice varieties during 2008 main cropping season. The combined analysis of variance revealed highly significant differences ($P<0.01$) among genotypes and environments for grain yield, number of spikelets per plant, days to heading and maturity and above ground biomass yield. Getachew (5655 kg ha^{-1}), Andasa (5505 kg ha^{-1}), NERICA-4 (5296 kg ha^{-1}) and NERICA-3 (5263 kg ha^{-1}) were genotypes which gave high mean grain yield across locations whereas the early maturing (104 day) genotype, NERICA-10 (3934 kg ha^{-1}) was the least yielding. The AMMI1 biplot showed that genotypes Superica-1 and Getachew were specifically adapted to Metema and Pawe areas, and NERICA-4 and Andasa were specifically adapted to Woreta area whereas NERICA-3 was adapted to all locations. However, further study is required on multi-locations for a number of years to generate confidential information that enables appropriate recommendations to be made.

Introduction

Rice belongs to the genus *Oryza* and most probably originated in India or south eastern Asia. It is the world's second most important cereal crop next to wheat. Rice is commonly characterized as a semi aquatic crop and well adapted to submerged anaerobic soil culture (Stoskopf, 1985). There are also varieties adapted to dry land culture on aerobic soils like any other cereal crops. These types of rice varieties can be defined as rice grown on both flat and sloping fields that are not bunded and called upland or dry land rice variety (IRRI, 1975). Upland rice is one of the main staple food crops in inter-tropical highland areas and much of the future expansion of the world's rice land will probably be in upland rice because most of the land suited to irrigated paddy culture is already allotted to lowland rice.

Eventhough, rice was introduced and tested initially in different areas of Ethiopia such as Gambella, Pawe, Woreta in the beginning of 1970s, due attention was not given prior to the mid 1990s (Wolelaw, 2005). At present, rice is becoming an important crop in the country and it is the first by the average productivity (2.9 t ha^{-1}) among cereals (CSA, 2008) followed by maize (2.1 t ha^{-1}). Since the mid of 1990s, however, about 10 upland rice varieties including four NERICA varieties have been released. Currently, the released varieties, especially NERICAs, have been under dissemination and expansion in diverse agro-ecologies of the country from lowlands of 750 m a.s.l to areas of about 2000 m a.s.l elevations by different governmental and non-governmental organizations. However, there is no sufficient information on the genotype by environment interaction effects and adaptability performance of varieties for specific locations. Therefore, this experiment was executed to estimate the magnitude of genotype by environment interactions and adaptability performance of upland rice varieties for specific and multi locations.

Materials and methods

Field experiment was conducted on nine upland rice genotypes (Kokit (IRAT-209)), NERICA-3, NERICA- 4, Superica-1, Getachew (AD-01), Andasa (AD-012),NERICA-1, NERICA-10 and Tigabe (IREM-194)) in north western Ethiopia at Metema, Pawe and Woreta during 2008 main cropping season. The design was randomized complete block design with three replications. Each experimental plot had a total area of 6 m^2 (1.2 m x 5 m) with six rows at 0.2 m interval. There was a 0.5 m distance between two consecutive plots within a replication. Seeds were sown in rows with manual drilling at a rate of 60 kg ha^{-1}. The fertilizer application was at a rate of 64/46 kg ha^{-1} N/P_2O_5. Nitrogen was applied three times in the form of urea. All P_2O_5 and one-third N were applied during planting. The second and the third one-third splits were applied at tillering and at panicle initiation stages, respectively. Data were collected on plot and plant basis. The data on plot basis were taken from the central four rows i.e., number of days to head and mature. The number of tillers per plant, number of effective tillers per plant, number of spikelets per panicle, panicle length and plant height were taken on the main tiller of five plants. The grain yield of each plot was taken after final cleaning, adjusted to 14% moisture level and then converted into kg ha^{-1}. Finally, the collected data were analyzed using different statistical software packages and some data were transformed using square root to stabilize coefficient of variation. Genstat (2007) and IRRISTAT (2005) were used for additive main effect and multiplicative interaction (AMMI) analysis and plotting genotype and environment means over the IPCA values, respectively.

Results and discussion

The AMMI analysis showed that there were significant differences among genotypes and environments for yield and yield related traits (Table 1). The highly significant genotype differences among these upland rice genotypes could be due to differences in their genetic make up and diverse nature of origins. Getachew, Andasa, NERICA-4 and NERICA-3 gave higher mean grain yield across locations whereas NERICA-10, NERICA-1, Kokit and Tigabe produced grain yield below the grand mean (Table 2). Locations differed in their grain yield potentioal ($P<0.01$). The average grain yield across locations was 4899 kg ha^{-1}. The highest mean grain yield was recorded at Metema (5305 kg ha^{-1}) followed by Pawe (5040 kg ha^{-1}). At Woreta, grain yield (4351 kg ha^{-1}) was recorded below the grand mean (Table 3).

Table 1. AMMI analysis of variance for grain yield (kg ha^{-1}) of upland rice genotypes tested at three locations during 2008 main cropping season.

Sources of variation	Degree of freedom	Sum of squares	Mean squares	Sum of square explained	
				% total	% GxE
Environment	2	13097169	6548584**	18.55	
Rep.within E	6	922013	153669		
Genotype	8	26494041	3311755**	37.53	
GxE	16	23382054	1461378**	33.12	
IPCA 1	9	21795675	2421742**	30.87	93.22
IPCA 2	7	1586379	226626^{ns}	2.25	6.78
Error	48	6700999	139604		
Total	80	70596276			
Grand Mean = 4898.92			CV (%) = 7.6		

*and ** = significant difference at $P<0.05$ and $P<0.05$, respectively. ns- non significant difference, GxE = Genotype by environment interaction, IPCA = Interaction principal component axis.

The number of tillers per plant was high at Woreta and relatively low at Metema and Pawe whereas for the number of spikelets per panicle and thousand kernels weight the reverse was noted. At Woreta, the relatively high number of tillers per plant, the lower number of spikelets per panicle and small thousand kernel weight was because of the scarcity of rainfall for some days starting from the beginning of September in which most genotypes could start to initiate panicles and flowers. Early stress during vegetative growth can interrupt floret initiation while drought during flowering causes spikelet sterility and terminal drought influences grain filling rate (Botwright *et al.*, 2008). Saini and Westgate (2000) have also underlined that water stress during flower initiation in cereals slows the rate of floral development, leading to a delay or even a complete inhibition of flowering.

AMMI analysis for grain yield

The additive main effects and multiplicative interaction analysis of grain yield showed that all the components of the treatment combination, namely environment, genotype, and genotype by environment interaction were highly significant (P<0.01) and accounted for 18.55%, 37.53%, and 33.12% of the total sum of squares, respectively. Most of the total sum of squares of the model (56.08%) was attributed to the main effects of environment and genotype, while 33.12% was found to be for the interaction effect (Table 1). Similar results of large main effects (60.30%) were also reported for upland rice varieties by Lafitte and Courtois (2002). The interaction sum of squares was partitioned into the interaction principal component axes (IPCA 1 and IPCA 2) but it was for the first IPCA that its mean square was highly significant with 9 degrees of freedom. These IPCAs explained 93.22% and 6.78% percent of the interaction sum of squares, respectively. The mean square of the second IPCA was not significant and it was treated as an AMMI residual.

Table 2. Grain yield and yield related traits of upland rice genotypes tested at three locations during 2008 main cropping season.

Genotypes	GY	DH	DM	PL	PH	NTPP	NETPP	NSPP	BY	HI	TKW	HLW
Kokit	4477	82.1	112.1	21.3	94.6	8.9 (3.05)	8.4 (2.96)	113.1 (10.6)	10094	44.3	30.5	54.3
NERICA-3	5264	81.8	111	21.8	96.4	9.5 (3.2)	8.6 (3.0)	154.4 (12.4)	10979	48.0	25.9	55.6
NERICA-4	5296	82.4	113.1	21.3	95.5	9.9 (3.2)	9.1 (3.1)	131.1 (11.4)	11778	45.3	26.7	56.1
Superic-1	5040	86.6	115.2	21.6	103.3	9.1 (3.1)	8.6 (3.0)	143.8 (11.9)	12344	40.7	28.1	55.1
Getachew	5655	87.3	115.4	23.4	115.2	10.0 (3.2)	9.3 (3.1)	138.7 (11.7)	12835	44.1	28.9	55
Andasa	5505	94.1	119.4	25	124.2	9.6 (3.2)	8.6 (3.0)	143.0 (12.0)	15268	36.4	27.1	53.8
NERICA-1	4145	82	111.2	22.1	90.3	8.4 (3.0)	7.7 (2.8)	130.9 (11.4)	9791	42.2	27.5	56
NERICA-10	3934	73	104.2	22	95.1	8.4 (3.0)	7.7 (2.8)	141.5 (11.7)	10867	34.9	26.3	53.2
Tigabe	4776	83.1	109.9	21.6	97.8	9.7 (3.16)	9.0 (3.0)	119.0 (10.8)	10342	46.4	31.6	53.1
Mean	4899	83.6	112.4	22.2	101.3	9.2 (3.1)	8.5 (3.0)	135.1 (11.5)	11589	42.5	28.1	54.7
CV (%)	7.6	1.4	0.5	5.1	17.4	8.2	8.4	6.9	6.6	5.6	5.3	3.3
SE±	124.55	0.39	0.21	0.49	1.72	0.084	0.083	0.265	255.2	0.79	0.5	0.61
LSD (5%)	354.11	1.105	0.59	1.38	4.9	0.24	0.237	0.753	725.69	2.25	1.42	1.73

GY = Grain yield, DH = Days to heading, DM = Days to mature, PL = Panicle length, PH = Plant height, BY = Biomass yield, HI = Harvest index, TKW = Thousand kernel weight, HLW = Hectoliter weight, NTPP = Number of tillers per plant, NETPP = Number of effective tillers per plant, NSPP=Number of spikelets per panicle. Numbers in parentheses are mean values for square root transformed data.

Table 3. Mean values for grain yield and yield related traits of upland rice genotypes over three locations in 2008.

Location	GY	DH	DM	PL	PH	BY	HI	TKW	HLW	NTPP	NETPP	NSPP
Metema	5305	76.93	97.41	24.34	114.19	11777.9	45.43	28.29	54.08	9.06 (3.07)	8.42(2.98)	166.4(12.85)
Pawe	5040	77.56	107.00	21.05	101.79	5040.0	42.69	28.91	55.19	7.29 (2.78)	6.12(2.56)	111.8(10.50)
Woreta	4351	96.33	132.82	21.29	88.14	10972.2	39.3	26.99	54.82	11.5 (3.45)	11.01(3.38)	127(11.26)
Mean	4899	83.61	112.41	22.23	101.37	9263.37	42.47	28.06	54.7	9.28 (3.10)	8.52(2.97)	135.06(11.53)
CV (%)	7.6	1.4	0.5	6.6	5.1	6.6	5.6	5.3	3.3	8.2	8.4	6.9
SE±	71.91	0.224	0.119	0.281	0.994	147.357	0.457	0.288	0.351	0.049	0.048	0.048
LSD (5%)	204.45	0.638	0.338	0.798	2.827	419.01	1.30	0.818	0.998	0.138	0.137	0.435

GY = Grain yield, DH = Days to heading, DM = Days to mature, PL = Panicle length, PH = Plant height, BY = Biomass yield, HI = Harvest index, TKW = Thousand kernel weight, HLW = Hectoliter weight, NTPP = Number of tillers per plant, NETPP = Number of effective tillers per plant, NSPP=Number of spikelets per panicle.

The environment and the genotype means were plotted against the first IPCA which helped in the interpretation of the interaction effects among genotypes and environments and in the assessment of the adaptability of genotypes (Fig. 1).

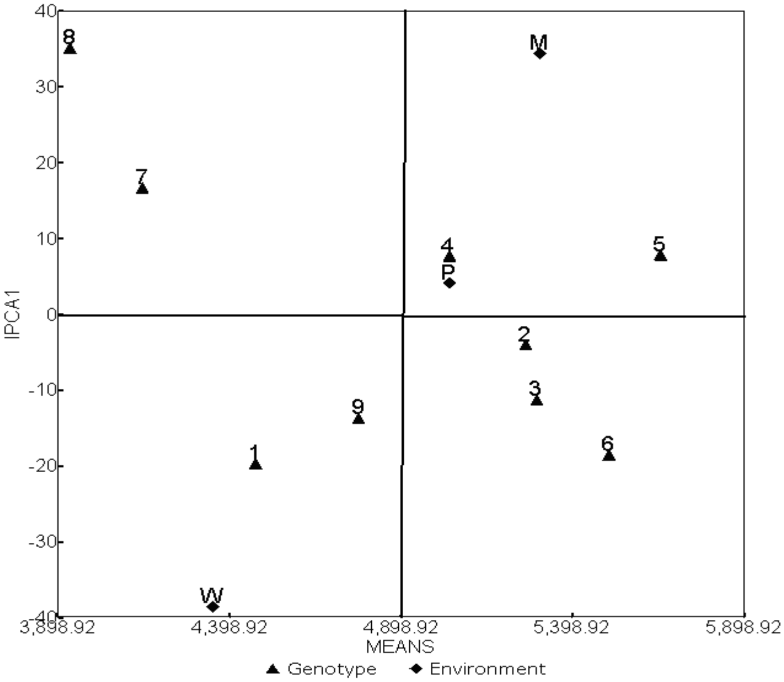

Fig. 1. AMMI1 biplot for grain yield (kg ha^{-1}) of upland rice genotypes tested at three locations in 2008.

Designations: 1-9 for genotypes and letters in upper cases for locations where: 1-kokit, 2=NERICA-3, 3=NERICA-4, 4=Superica-1, 5=Getachew, 6=Andasa, 7=NERICA-1 8=NERICA-10, 9=Tigabe, M- Metema, P- Pawe and W-Woreta. IPCA- interaction principal component axis, AMMI- additive main effect and multiplicative interaction

In the AMMI1 biplot, if genotypes have a zero or nearly zero IPCA 1 scores, then they are stable across their testing sites. If a genotype is farther from zero, it is highly responsive and does not perform consistently across environments (Samonte *et al.*, 2005)**.** If a genotype and an environment have similar signs on the principal component axis, then the interaction between them is positive and this genotype is well adapted to this environment. However, if they have opposite sign of IPCA 1 scores, their interaction is negative and the environment is not favorable to this genotype (Crossa *et al.*, 1990; Zobel *et al.*, 1988). In the AMMI1 biplot

(Fig. 1), there were differences among genotypes both for the interaction effects and mean grain yields i.e., the variation for main effect (mean grain yield) and interaction effect could be simply read across the abscissa and the ordinate, respectively. There were also differences among the locations for both cases.

Woreta was different from other locations in both the interaction and for the main effects. It had mean grain yield below the grand mean and negative score while the other two locations possessed positive environment scores (Table 4) and mean grain yield above the grand mean. Location Pawe had near zero environmental score when compared with others and then it had relatively small interaction effects indicating that it was suitable for the performance of all genotypes. The near zero genotype scores for genotypes NERICA-3, Superica-1 and Getachew were also an indication of their adaptability, particularly NERICA-3, to the three location regardless of the environmental effect.

Table 4. Mean grain yield (kg ha^{-1}) and environment and genotype IPCA 1 scores for nine upland rice genotypes tested at three locations in 2008.

No.	Genotypes	Locations			Genotype	
		Metema	Pawe	Woreta	Mean	IPCA 1
1	Kokit	4166	4599	4665	4476	-19.73
2	NERICA-3	5452	5527	4812	5264	-3.97
3	NERICA- 4	5376	5283	5228	5296	-11.28
4	Superica-1	5729	5186	4205	5040	7.73
5	Getachew	6447	5630	4889	5655	7.8
6	Andasa	5189	5707	5618	5505	-18.6
7	NERICA-1	4888	4760	2785	4144	16.69
8	NNERICA-10	5638	4068	2095	3934	35.07
9	Tigabe	4863	4601	4865	4776	-13.7
Env.	Mean	5305	5040	4351	4899	
	IPCA 1	34.44	4.18	-38.62		

*and ** denote significant and highly significant differences at P<0.05 and P<0.001, respectively, ns denotes non significant difference. GxE = Genotype by environment interaction, IPCA = Interaction principal component axis, and Env. = Environment.

Similar sign for IPCA 1 scores of the genotypes Superica-1 and Getachew and locations Metema and Pawe implied that their interaction was positive and the higher yields of these genotypes were found in particular at these locations. These two genotypes scored mean grain yield above the grand mean and hence they were found to be the best adapted genotypes for Metema and Pawe. These locations were again considered as the favorable environments for these two genotypes.

The genotypes Kokit, NERICA-4, Andasa and Tigabe and Woreta had positive interaction effects as they all owned similar (negative) IPCA 1 scores indicating that these genotypes performed well at Woreta. Genotypes NERICA-4 and Andasa had mean grain yield above the grand mean and they were found to be suitable for Woreta.

Conclusion and recommendation

There were significant differences among rice genotypes and locations for grain yield and other traits. The first IPCA of the AMMI analysis explained large portion of the interaction sum of squares (93.22%). The plotting of environment and genotype means against the first IPCA for grain yield helped in the interpretation of the interaction effects among genotypes and environments as well as the adaptability of the genotypes. Getachew, Andasa, NERICA-4 and NERICA-3 were the genotypes with high mean grain yield across locations. Among locations, the highest mean grain yield (5305 kg ha^{-1}) was recorded at Metema followed by at Pawe (5040 kg ha^{-1}). NERICA-3 had less response to all locations indicating that it was widely adapted genotype. Metema was found to be the most favorable environment for genotypes Superica-1 and Getachew. On the other hand, Woreta was found to be favorable to NERICA-4 and Andasa. This study gave an insight for consideration of the dissemination of upland rice varieties to different agro-ecologies of the country since the upland rice genotypes were found to have different responses to the environments considered. However, further study is required on multi-locations for a number of years to generate confidential information that enables appropriate recommendations to be made.

References

Botwright, A.T.L., H.R. Lafitte and L.J. Wade., 2008. Genotype x Environment Interactions for Grain Yield of Upland Rice Backcross Lines in Diverse Hydrological Environments. *Field Crops Research.108:117-125.*

Crossa, J., H.G. Gauch and R.W. Zobel, 1990. Additive Main Effect and Multiplicative Interaction Analysis of Two International Maize Cultivar Trials. *Crop Sci. 30:493-500.*

CSA (Central Statistical Authority), 2008. Agricultural Sample Survey Report on Area and Production for Major Crops. The FDRE Statistical Bulletin 302. Addis Ababa, Ethiopia.

GenStat, 2007. Release 7.2 DE (PC/Windows XP). Lawes Agricultural Trust (Rothamsted Experimental Station)

IRRI, 1975. Major Research in Upland Rice. Los Banos, Philippines.

IRRI, 2005. IRRISTAT 5.0 for Windows. Biometerics Units, Los Banos, Philippines.

Lafitte, H.R. and B. Courtois, 2002. Interpreting Cultivar x Environment Interactions for Yield in Upland Rice: Assigning Value to Drought-Adaptive Traits. *Crop Sci.* 42:1409-1420.

Samonte, S.O.P.B., L.T. Wilson, A.M. McClung and J.C. Medley, 2005. Targeting Cultivars onto Rice Growing Environments Using AMMI and SREG GGE Biplot Analyses**.** *Crop Sci. 45:2414-2424.*

Saini H.S. and M.E. Westgate, 2000. Reproductive Development in Grain Crops during Drought. *Advances in Agron. 68:59-96.*

Stoskopf, N. C., 1985. Cereal Grain Crops. Reston Publishing Company, Inc., A Prentice Hall Company, Reston, Virginia, USA.

Wolelaw S., 2005. Factors Determining Supply of Rice: A Study in Fogera District of Ethiopia. Msc. Thesis. Haramaya University, School of Graduate Studies. Haramaya, Ethiopia.

Zobel, R.W., M. J. Wright, and H. G. Gauch, 1988. Statistical Analysis of a Yield Trial. Agron. J. 80:388–393.

Yield stability and Genotype x Environment interactions in rice *(Oryza sativa* L.*)* genotypes in northwestern Ethiopia

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Abstract

Rice is a recent introduction in Ethiopia. However, recognizing its importance as a food security crop, source of income and job opportunities, the government of Ethiopia has named it the “millennium crop” and has ranked it among the priority commodities of the country. Variety development is one of the key research components to bring sustainable production. Accordingly**,** 16 rainfed lowland rice genotypes were evaluated at three locations of eight environments in northwestern Ethiopia from 2006 to 2008 to identify stable and high yielding genotypes. The experiment was conducted using randomized complete block design with three replications. Combined analysis of variance showed highly significant differences among genotypes, environments and genotype by environment interactions for grain yield. The additive main effects and multiplicative interaction (AMMI) analysis of variance indicated that the genotype by environment interaction (GEI) sum of squares was about 3.5 times larger than that for genotypes, which determined substantial differences in genotypic response across environments. The presence of GEI was clearly demonstrated by the AMMI model, when the interaction was partitioned among the first four interaction principal component axis (IPCA) which cumulatively captured 91.13% of the total GEI. The stability study indicated that among GEN13,GEN12,GEN10 and GEN9, no variety was found to be stable. In this study, environments fell in to three sections where most of the tested genotypes showed specificity. Among the tested genotypes, the highest grain yield was obtained from GEN13, GEN12 and GEN9, respectively across environments. These genotypes were selected and verified, of which GEN9 has been officially released for large scale production with the breeder name “EDGET”.

Key words: AMMI, GEI, rice, stability.

Introduction

Among the target commodities that have received due attention in promotion of agricultural production, rice is considered as the “millennium crop” expected to contribute in ensuring food security in Ethiopia (MoARD, 2010). Though introduced recently, the importance of rice is being recognized well both by the Government and different stakeholders as the crop is treated as one of the major national research projects, the trend of area coverage and total production is on the increase, the number of smallscale farmers and private investors involving in production and processing and the request for improved rice varieties is increasing.

Variety development is one of the major research focuses of the national rice research project. The general rice breeding scheme includes evaluating a number of genotypes at various stages and testing selected ones at several locations. The multi-locational testing however, usually results in genotype-by-environment (GxE) interactions that often complicate the interpretation of results obtained and reduce efficiency in selecting the best genotypes (Mosavi *et al*., 2013).

Information on genotype x environment interaction leads to successful evaluation of stable genotype , which could be used for general cultivation. Yield is a complex quantitative character and is greatly influenced by environmental fluctuations; hence, the selection for superior genotypes based on yield per se at a single location in a year may not be very effective (Sheathe *et al*., 2012). Thus , evaluation of genotypes for stability of performance under varying environmental conditions for yield has become an essential part of any breeding program.

Several methods have been proposed to analyze genotype x environment interactions and phynotypic stability. These methods can be divided in to two major groups: univariate and multivariate stability statistics. A combined analysis of variance can quantify the interactions and describe the main effects. However, it is uninformative for explaining GEI. Among multivariate methods, the additive main effect and multiplicative interaction analysis (AMMI) has been extensively applied in the statistical analysis of multi-environment cultivar trials (Gauch and Zobel, 1997; Sanni *et al.,* 2009; Nassir and Ariyo, 2011).

The AMMI model is a hybrid that involves both additive and multiplicative components of the two-way data structure. AMMI biplot analysis is considered to be an effective tool to diagnose GEI patterns graphically. In AMMI the additive portion is separated from interaction by analysis of variance (ANOVA). Then the principal component analysis (PCA) , which provides a multiplicative model, is applied to analyze the interaction effect from the additive

ANOVA model. The biplot display of PCA scores plotted against each other provides visual inspection and interpretation of GEI components. Integrating biplot display and genotypic stability statistics enables genotypes to be grouped based on similarity of performance across diverse environments (Thillainathan and Femandez, 2001; Banik *et al*., 2010; Davoud, 2011; Nassir and Ariyo, 2011).

This method has been shown to be effective because it captures a large portion of the G x E sum of squares, it clearly separates main and interaction effects that present agricultural researchers with different kinds of opportunities and the model provides agronomically meaningful interpretation of the data (Ebdson and Gauch, 2002). The results of AMMI analysis are useful in supporting breeding program decisions such as specific and broad adaptation and selection of environment (Gauch and Zobel, 1997). Therefore, the objectives of this study were to assess the extent of Genotype x Environment (GE) interaction for grain yield, to evaluate rice genotypes for their yield performance and stability and to select and release genotypes with high grain yield and other desirable traits either for specific and/or wide area production depending on their differential responses to environments.

Materials and methods

Fourteen rainfed lowland rice genotypes which were promoted from preliminary variety trial to national variety trial plus two checks were evaluated in northwestern Ethiopia from 2006 to 2008 at three locations of eight environments (ENV) including, Woreta (ENV1, ENV2, ENV3), Addis Zemen (ENV4, ENV5) and Pawe (ENV6, ENV7, ENV8). The locations were different in soil type, altitude, temperature and total rainfall (Table 1).

Table 1. Description of experimental sites.

Agroecological character	Locations		
	Woreta	Pawe	Addis Zemen
Latitude	11^0 58'N	11^0 9'N	11^0 92'N
Longitude	37^0 41'E	36^0 3'E	37^0 7'E
Altitude (masl)	1810	1050	1780
Annual rainfall (mm)*	1300	1457	1032
Mean maximum temperature (0_C)*	27.9	32.75	29.96
Mean minimum temperature (0_C)*	11.5	17.17	11.31
Soil type	Vertisol	Cambisol	Fluvisol

*Mean of three years data (2006-2008).

Randomized Complete Block Design with three replications was used. Each plot had six rows of 5 m length and spaced 0.2 m apart. Fertilizer was applied at the rate of 69/23 kg/ha of N/P_2O_5 in the form of Urea and DAP, respectively. DAP was applied all at planting while Urea was applied one third at planting, one third at tillering and the remaining one third at panicle initiation. A seed rate of 60 kg/ha was used and seeds were drilled in a row. Plantings were done following the optimal dates in each respective location. Data on grain yield and some other traits were collected. However, this paper mainly focuses on grain yield data (at 14% moisture level and estimated on the basis of four central harvestable rows). Analysis of variance was done for each environment. Bartlett's test was used to assess homogeneity of error variances prior to combined analysis over environments. The grain yield data for 16 genotypes in 8 environments were subjected to be combined and AMMI analysis of variance using CropStat version 6.1 statistical software. (CropStat, 2007). In the analysis, each combination of a single location and year was considered as an environment.

AMMI uses ordinary ANOVA to analyze the main effects (additive part) and PCA to analyze the non additive residual left over by the ANOVA (Crossa, 1990). The interaction is the genotype PCA score multiplied by that of the environment. When a genotype and environment have the same sign on their respective first PCA axis, their interaction is positive, if different, their interaction is negative. An AMMI plot is a graph where aspects of both genotypes and environments are plotted on the same axis so that interrelationship can be visualized. It provides a pictorial view of the transformed G x E interaction (Crossa, 1990) for any interpretation. In a biplot where the first interaction principal component axis (IPCA1) is on the vertical axis and mean yield on the horizontal, genotypes that appear almost on a perpendicular line had similar means and those that fall almost on a horizontal line had similar interaction patterns. Genotypes or environments with large IPCA1 scores, either positive or negative had large interactions, where as genotypes with IPCA1 score of zero or nearly zero had smaller interactions (Crossa, 1990). The biplot of the first two IPCA axes demonstrates the relative magnitude of the GEI for specific genotypes and environments. The further away from the axes center genotype or environment is, the larger the GEI.

Results and discussion

Analysis of variance

The analysis of variance for grain yield indicated that there were significant differences among the tested genotypes in each respective environment (Table 2). Bartlett's test indicated homogenous error variance for grain yield in each of eight environments and allowed to proceed further for pooled analysis and the combined analysis of variance is presented in Table 3.

Genotype (G), Environment (E) and Genotype x Environment (GxE) were significant ($P \leq 0.01$) for grain yield. Such statistical interaction resulted from the changes in the relative ranking of the genotypes from one environment to another. The significant GxE effects demonstrated that genotypes responded differently to the variation in environmental conditions of location which indicated the necessity of testing rice varieties at multiple locations. This also shows the difficulties encountered by breeders in selecting new varieties for release.

Table 2. Grain yield (t/ha) of lowland rice genotypes tested at 3 locations (Woreta, Addis Zemen and Pawe) of 8 environments from 2006 to 2008.

Genotypes	Genotype code	ENV1 W-2006	ENV2 W-2007	ENV3 W-2008	ENV4 AZ-2007	ENV5 AZ-2008	ENV6 P-2006	ENV7 P-2007	ENV8 P-2008	Mean
TOX3449-117-3-3-3	GEN1	4.83^{abcd}	1.43^{e}	$3.16d^{e}$	1.38^{f}	2.34^{de}	2.56^{cd}	3.89e	2.88^{abc}	2.81
TOX4339-WAT-44-3-3-1-2-1	GEN2	2.26^{fg}	$2.6cd^{e}$	2.00^{e}	1.27^{f}	1.43^{e}	2.06^{de}	1.51^{bcd}	2.45^{abcd}	1.96
HOO4-7-1-B5	GEN3	2.93^{efg}	1.41^{e}	5.21^{ab}	2.18^{abcde}	3.75^{abc}	3.35^{abcd}	2.67^{abcd}	2.95^{abc}	3.06
HO13-5-3-B4	GEN4	4.50^{bcde}	$2.01d^{e}$	3.96^{bcd}	1.84^{abcdef}	2.56^{cde}	3.52^{abcd}	2.17^{abcd}	2.03^{bcd}	2.83
SIK273-388-2-1-2	GEN5	5.75^{ab}	3.43^{dc}	5.53^{a}	1.90^{abcdef}	2.96^{bcd}	3.55^{abcd}	2.39^{abcd}	1.15^{d}	3.34
SIK295-291-4-2	GEN6	5.89^{dab}	3.13^{dc}	4.32^{abcd}	1.41^{ef}	2.38^{de}	4.95^{a}	2.26^{abcd}	2.99^{abc}	3.42
FOFIFA3737	GEN7	3.42^{defg}	5.25^{ab}	3.58^{cd}	1.65^{cdef}	1.67^{e}	4.09^{abc}	2.22^{abcd}	2.35^{abcd}	3.03
FOFIFA3730	GEN8	3.41^{defg}	5.24^{ab}	3.62^{bcd}	1.26^{f}	2.69^{cde}	3.49^{abcd}	1.37^{cd}	2.73^{abcd}	3.01
WAB189-B-B-B-8-HB	GEN9	4.82^{abcd}	6.60^{a}	5.67^{a}	1.80^{bcdef}	2.14^{de}	3.76^{abc}	2.21^{abcd}	2.47^{abcd}	3.69
IAC164 (Check)	GEN10	6.48^{a}	5.73^{ab}	5.64^{a}	1.88^{abcdef}	4.05^{ab}	0.69^{e}	0.97^{d}	3.66^{ab}	3.63
TGR42	GEN11	2.13^{g}	4.02^{bc}	4.97^{abc}	1.47^{def}	3.17^{abcd}	2.96^{bcd}	2.97^{abc}	3.04^{abc}	3.09
AD03	GEN12	3.02^{efg}	5.34^{ab}	5.29^{ab}	2.42^{abc}	4.31^{a}	4.39^{ab}	3.02^{abc}	3.88^{a}	3.96
AURAT17	GEN13	4.02^{cdef}	5.41^{ab}	5.07^{abc}	2.49^{ab}	3.74^{abc}	4.49^{ab}	3.46^{ab}	3.83^{a}	4.07
AURAT05	GEN14	2.79^{efg}	5.25^{ab}	4.33^{abcd}	2.62^{a}	4.02^{ab}	3.84^{abc}	2.69^{abcd}	2.87^{abc}	3.55
AURAT7	GEN15	2.98^{efg}	5.56^{ab}	4.49^{abc}	2.53^{ab}	3.27^{abcd}	3.67^{abc}	3.06^{abc}	1.40^{cd}	3.40
XJIGNA(check)	GEN16	5.64^{abc}	6.32^{a}	4.52^{abcd}	2.22^{abcd}	2.32^{de}	2.52^{cd}	0.86^{d}	1.90^{cd}	3.29
MEAN		4.05	4.30	4.47	1.89	2.92	3.37	3.36	2.60	
CV (%)		22	21.5	17	21.6	22	24.4	32	31.7	
F-test : 5%,1%		*,**	*,**	*,**	*,**	*,**	*,**	*,NS	*,NS	

*, ** indicate significance at P ≤0.05 and P≤0.01, respectively. ENV = Environment, GEN = Genotype, W = Woreta, AZ = Addis Zemen, P = Pawe, NS = non significant.

Table 3. Combined analysis of variance of grain yield for 16 lowland rice genotypes evaluated at eight environments in 2006-2008.

Source of variation	Degree of freedom	Sum of square	Mean square	Explained SS (%)
Total	383	888.278		
Replications	2	0.147		
Environment (E)	7	302.819	43.259**	34.09
Genotypes(G)	15	93.441	6.229**	10.52
G*E	105	309.091	2.943**	34.78
Error	254	182.850	0.719	

** Significant at P≤0.01.

The factors explained (%) show that rice grain yield was affected by environment (34.09%), genotype (10.52%) and their interaction (34.78%). The mean grain yield of the 16 genotypes ranged from 1.96 to 4.07 t/ha. And the highest grain yield was obtained from genotypes, GEN13, GEN12 and GEN9 (Table 4).

AMMI analysis

The AMMI analysis of variance for grain yield of 16 genotypes tested in eight environments showed that 42.02% of the total sum of squares was attributed to environmental effects, only 12.9% to genotypic effects and 45.19% to GxE interaction effects (Table 3). As indicated in Table 1, the testing locations and/or environments were diverse and caused the greatest variation in grain yield which is in agreement with the findings by Sanni *et al*. (2008), Nassir and Ariyo, (2011) and Sadeghi *et a*l. (2011). This indicated the overwhelming influence that the environments have on the performance of genotypes.

Table 4. Grain yield and some other agronomic traits of lowland rice genotypes tested in eight environments from 2006 to 2008.

Genotype	Genotype code	Grain yield (t/ha)	Days to maturity	Plant height (cm)	% filled spikelets/ panicle	Thousand seed Weight (g)	Disease score (0-9)	
							LB	PB
TOX3449-117-3-3-3	GEN1	2.81^{f}	143.0^{ab}	92.1^{bcde}	89.3^{cd}	29.6^{bc}	1.3	1.5
TOX4339-WAT-44-3-3-1-2-1	GEN2	1.96^{g}	141.6^{bc}	89.0^{def}	88.7^{cde}	27.7^{de}	1.5	1.6
HOO4-7-1-B5	GEN3	3.06^{def}	141.4^{bc}	97.6^{b}	85.4^{de}	27.0^{ef}	1.5	1.9
HO13-5-3-B4	GEN4	2.83^{f}	143.0^{ab}	89.6^{def}	90.2^{bc}	30.5^{b}	1.6	2.0
SIK273-388-2-1-2	GEN5	3.34^{abcd}	139.1^{c}	87.3^{ef}	91.4^{bc}	27.6^{de}	1.8	1.4
SIK295-291-4-2	GEN6	3.42^{bcde}	145.0^{a}	85.7^{f}	84.3^{de}	29.0^{cd}	1.2	1.3
FOFIFA3737	GEN7	3.03^{def}	130.0^{ef}	94.0^{bcd}	92.4^{abc}	30.9^{b}	1.5	1.4
FOFIFA3730	GEN8	3.01^{ef}	130.5^{e}	88.5^{def}	93.1^{abc}	30.4^{b}	1.6	1.3
WAB189-B-B-B-8-HB	GEN9	3.69^{abc}	127.7^{f}	87.8^{ef}	96.8^{a}	32.3^{a}	1.0	1.o
IAC164 (Check)	GEN10	3.63^{abc}	135.9^{d}	90.5^{cdef}	92.1^{abc}	23.8^{g}	2.0	2.4
TGR42	GEN11	3.09^{def}	132.0^{e}	94.1^{bcd}	89.2^{cd}	28.2^{cde}	1.8	2.0
AD03	GEN12	3.96^{ab}	133.1^{e}	96.1^{bc}	93.7^{abc}	27.8^{de}	2	2.5
AURAT17	GEN13	4.07^{a}	132.1^{e}	105.0^{a}	92.1^{abc}	28.3^{cde}	1.5	1.5
AURAT05	GEN14	3.55^{abcde}	131.6^{e}	103.4^{a}	93.5^{abc}	28.1^{de}	2.1	2.5
AURAT7	GEN15	3.40^{abcde}	131.6^{e}	97.5^{b}	92.4^{abc}	27.7^{de}	1.8	2.4
XJIGNA(check)	GEN16	3.29^{cdef}	130.9^{e}	96.3^{bc}	94.3^{ab}	25.8^{f}	2.0	2.0
MEAN		3.26	135.5	93.4	91.2	28.4	1.6	1.9
CV(%)		25.6	3.5	10.1	6.3	8.4		
F-test(5%, 1%):								
Genotype(Gen)		*,**	*,**	*,**	*,**	*,**		
Environment (Env)		*,**	*,**	*,**	*,**	NS		
Gen *Env		*,**	*,**	*,**	*,**	*		

Means followed by the same letter with in column are not significantly different NS = Not significant, *, ** indicate significance at P≤0.05 and P≤0.01, respectively; LB = Leaf blast, PB = Panicle blast, ENV = Environment, GEN = Genotype.

Sanni *et al*. (2009), Banik *et a*l. (2010), Nassir and Ariyo (2011), and Hassanpanah (2011) also reported similar results that all the genotypes, environments and genotype x environment effects were declared significant in the ANOVA of AMMI. The GxE sum of squares was about 3.5 times larger than that for genotypes, which determined substantial differences in genotypic response across environments.

The presence of GEI was clearly demonstrated by the AMMI model, when the interaction was partitioned among the first four interaction principal component axis (IPCA) as they were significant P = 0.01 in a post assessment. The IPCA1 explained 39.01% of the interaction sum of squares in 21% of the interaction degree of freedom (DF). Similarly, the second, third and fourth principal component axis (IPCA 2-4) explained a further 29.27%, 14.62% and 8.63% of the GEI sum of square, respectively (Table 5).

Table 5. Additive Main effects and Multiplicative Interaction (AMMI) analysis of variance for grain yield of 16 lowland rice genotypes across eight environments.

Source	DF	SS	MS	Explained SS (%)
Genotype(G)	15	30.94	2.06**	12.79
Environment(E)	7	101.63	14.52**	42.02
G*E	105	109.28	1.04**	45.19
IPCA1	21	42.64	2.03**	39.01
IPCA2	19	31.99	1.68**	29.27
IPCA3	17	15.99	0.94**	14.62
IPCA4	15	9.43	0.63*	8.63
G*E residual	33	9.23	0.27	
Total	127	241.85		

*, ** Significant at P ≤0.05 and P≤ 0.01, respectively.

They cumulatively captured 91.13% of the total GEI using 72 DF. This implied that the interaction of the 16 rice genotypes with eight environments was predicted by the first four components of genotypes and environments which is in agreement with the recommendation of Sivapalan *et al*. (2000). However; this contradicted the findings of Gauch and Zobel (1997) which recommended that the most accurate model for AMMI can be predicted using the first two IPCAs. These results indicate that the number of terms to be included in an AMMI model cannot be specified a prior without first trying AMMI predictive assessment (Kaya *et al*., 2002). In general, factors like type of crop, diversity of the germplasm and range of environmental conditions will affect the degree of complexity of the best predictive model (Crossa, 1990; Muthuramu *et al*., 2011).

The AMMI analysis provided a biplot (Fig 1) of main effects and the first principal components (IPCA1) of both genotypes and environments. The differences among genotypes in terms of direction and magnitude along the X-axis (yield) and Y-axis (IPCA1 scores) are important. In the biplot display, genotypes or environments that appear almost on a perpendicular line of a graph had similar mean yields and those that fall almost on a horizontal line had similar interactions (Crossa, 1990). Thus the relative variability due to environments was greater than that due to genotypic differences. Genotypes or environments on the right side of the mid point of the perpendicular line have higher yields than those on the left side. As a result, genotypes including GEN13, GEN12, GEN9, GEN10, GEN14 and GEN6 were generally high yielding (4.07, 3.96, 3.69, 3.64, 3.55 and 3.42 t/ha, respectively (Fig 1). In contrast genotypes including GEN1, GEN2 and GEN4 were generally low yielding genotypes. Environments including ENV1, ENV2, ENV3 and to some extent ENV6 were always on the right hand side of the mid point of the main effect axis ,seemed to be favorable environments, while ENV4 and ENV5 were generally less favorable environments.

Genotypes or environments with large negative or positive IPCA scores have high interactions, while those with IPCA1 scores near zero (close to horizontal line) have little interaction across environments and vice versa for environments (Crossa, 1990) and are considered more stable than those further away from the line. In the biplot, genotypes including GEN13, GEN12, GEN10 and GEN9 were vertically distant apart; however, they did not fall close to the horizontal line. This implies that these genotypes lack stability but had high yield potential in favorable environments.

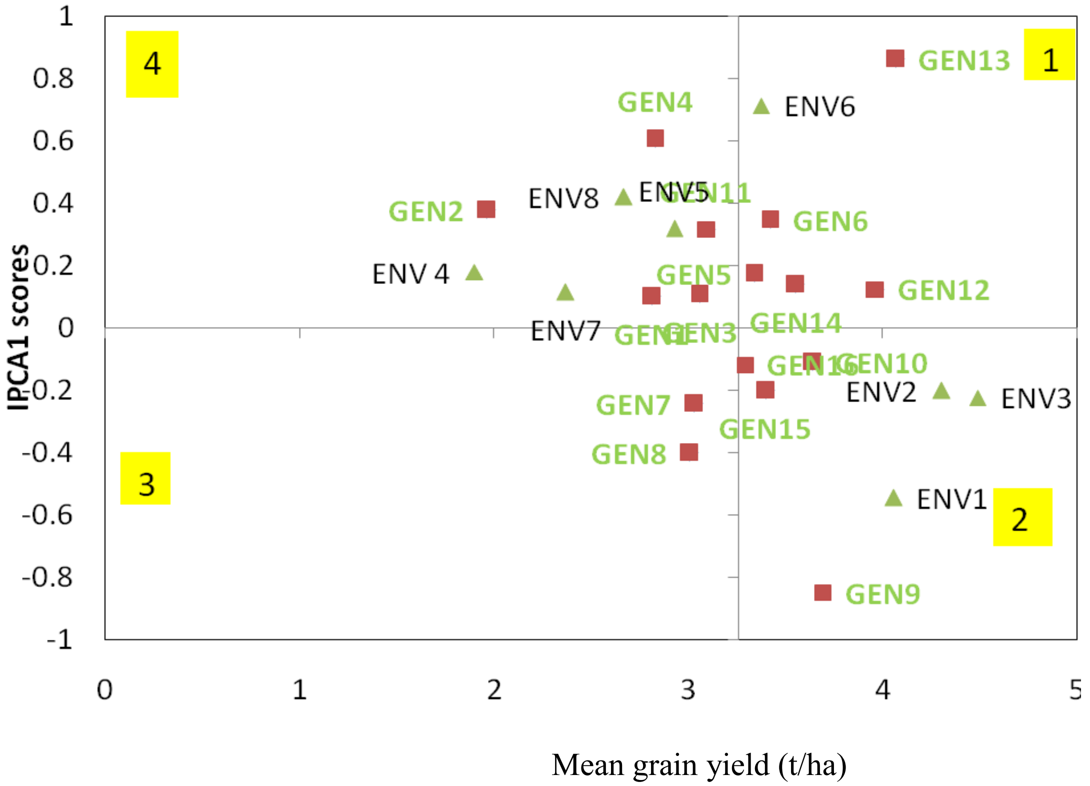

Fig 1. AMMI biplot of 16 rice genotypes and eight environments for grain yield (t ha^{-1}) using genotypic and environmental scores.

GEN1 = TOX3449-117-3-3-3, GEN2 = TOX4339-WAT-44-3-3-1-2-1, GEN3 = HOO4-7-1-B5, GEN4 = HO13-5-3-B4, GEN5 = SIK273-388-2-1-2, GEN6 = SIK295-291-4-2, GEN7= FOFIFA3737, GEN8 = FOFIFA3730, GEN9 = WAB189-B-B-B-8-HB, GEN10 = GEN10 = IAC164, GEN11 = TGR42, GEN12 = AD03, GEN13 = AURAT17, GEN14 = AURAT05, GEN15 = AURAT 7, GEN16 = X-Jigna ENV1 = Woreta06, ENV2 = Woreta07, ENV3 = Woreta08, ENV4 = AddisZemen07, ENV5 = Addis Zemen08, ENV6 = Pawe06, ENV7 = Pawe07, ENV8 = Pawe.

Since, IPCA2 scores were also important (29.27% of G x E SS) in explaining GEI, the biplot of the first two IPCAs was also used to demonstrate the relative magnitude of the GEI for specific genotypes and environments (Fig 2). The IPCA scores of genotypes in the AMMI analysis is an indication of stability or adaptation over environments (Gauch and Zobel, 1997). The greater the IPCA scores, the more specifically adapted is a genotype to certain environments Sanni *et al*. (2009). The more the IPCA scores approximate to zero, the more stable or adapted the genotype is over all the environments sampled. The biplot of the first two IPCA didn't show the best adapted genotype and/or genotypes to most environments. However; GEN13, and GEN12 were well adapted to high yielding environment, ENV6 while GEN9 and GEN15 were well adapted to high yielding environment, ENV2. The varieties used as check (GEN10 and GEN16) were found to be well adapted to the high yielding environments of ENV1 and ENV3).

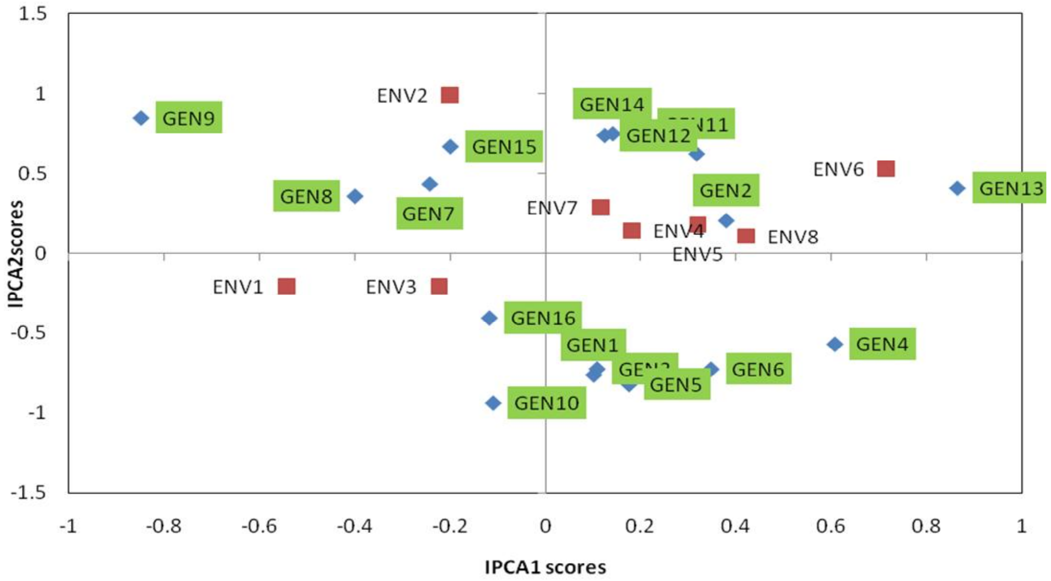

Fig. 2. Biplot of the second interaction principal component axis (IPCA2) against the first interaction principal component axis (IPCA1) scores for grain yield of 16 lowland rice genotypes in eight environments.

1-B5, GEN4 = HO13-5-3-B4, GEN5 = SIK273-388-2-1-2, GEN6 = SIK295-291-4-2, GEN7 = FOFIFA3737, GEN8 = FOFIFA3730, GEN9 = WAB189-B-B-B-8-HB, EN10 = GEN10 = IAC164, GEN11=TGR42, GEN12 = AD03,GEN13 = AURAT17, GEN14 = AURAT05, GEN15 = AURAT 7, GEN16 = X-Jigna ENV1 =Woreta06, ENV2 = Woreta07, ENV3 = Woreta08, ENV4 = AddisZemen07, ENV5 = Addis Zemen08, ENV6 = Pawe06, ENV7 = Pawe07, ENV8 = Pawe08.

In Fig 2, the environments fell in to three sections: the best genotypes with respect to ENV1, ENV2 and ENV3 (Woreta) were GEN10, GEN16, GEN9, GEN7, GEN8 and GEN15-

Genotypes, GEN14, GEN12, GEN11, GEN2 and GEN13 were best for ENV4, ENV5 (Addis Zemen) and ENV6, ENV7, ENV8 (Pawe). On the other hand, genotypes, GEN4, GEN1, GEN3, GEN5 and GEN6 were not found to be fit to any of the testing environments and/or locations.. Considering the environments tested in this study, no single environment had both IPCA 1 and IPCA2 scores close to zero line. This indicates that all the environments had potential for large GEI.

Conclusion

The AMMI statistical model has shown that the largest proportion of the total variation in grain yield was attributed to environments in this trial. As a result, almost all of the evaluated genotypes were affected by the GEI effects, so that no genotype had superior performance in all environments. Most of the genotypes showed environment specificity. In this study, the AMMI model classified the testing environments in to three sections. Accordingly, six of the tested genotypes were found best for ENV1, ENV2 and ENV3; while the other six genotypes were found best for environments ENV4, ENV5, ENV6, ENV7 and ENV8. However, four of the tested genotypes were not found best to any of the testing environments. As a breeding strategy, it is be better to execute national variety trials at a number of locations in different regions of the country. So that it would be possible to cluster the testing locations in to homogenous groups to be used for breeding for specific adaptation and/or for broad adaptation. Among the tested genotypes, GEN 9 has been officially released for large scale production. With the vernacular name “EDGET” for its better performance in grain yield and other agronomic traits and considering farmers’ preferences.

References

Banik, B.R., Khaldm, A.B.M., Mondal, A.A., Islam, A. and Rdiman, M.M. 2010. Assessment of genotypes –by-environment interaction using additive main effects and multiplicative minteraction model (AMMI) in maize (*Zea mays* L.) hybrids. *Academic Journal of Plant Sciences* 3(4):134-139.

CropStat 6.1for Windows.Tutorial Manual. (2007). Crop Research Informatics Laboratory International Rice Research Institute. 360 pp.

Crossa , J. (1990).Statistical analysis of multi-location trials. *Adv. Agron*. 44:55-85.

Dixon, A.G.O. and Nukenine, E.N. 1997. Statistical analysis of cassava yield trials with additive main effects and multiplicative interaction (AMMI) model. Afr.J. Root Tuber Crops 3:46- 50.

Ebdon J.S. and Gauch, H.G. 2002. Additive main effect and multiplicative interaction analysis of national turfgrass performance trials. II Cultivar recommendations. *Crop Sci. 42*: 497-506.

Gauch, H.G. and Zobel, R.W. 1997. Identifying mega-environments and targeting genotypes. *Crop Sci*. 37: 311-326.

Hassanpanah, D. 2011. Analysis of GXE interaction using additive main effects and multiplicative interaction (AMMI) in potato cultivars. *Afri. J. Biotech.* 10(2):154-158.

Kaya,Y., Palta, C. and Taner, S. 2002. Additive main effects and multiplicative interactions analysis of yield performance in bread wheat genotypes across environments. *Turk.J.Agric*. 26: 275-279.

Ministry of Agriculture and Rural Development (MoARD). (2010). National Rice Research and Development Strategy of Ethiopia. Addis Ababa, Ethiopia.48pp.

Mosavi, A.A., Jelodar, N.B. and Kazemifabar, K.2013. Environmental responses and stability analysis for grain yield of some rice genotypes. *World Applied Sci. J.* 21(1):105-108.

Muthuramu, S., Jebaraj, S. and Gnanasekaran, M. 2011. AMMI biplot analysis for drought tolerance in rice (*Oryza sativa* L.). *Research J. Agric. Sci.* 2(1):98-100.

Nassir, A.L. and Ariyo, O.J. 2011. Genotype x environment interaction and yield stability analysis of rice grown in tropical inland swamp. *Not Bot. Hort. Agrobot. Cluj*. 39(1):220-225.

Sadeghi,S.M., Samizadeh, H., Amiri, E. and Ashouri, M. 2011. Additive main effects and multiplicative interaction s (AMMI) analysis of dry yield of tobacco hybrids across environments. *Afri. J. Biotech.* 10(21):4358-4364.

Sanni, K.A., Ariyo, O.J., Ojo, D.K., Gregorio, G., Somado, E.A., Sanchez, I., Sie, M., Futakuchi ,K., Ogunabayo , S.A., Guel, R.G, and Wopereis, M.C.S. 2009. Additive main effects and multiplicative interaction analysis of grain yield performance in rice genotypes across environments. *Asian J. Plant Sci.* 8(1):48-53.

Shrestha, S.P., Asch, F., Dusserre , J., Ramanantsoanirine, A. and Brueck, H. 2012. Climate effects on yield components as affected by genotypic responses to variable environmental conditions in upland rice systems at different altitudes. *Field crops Res.* 134: 216-228.

Sivapalan, S., Brien, L.O., Ferrana, G.O., Hollamby, G.L., Barelay, I. and Martin, P.J. 2000. An adaptation analysis of Australian and CIMMYT/ICARDA wheat germplasm in Australian production environments. *Aust. J. Agric. Res*. 51: 903-915.

Thillainathan, M. and Fernandez, G.C.J. 2001. SAS applications for Tai's stability analysis and AMMI model in genotype x Environmental Interaction (GEI) effects. *Hered* 92(4): 367-371.

Performance of elite Finger millet (*Eleusine coracana*) genotypes in West Amhara

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Abstract

Sixteen genotypes together with the standard and local checks were grown at Adet, Merawi and Finoteselam in 2005, 2006, 2007 and 2008 cropping seasons with objective of selecting the better yielding and widely adaptable varieties. The combined analysis results showed that there was highly significant differences (p<0.001) between genotypes in plant height, finger length, hectoliter weight, grain yield, and lodging as well as a significant Genotype x Environment Interaction. Two genotypes namely Acc# 203572 and Acc# 203539 out yielded the checks in most environments with an average grain yield of 2461.5 kg/ha and 2394.6 kg/ha, respectively. AMMI yield stability analysis indicated that Acc# 203539 showed wider adaptation and better yield potential while Acc# 203572 showed less stability and higher grain yield. As a result the national variety releasing committee has decided to release Acc# 203572 for the regional in 2011 due to the preference of the farmers during the evaluation.

Key words: AMMI, G x E, PCA.

Introduction

Finger millet (*Eleusine coracana*) is mainly grown as a grain cereal in the semi-arid tropics and subtropics of the world under the rain fed conditions. It is a staple food crop in the majority of drought prone areas in the world and often considered as a component of food security strategies. By virtue of its hardy nature, it can give reliable yield under circumstances where other crops give negligible yield (National Research Council, 1996).

In Ethiopia, it is an indigenous crop grown by subsistence farmers. Sole cropping is the common practice in rotation with other annual crops, preferably legumes. The crop is produced in Tigray, Amhara, Oromia, Benishangul-Gumuz, Southern Nations and Nationalities and Peoples (SNNP), and Gambela regional states. The Amhara region alone accounts for more than half of the total area and production of finger millet in the country (CSA, 2011). It is produced in all administrative zones of the Amhara region except North

Shewa. The total production area allotted for finger millet production in the region is 196114.7 ha with a production of 6.09% of total cereal yield and with an average yield of 13.54 q/ha. North Gondar, West Gojam, and Awi zones are the largest in area allocation while North Wolo, Awi and South Gondar zones rank highest in average yield (CSA, 2011).

Despite its importance and significance, finger millet production practices, the challenges farmers are facing, opportunities of finger millet production; marketing, and utilization issues were not systematically assessed and documented. Moreover, the regional average yield of the crop is low under farmers' management (National Research Council, 1996). This owing to low productivity of the local variety, which is characterized by high vegetative growth, high lodging, low threshability and infestation with head blast (Alelign Kefyalew and Regassa Ensermu, 1992). Therefore, it was essential to develop varieties, which are widely adapted, high yielding and better performing in major agronomic parameters.

Targeting variety selection onto its growing environments is the prime interest of any plant breeding program. To realize this breeding programs usually undertake a rigorous genotypes performance evaluation across locations and years mostly at the final stage of variety development process. In such type of multi-environment trials, the occurrence of genotype x environment interaction is inevitable (Ceccarelli *et al*., 2006). To this effect Adet agricultural research center has been taking a number of variety development activities on finger millet as a regional research center with the objectives: a) to select high yielding disease resistant and/or tolerant finger millet genotypes, b) to select adaptable and stable finger millet genotypes for release.

Materials and methods

Sixteen finger millet lines including the local and standard checks (Degu and Tadesse) were tested using RCBD with three replications at Adet, Merawi and Finoteselam (all on red soil) locations in the main cropping season for four consecutive years (2005-2008) at Adet, three years (2005-2007) at Merawi and two years (2005 & 2008) at Finoteselam i.e., a total of 9 environments. The three experimental locations are believed to have different agro ecological environments in the Western Amhara Region. Adet is located in midto highland agroecology, Merawi represents the mid to lowland agroecology whereas Finoteselam is typical midaltitude agroecology. The experimental sites have also different amount of annual rainfall amount and distribution. The experiment had plots of three rows with five meters length with inter-row and inter-replication spacing of 0.75 m and 1.5 m, respectively. A fertilizer rate of 50/100 kg ha^{-1} of DAP/Urea was applied with the application time of all DAP at planting while Urea was applied at tillering or after first weeding. Weeding was done three times in the cropping season starting from 30-35 days after planting and depending on the weed infestation.

All the necessary data i.e., days to heading, days to maturity, plant height (cm), finger length (cm), number of ear per plant, number of fingers per ear, number of tillers per plant, hectolitre weight (kg/hl), thousand grain weight (kg/ha), lodging (%), stand (%) at harvest, blast severity (%), grain yields (g/plot)) were recorded. as The data on grain yield and other agronomic parameters was analyzed using Cropstat V.6.1 (2007) and the AMMI stability analysis was done using GenStat V.12.1(2011). AMMI stability value was calculated to observe the stability of genotypes.

Results and discussion

Most of the agronomic parameters showed significant differences in all cropping seasons at the different sites except plant height which was non significant across environments (Tables 1 and 2). The mean performances grain yield and other agronomic traits of genotypes are presented in Table 3. The standard checks Tadesse and Degu were out yielded by 6 genotypes and the local check by all except Tadesse. Genotypes Acc# 203572 and Acc# 203539 had a yield advantage of 17.6% and 14.4% over the better check (Tadesse), respectively (Table 3).

Table 1. ANOVA for grain yield of each environment for genotypes.

Location	Year	Source of Variation	df	SS	MS	F	F-Prob
Adet	2005	Replication	2	2086836	1043418	7.12	0.003
		Genotype	15	4304127	286942	1.96	0.057
		Residual	30	4397315	146577		
		Total	47	10788278			
	2006	Replication	2	789343	394671	2.69	0.084
		Genotype	15	8142926	542862	3.71	0.001
		Residual	30	4395574	146519		
		Total	47	13327843			
	2007	Replication	2	1315268	657634	6.16	0.006
		Genotype	15	9410122	627341	5.87	<.001
		Residual	30	3203756	106792		
		Total	47	13929146			
	2008	Replication	2	2915706	1457853	5.05	0.013
		Genotype	15	5509037	367269	1.27	0.028
		Residual	30	8661307	288710		
		Total	47	17086049			
Merawi	2005	Replication	2	732220	366110	2.97	0.066
		Genotype	15	3696434	246429	2.00	0.052
		Residual	30	3694638	123155		
		Total	47	8123292			
	2006	Replication	2	2057024	1028512	5.24	0.011
		Genotype	15	1697262	113151	0.58	0.870
		Residual	30	5893030	196434		
		Total	47	9647317			
	2007	Replication	2	10760	5380	0.09	0.913
		Genotype	15	831785	55452	0.94	0.031
		Residual	30	1763203	58773		
		Total	47	2605747			
Finoteselam	2005	Replication	2	814964	407482	1.14	0.334
		Genotype	15	5123600	341573	0.95	0.023
		Residual	30	10759886	358663		
		Total	47	16698451			
	2008	Replication	2	1318767	659383	8.14	0.002
		Genotype	15	3021676	201445	2.49	0.016
		Residual	30	2430466	81016		
		Total	47	6770909			

Table 2. Mean squares for traits ANOVA across environments.

Source of Variation	DF	Yield	DH	DM	PH	TPP	EPP	FPE	FL	HLW
Environment	8	42425929***	2374.687***	8018.379***	3240.15	880.289***	2581.87^{1***}	4.5196***	66.52***	351.405***
Replication (Environment)	18	668938***	6.839	8.818	169.93	15.200***	27.374***	1.0138	12.35	7.008
Genotype	15	570776***	382.076***	291.546***	1071.33	29.524***	146.942***	42.4169***	88.70***	88.392***
Environment x Genotype	120	276461***	28.635***	28.690***	94.52	7.669***	20.080***	0.9780***	14.34	9.378***
Residual	270	167404	4.469	5.845	43.91	3.731	7.913	0.5743	14.52	5.502
Total	431									

Table 3: Grain yield and other agronomic traits performances of 16 finger millet genotypes across locations, 2005-2008.

Genotype	DH	DM	PH (cm)	TPP	EPP	FPE	FL (cm)	HLW (kg/hl)	GY (kg/ha)	Yield adv. (%)	Lodging (%)	Stand at harvest (%)	Blast severity (%)
Acc# 229463	103	164	96.8	9.3	11.7	8.3	10.1	81.5	2071.4		10.8	81.3	9.3
Acc # 229465	104	164	99.7	8.7	11.4	8.4	9.6	82.8	1986.7		12.4	85.4	8.7
Acc # 203572	97	156	90.0	7.9	11.3	7.8	10.9	82.5	2461.5	17.6	8.4	80.6	8.9
Acc # 203587	100	163	97.6	8.0	10.7	8.0	10.6	82.9	1962.0		11.7	80.4	9.4
Acc # 229407	104	160	89.8	7.5	9.5	5.0	8.1	79.0	2092.8		4.5	79.7	8.5
Acc # 229415	104	162	91.2	6.8	8.3	5.2	10.8	79.7	2217.5		3.0	79.5	8.7
Acc # 229440	94	155	91.5	8.6	10.3	5.0	7.5	81.7	2105.7		7.8	73.9	9.1
Acc # 229458	104	162	93.4	7.1	9.7	5.3	8.5	79.7	2108.5		3.0	79.1	8.9
Acc # 229461	105	163	88.8	7.5	8.6	5.0	8.0	79.2	2118.4		3.0	79.5	8.9
Acc # 229468	101	162	96.4	6.6	7.5	5.7	7.9	77.9	2086.3		3.0	76.3	9.3
Acc # 229469	102	161	95.4	7.0	8.3	6.0	7.0	79.7	2113.1		3.0	78.0	8.9
Acc # 203410	102	161	93.9	7.4	8.7	6.9	7.2	79.4	2226.9		4.5	76.2	9.1
Acc # 203539	97	156	72.8	8.7	12.0	6.7	5.1	80.1	2394.6	14.4	3.0	77.1	9.1
Tadesse(St.chk)	103	161	85.7	7.1	8.3	5.4	6.1	79.6	1924.4		3.0	78.9	9.3
Degu (St.check)	99	158	92.5	9.4	15.3	6.5	9.9	83.6	2093.0		12.6	81.5	8.7
Local check	97	159	92.7	9.0	14.2	6.5	10.0	83.5	1986.4		44.3	82.5	28.7
Mean	101.0	160.4	91.8	7.91	10.36	6.36	8.58	80.80	2121.8		6.75	79.37	8.97
SE	1.47	2.55	2.25	0.91	1.45	0.19	0.71	0.67	195.62		3.83	2.94	1.14
CV (%)	2.2	1.5	8.1	25.2	27.9	12.2	41.8	2.9	21.0		-	-	-
LSD (5%)	4.08	7.09	6.26	2.54	4.03	0.52	1.98	1.86	543.74		10.67	8.18	3.28

DH = Days to heading, DH = Days to maturity, PH = Plant height, TPP = Number of tillers per plant, EPP = Number of ears per plant, FPE = Number of fingers per ear, FL = Finger length, HLW = Hectoliter weight, GY = Grain yield.

Across environment analysis for grain yield (Table 4) showed that environment, genotypes and genotype x environment interaction were significant ($p<0.001$) which led to undertake additive main effect and multiplicative interaction (AMMI) stability analysis. The ANOVA for AMMI model also revealed that the two interaction principal component axis (IPCA1 and IPCA2) contributed 61.22% of the variations among the genotypes (Table 5).

Table 4. Analysis of variance for grain yield across environments.

Source of Variation	DF	SS	MS	F. ratio	F pr.
Environment	8	339407428.	42425929.	253.43	<.001
Rep (Environment)	18	12040887.	668938.	4.00	<.001
Genotype	15	8561644.	570776.	3.41	<.001
Environment x Genotype	120	33175325.	276461.	1.65	<.001
Residual	270	45199174.	167404.		
Total	431	438384459.			

Grand Mean = 2122 kgha^{-1}.

Table 5. The ANOVA table for AMMI model

Source	df	SS	MS	F	F_ prob.	Variation %
Treatments	143	381144397	2665345	15.92	0.00000	
Genotypes	15	8561644	570776	3.41	0.00003	
Environments	8	339407428	42425929	63.42	0.00000	
Blocks	18	12040887	668938	4.00	0.00000	
Interactions	120	33175325	276461	1.65	0.00042	
IPCA1	22	12388587	563118	3.36	0.00000	33.52%
IPCA2	20	8970672	448534	2.68	0.00019	27.70%
Residuals	78	11816066	151488	0.90	0.69500	
Error	270	45199174	167404	*	*	
Total	431	438384459	1017133	*	*	

NB: the block source of variation refers to blocks within environments

The AMMI stability value (ASV) of the genotype means was also calculated i.e., the smaller ASV value is the better stability of a given genotype. Accordingly, Acc# 203539 was the most stable with 2nd rank in grain yield (2395 kg ha^{-1}) while Acc# 203572 was less stable although was the highest grain yielding genotype (2461 kgha^{-}1) (Table 6).

Table 6: AMMI stability analysis for the Genotype means and scores.

Genotype	Description	Genotype Mean	IPCAg[1]	IPCAg[2]	AMMI stability value
G1	Acc# 229463	2071	-10.30600	-12.04884	18.64789
G2	Acc # 229465	1987	-8.43578	0.85818	11.68146
G3	Acc # 203572	2461	-12.75059	-24.35743	30.05579
G4	Acc # 203587	1962	-20.52394	4.55711	28.70777
G5	Acc # 229407	2093	4.65962	-0.59991	6.46288
G6	Acc # 229415	2217	9.11015	11.05436	16.74771
G7	Acc # 229440	2106	1.77062	7.69945	8.07841
G8	Acc # 229458	2109	5.51950	9.48876	12.17123
G9	Acc # 229461	2118	9.57367	12.63447	18.28752
G10	Acc # 229468	2086	17.88230	-17.66475	30.36310
G11	Acc # 229469	2113	9.94581	1.00414	13.77192
G12	Acc # 203410	2227	9.63671	-6.54567	14.83102
G13	Acc # 203539	2395	3.85059	2.18226	5.74806
G14	Tadese (St.chk)	1924	7.34443	-0.01671	10.14274
G15	Degu (St. check)	2093	-6.98171	-1.47161	9.75347
G16	Local check	1986	-20.29538	13.22618	30.99205

AMMI Stability Values close to zero = Stable genotype

A biplot was generated using genotypic and environmental scores of the first and second IPCA scores. Figure 1 shows the biplot of genotypes and environments against IPCA 1 while Figure 2 shows the biplot against IPCA 2 and figure 3 displayed the interaction against IPCA 1 and IPCA 2.

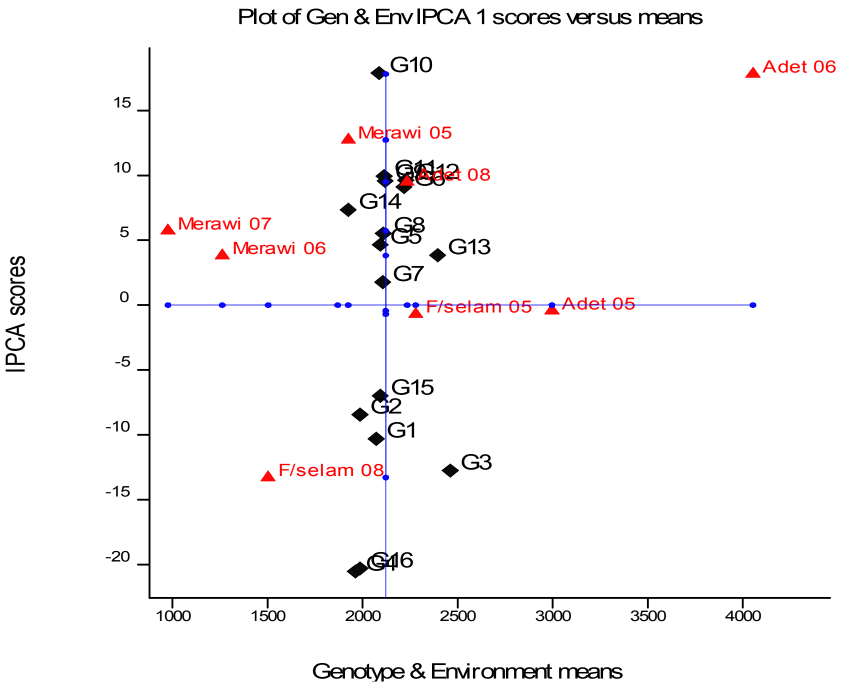

Figure 1. Biplot of 16 genotypes and 9 environments for grain yield using genotypic and environmental scores against IPCA1. Grand mean = 2122 kgha-1.

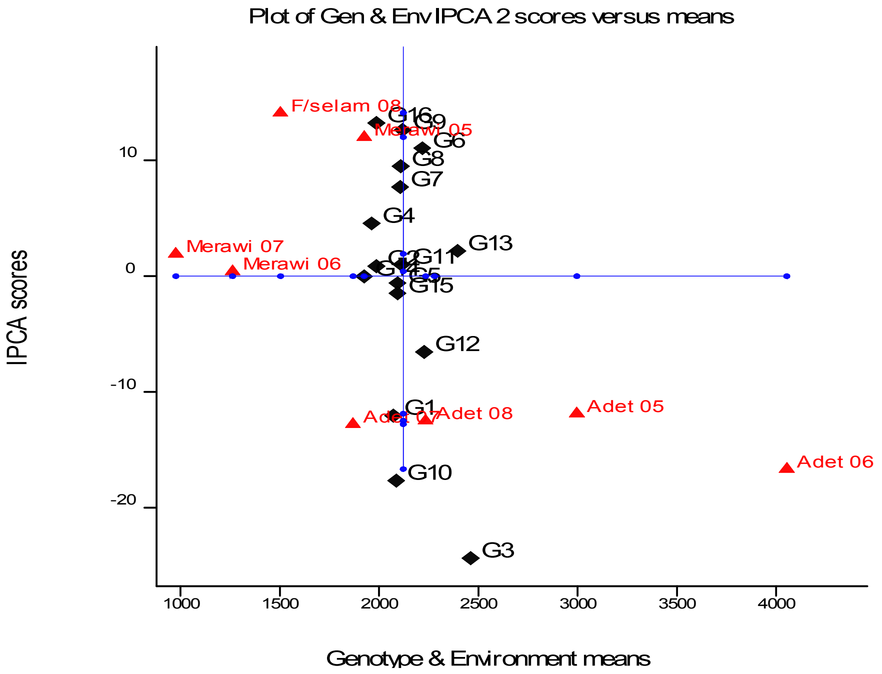

Figure 2. Biplot of 16 genotypes and 9 environments for grain yield using genotypic and environmental scores against IPCA2. Grand mean = 2122 kgha-1.

Genotype G13 (Acc# 203539) was more stable with above average grain yield performance and better than most genotypes in all environments. Genotype G7 (Acc# 229440) was also most stable but with below average grain yield performance (Figure 1). Figure 2 and 3 of biplot also showed that G13 (Acc# 203539) and G3 (Acc# 203572) were the higher yielding genotypes with G13 (Acc# 203539) more stable than G3 (Acc# 203572).

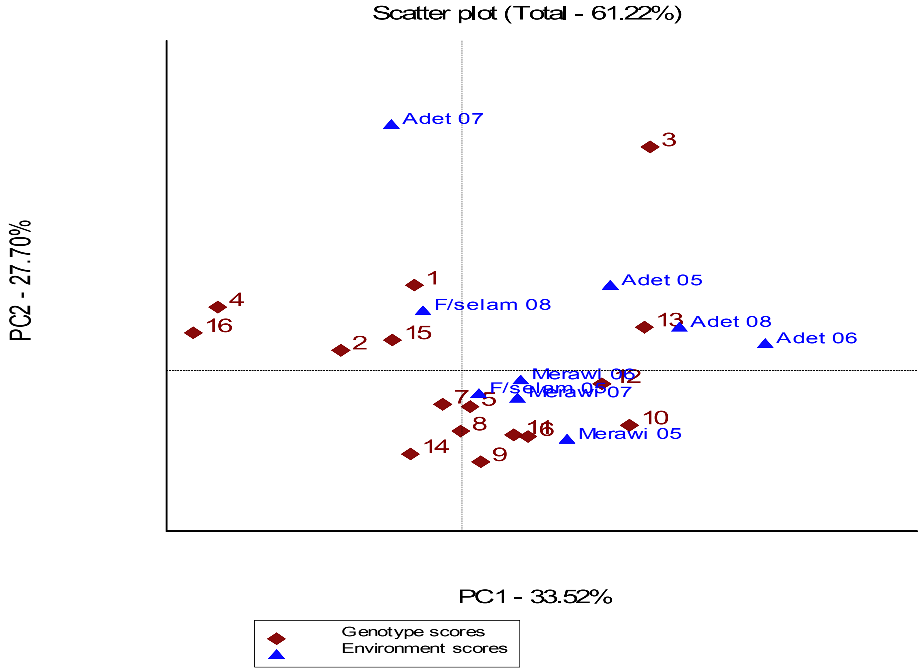

Figure 3. Biplot of 16 genotypes and 9 environments for grain yield of IPCA1 against IPCA2. Grand mean = 2122 kgha^{-1}.

Conclusion and recommendation

Acc# 203572 and Acc# 203539 out yielded all genotypes including the across locations and years. The genotype Acc#203539 was the highly stable and better yielding than Acc# 203572 which was highest yielder but better stable genotype. Hence, Acc# 203572 is going to be released by the national variety release committee regionally for wider production considering farmers' preference of overall morphology (expected biomass yield, straw palatability to cattle, finger number and length) and seed colour (whiteness). The farmers preferred the genotype with high yielding, loose panicle or ear, long fingers, high tillering capacity, high expected biomass and much number of fingers which were lacking in the highest stable genotype Acc#203539 while Acc# 203572 was fulfilling these characters.

Acknowledgement

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References

Alelign Kefyalew, and Regassa Ensermu, 1992, Bahir Dar Mixed Farming Zone Diagnostic Survey Report .Research Report, No 18 IAR, Addis Ababa.

Ceccarelli S, Grando S and Booth RH. 2006. Crop improvement in difficult environments: International breeding programs and resource-poor farmers, ICARDA, Allepo, Syria.

Cropstat Version 6.1. 2007. Crop Research Informatics Laboratory; International Rice Research Institute.

CSA, 2011. The federal democratic republic of Ethiopia central statistical agency, Agricultural Sample Survey, 2007/2008. Report on area and production of crops. Statistical Bulletin 417, Volume I, Addis Ababa. June, 2008 128p.

National Research Council, 1996. Finger millet. In: Lost crops of Africa: volume I: grains, *National Academy of Sciences*. pp. 39-57.

Determining time and frequency of weeding in direct seeded upland rice in Metema, North Gondar Zone

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Abstract

Rice production by smallholder farmers in Metema area of North Gondar is constrained by weed competition. A field study was conducted at Metema Woreda in two kebeles (Aftit and Kumer) in the 2008/9 cropping season. The objective of the experiment was to determine the optimum time and frequency of weeding in direct seeded upland rice. Treatments consisted of seven time and frequencies of hand weeding (HW1-no weeding, HW2-weed free check, HW3-hand weeding at 20 days after emergence /DAE/, HW4- hand weeding at 35 DAE, HW5- hand weeding at 50 DAE, HW6-hand weeding at 20 and 35 DAE, HW7- hand weeding at 20, 35 and 50 DAE of rice. A rice variety called NERICA-4 was used. Results showed that there were highly significant differences in grain yield between the weeding time and frequencies. Weeding rice at 20, 35 and 50 DAE gave the highest significant yield of 3530 kg ha^{-1} next to the weed free check which gave a yield of 3640 kg ha^{-1}. This weeding time and frequency was also found economically profitable. Hence, is recommended for rice production in Metema.

Keywords: Hand weeding, rice, weed.

Introduction

Rice (*Oryza sativa* L.) is the world's third largest crop next to maize and wheat. It is the staple food for more than half of the world population (FAO, 2004). It is the most rapidly growing source of food, becoming increasingly important in Africa and is of significant importance to food security in an increasing number of low-income food-deficit countries (FAO, 2004). Efficient and productive rice-based production systems are essential for economic development and for improved quality of life of much of the world's population (FAO, 2004).

Rice was introduced and grown initially in different areas of Ethiopia; Gambella, Pawe, and Woreta in the early 1970s. Nevertheless, the crop did not get due attention until the mid 1990s (Wolelaw, 2005). Since the mid of 1990s, however, about seven upland rice varieties including four NERICA varieties have been released. Currently, the released varieties, especially NERICAs, are under dissemination and expansion in the different agroecologies of the country, from lowlands of 750 m above sea level to areas of about 2000 m above sea level elevations.At present, rice is becoming an important crop in the country and it is the first by the average productivity (2.9 t ha^{-1}) among cereals (CSA, 2008) followed by maize (2.1 t ha^{-1}). It has been also reported that the average productivity of rice ranges from 2.5 to 4.0 t ha^{-1} under on-farm conditions in the country (MoARD, 2007).

Weeds are the major source of yield loss in upland rice. Weeds affect rice crop by competing for nutrient, light, water and space (AICAF, 2001). The estimated yield losses due to weeds ranges from 33-75% in lowland and 70-100% in upland rice varieties (Akobundu, 1987). Weed interference in rice is known to reduce grain yield by affecting yield grains per panicle (Adeosun, 2008). The objective of this study was to determine the optimum timing and weeding frequency in direct seeded upland rice in Metema area.

Materials and methods

The experiment was conducted in 2008/9 on farmers' fields in Metema woreda (Kokit and Afitit Kebeles). The area is situated at an altitude of 650-890 m above sea level with an annual average rainfall of 980 mm. The experiment was in randomized complete block design with three replications. Treatments consisted of seven time and frequency of weeding (HW1-no weeding, HW2- weed free check, HW3-hand weeding at 20 days after emergence/DAE/, HW4- hand weeding at 35 DAE, HW5- hand weeding at 50 DAE, HW6- hand weeding at 20 and 35 DAE, HW7- hand weeding at 20, 35 and 50 DAE). Var. NERICA-4 was used. The gross and net plot sizes were 5 m X 6 m (30 m^2) and 4 m X 5 m (20 m^2), respectively. The seeding rate was 100 kg ha^{-1} and fertilizer rate was 46/23 N/P_2O_5 kg ha^{-1} and other crop management practices were done as per farmers practice. Data were analyzed using SAS statistical software. Economic analysis was performed following the

CIMMYT partial budget methodology (CIMMYT, 1988). Average market price of rice grain during the experimental period was used. The only variable cost used in the analysis was weeding labor cost. The yield of rice is adjusted by 10% for the economic analysis. As shown in Table 1 sensitivity analysis was made assuming a 20% increase in variable costs and rice grain price. Total costs that vary for each treatment was calculated and treatments ranked based on their total variable cost in ascending order to undertake dominance analysis. Finally, the Marginal rate of return and sensitivity analysis was calculated for the non-dominated treatments.

Table 1. Cost of inputs and price of rice grain.

Cost/price of input/output	Current situation	Sensitivity analysis
Cost of weeding (ETB/man days)	25	30
Price of rice grain (ETB/kg)	4.5	5.4

Results and discussions

Weed management and yield of rice

Rice yield has significantly responded to the timing and frequency of weeding. Hand weeding at 20, 35 and 50 days after emergence showed the highest significant yield (3530 kg ha^{-1}) next to the weed free check (3640 kg ha^{-1}) (Table 2). The lowest yield was recorded in the unwed check (140 kg ha^{-1}).

Weed population was significantly lower with hand weeding at 20, 35 and 50 days after emergence next to the weed free check (Table 3). Highest weed population was recorded in the unweeded plot and the lowest was recorded at hand weeding at 20, 35 and 50 days after emergence next to the weed free check.

Table 2. Effect of time and frequency of weeding on the yield of upland rice at Metema (across locations) in 2008/9.

Treatments	Yield (kg ha^{-1})	Yield loss (%)
No weeding (HW1)	140^{d}	96.1
Weed free (HW2)	3640^{a}	0
Hand weeding at 20 DAE (HW3)	1420^{c}	60.9
Hand weeding at 35 DAE(HW4)	2010^{bc}	44.8
Hand weeding at 50 DAE(HW5)	1490^{c}	59.1
Hand weeding at 20,35 DAE(HW6)	2630^{b}	27.7
Hand weeding at 20, 35, 50 DAE(HW7)	3530^{a}	3
Grand mean	2130	-
CV (%)	18.83	-

Table 3. Effect of time and frequency of weeding on the weed population of direct seeded upland rice in Metema (across locations) in 2008/9.

	Weed count/m^2			
Treatments	1st weeding	2nd weeding	3rd weeding	Average
No weeding (HW1)	135^{a}	218^{a}	279^{ab}	161^{a}
Weed free (HW2)	62^{c}	41^{b}	9^{d}	30^{c}
Hand weeding at 20 DAE (HW3)	91^{b}	213^{a}	284^{a}	150^{b}
Hand weeding at 35 DAE (HW4)	155^{a}	58^{b}	188^{c}	103^{b}
Hand weeding at 50 DAE (HW5)	141^{a}	220^{a}	70^{d}	111^{b}
Hand weeding at 20,35 DAE (HW6)	80^{b}	91^{b}	217^{bc}	100^{b}
Hand weeding at 20, 35, 50 DAE (HW7)	70^{bc}	49^{b}	12^{d}	35^{c}
Grand mean	105	127	151	99
CV (%)	13.25	25.18	24.03	16.81

Partial budget analysis for weed management in direct seeded upland rice

Partial budget analysis was done to identify the most profitable weeding time and frequency. Results showed that hand weeding at 20, 35 and 50 DAE had the highest net benefit and marginal rate of return (Table 4). This result indicated that that for each one ETB additional investment on weeding farmers will gate a return of ETB 23.30. The results of the sensitivity analysis also showed similarly hand weeding at 20, 35 and 50 days after emergence still financially viable weeding time and frequency. Given the price of rice grain, a 20% increase in weeding cost will yield a return of ETB 19.25 (Table 5).

Table 4. Partial budget analysis for time and frequency of weeding in direct seeded upland rice at Metema in 2008/9.

Treatment	Unadjusted yield (kg ha^{-1})	Adjusted yield (kg ha^{-1})	Gross field benefit (ETB ha^{-1})	Labor cost (ETB ha^{-1})	Total cost that vary (ETB ha^{-1})	Net benefit (ETB ha^{-1})	Dominance	MRR
HW1	140	126	-5419	0	0	-5419		
HW2	3640	3276	13481	4600	4600	8881	D	
HW3	1420	1278	1493	800	800	693		764
HW4	2010	1809	4679	1000	1000	3679		1493
HW5	1490	1341	1871	1200	1200	671	D	
HW6	2630	2367	8027	1400	1400	6627		737
HW7	3530	3177	12887	1600	1600	11287		2330

HW = Hand weeding.

Table 5. Sensitivity analysis for time and frequency of weeding in direct seeded upland rice at Metema in 2008/9.

Treatment	Unadjusted yield (kg ha^{-1})	Adjusted yield (kg ha^{-1})	Gross field benefit (ETB ha^{-1})	Labor cost (ETB ha^{-1})	Total cost that vary (ETB ha^{-1})	Net benefit (ETB ha^{-1})	Dominance	MRR
HW1	140	126	-6654	0	0	-6654		
HW2	3640	3276	12246	5520	5520	6726	D	
HW3	1420	1278	258	960	960	-702		620
HW4	2010	1809	3444	1200	1200	2244		1227.5
W5	1490	1341	636	1440	1440	-804	D	
HW6	2630	2367	6792	1680	1680	5112		597.5
HW7	3530	3177	11652	1920	1920	9732		1925

HW = Hand weeding.

Conclusions and recommendations

Weeds in rice crop at Metema are found serious production constraint. The results of the current study showed that the rice crop is sensitive to weed infestation where a yield loss reaching as high as 91.73% to 100% was recorded in rice fields which were not weeded.

Nevertheless, relatively little attention has so far been paid to research and extension on weed management in rice. In the current study, it was found that weeding rice at 20, 35 and 50 DAE had increased both productivity and profitability in Metema. Therefore, this weeding time and frequency is recommended for rice production in Metema.

Acknowledgment

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References

Adeosun, J.O. 2008. Predicting yield of upland rice (*Oryza sativa* L.) under weed infestation. Nigerian Journal of Weed Science Society 21:50-66.

AICAF. 2001. Rice Pest in Tropics, Japan. Association for International Cooperation of Agriculture & Forestry, Japan, March 2001. Ichibancho, Chiyoda-ku, Tokyo, Japan. 119 pp.

Akobundu, I.O. 1987. Weed Science in the tropics: Principles and Practices, John Wiley and Sons-Interscience Publication, New York.

CIMMYT (International Maize and Wheat Improvement Centre). 1988. From Agronomic Data to Farmer Recommendation: An Economics Training manual. Completely Revised Edition. CIMMYT. Mexico. D.F.

CSA (Central Statistical Authority). 2008. Agricultural Sample Survey Report on Area and Production for Major Crops (Private Peasant Holdings 'Meher' season). The FDRE Statistical Bulletin. 302. Addis Ababa, Ethiopia.

FAO. 2004. Rice and Us. Food and Agricultural Organization of the United Nations, Rome, Italy.

RDA Suwon. 2006. Occurrence and Management of weeds on rice. Korea crop protection association, Korea.

Wolelaw, S. 2005. Factors Determining Supply of Rice: A Study in Fogera District of Ethiopia. Msc. Thesis. Haramaya University.

Yield and yield components of potato (*Solanum tuberosum* L.) cultivars as jnfluenced by seed tuber storage duration at Adet, Northwest Ethiopia

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Abstract

A field experiment was conducted at Adet in 2009/2010 to determine the effects of seed tuber storage durations on yield and yield components of improved potato cultivars. Seeds of Potato cultivars, Guassa and Zengena, stored in diffused light store for periods of 2, 3, 4, 5, 6 and 7 months prior to planting. Field experiment was carried out 2 x 6 factorial arrangements in a randomized complete block design with three replications, and cultivar and storage durations were completely randomized within each block. Analysis of variance indicated that statistically significant ($P < 0.05$) variation was observed among the storage durations. Results of this study also indicated that, days to emergence, stem number per hill, days to maturity, tuber number per hill and total tuber yield were found to be the parameters most affected by seed tuber storage duration. Six months stored tubers of both cultivars gave plants which are early to emerge, better leaf area, stem number, biomass, and tuber number and weight, yield, specific gravity and dry matter. The highest total tuber yield was recorded from 6 months old tubers of Guassa (30.30 ton ha^{-1}) and Zengena (27.49 ton ha^{-1}) and the lowest was from 7 months old seed tubers (20.66 ton ha^{-1}). Generally it was found that 32.01% yield advantage was recorded from 6 months compared to 7 month storage. Therefore, it is concluded that both cultivars have attained optimum seed tuber physiological developmental stage at 6 months storage duration at Adet for high crop productivity. Since this experiment was conducted at one location for one season; it is difficult to give final recommendations at this stage. Thus, considering additional storage durations, further study across locations and season can provide more information on the impact of seed tuber age on seed quality and yield potential of the crop.

Introduction

In Ethiopia, potatoes are basically stored for two reasons: ware and seed. Farmers use different traditional potato storage system (underground storage, floor storage, and raised beds and in sacks) depending on the use (ware or seed). Nearly all the major physical, physiological and disease problems that cause quality loss were not effectively regulated in the above mentioned tuber storage methods. Thus, the problem is very critical in affecting seed quality and subsequent performance of the crop in the field (Endale *et al*., 2008). Observations made at Holleta indicated that tubers could be stored as along as 7 months without considerable loss of seed quality. The storage performance, however, was noted to vary depending on cultivar and location (Endale *et al*., 2008).

Entire crop may fail if seed tubers that are not at proper stage of physiological development are planted (Endale *et al*., 2008). Hence, lack of proper storage facilities is one of the main factors forcing farmers in Ethiopia to sell their potatoes on harvesting, even at low prices. Due to the high perishability of potato and poor storage facilities and methods, most farmers cannot store potatoes for a long time. Problems in both seed and ware potato storage are a serious challenge for most farmers leading to storage losses that can reach up to 50% and some times higher (Bergel, 1980). In Ethiopia, farmers store seed potato for 8-9 months which is quite open for disease build up and tuber degeneration. At this stage, seed tubers of the varieties under evaluation have very long and weak sprouts. This means that the genotypes are being evaluated under sub-optimal physiological conditions.

Moreover, still there is no research recommendation at Adet agricultural research center regarding storage durations for improved varieties. In addition, information regarding the effect of seed tuber storage duration on subsequent crop performance of potato under Adet condition is scanty. Therefore, the study was conducted to investigate the effect of seed tuber storage duration on yield and yield components of improved potato cultivars.

Materials and methods

The study area

The experiment was conducted at Adet Agricultural Research Center, Northwestern Ethiopia, during 2009/2010 cropping season. Adet lies between 11^0 16’N latitude and 37^0 29’ E longitude at an altitude of 2240 meters above sea level. The mean annual rainfall of the area is 1250 mm and the maximum and minimum temperatures recorded were 26.54 ^{0}C and 11.37 ^{0}C, respectively (Data taken from Adet Meteorological Station). The soil is well drained red brown camisole with an organic matter content of 6.53% and a pH of 5.43.

Experimental materials, treatments and design

A 2 x 6 factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Two cultivars of potato (Guassa and Zengena) and six seed storage durations (2, 3, 4, 5, 6 and 7 months after harvesting) were combined to produce 12 treatments, and each treatment was randomly assigned to the experimental plots in each block. A gross plot size of 3.75 x 3.3 m accommodating five rows and 11 tubers per row and a net plot size of 1.5 x 2.7 m were used for data collection.

Trial management and crop culture

Tubers from each cultivar were stored in a Diffuse Light Store (DLS) at maximum and minimum temperatures ranging from 29.98 ^{0}C to 8.04 ^{0}C for two to seven months storage durations. Uniform in size and healthy seed tubers from each variety and age group were planted in the first week of December 2009 at the spacing of 75 cm between rows and 30cm between plants. Phosphorus was applied as Diammonium Phosphate (DAP) at the rate of 69 kg P_2O_5 ha^{-1} and Nitrogen was side dressed at the rate of 81 kg N ha^{-1} in the form of urea. To maintain adequate moisture in the soil, plots were irrigated weekly. Other cultural practices like weeding, hoeing and cultivation were carried out as required. The vines were killed two weeks before harvesting for proper skin set and wound healing.

Data Collection

Days to emergence was recorded when 50 percent of the plants per plot were emerged and emergence percentage per plot was also recorded after emergence. Days to flowering was recorded as the number of days from emergence to 50 per cent of flowering. Plant height was measured as the distance from the base of the stem to the tip of five randomly selected matured plants per plot of the central rows. Leaf area was estimated using a portable leaf area meter (Model CI-202-Area Meter CID.Inc., USA) on five selected hills per plot after 50 percent flowering. Six weeks after flowering, while the vines were green but had practically ceased growth (CIP,1983), five randomly selected hills per plot were harvested and dried in oven at 72 ^{0}C to a constant mass to determine aboveground (stem, branches and leaves) and underground (root, stolon and tuber) dry biomass. Days to physiological maturity were recorded when the haulms of 50% of the plants in each plot turned yellowish.

The actual number of main stems per hill was recorded from five sampled hills per plot at physiological maturity. Marketable and total tuber yields were recorded from two central rows of plants excluding two plants from each end of the two rows. Average tuber weight was determined from 10 tubers sampled per plot at harvest. Tuber specific gravity was determined using weight-in-air and weight-in-water method (Murphy and Goven, 1959) from five kilogram tubers. For tuber dry matter content, 100 g of tubers from 10 sampled tubers was chopped and oven dried at a temperature of 72 ^{0}C to a constant mass.

Data analysis

The field data collected was subjected to analysis of variance SAS statistical software Version 9.00 (SAS institute, 2000). Means of significant differences were compared using Least Significant Difference (LSD) test at 5% probability level.

Results and discussions

Sprout number and sprout length

Data recorded during tuber storage indicated that sprout number was highly influenced by seed tuber storage durations and cultivar (Figure 1). Maximum number of sprouts (4.0) was recorded from Guasa stored for 5 months while minimum number of sprouts (1.2 on averages) was from 3 and 4 months old Guassa and Zengena tubers, respectively. Zengena did not produce sprouts until 3 months of storage indicating its long dormancy period as compared to Guassa. Caldiz (1991) reported that number of sprouts and their behavior was highly affected by seed tuber storage age at planting. The number of sprouts per seed tuber has an implication on number of main stems produced in the field (Morris, 1969). Goodwin *et al.* (1969) found that the number of main stems in the field was proportional to the number of sprouts at planting. The length of sprout increased with increasing storage durations considered as indicated in Figure 2. The longest sprout was recorded from 7 months stored tubers. This is in conformity with Kawakami (1952) who found that the rapidity of sprout length growth increased with seed tuber age during storage though too long and weak sprouts are not desirable as they could be damaged during handling and transport.

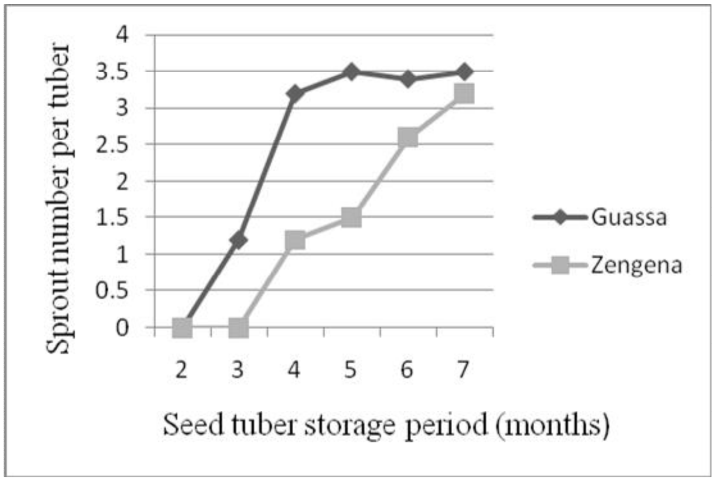

Figure 3. Number of sprouts versus storage period.

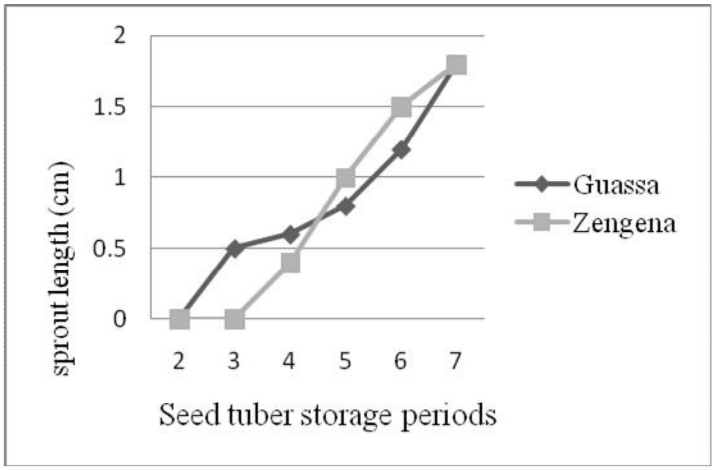

Figure 4. Length of sprouts per tuber versus storage periods.

Storage losses

Storage losses of up to 26.8% of Guassa and 29.4% of Zengena were recorded in 7 months storage period. Similarly, Tesfaye and Yigzaw (2007) reported that seed tuber losses could reach up to 50% during 7- 8 months storage at Adet depending on a variety.

Days to Emergence and Emergence Percent

The analysis of variance indicated that days to emergence was significantly ($P<0.05$) influenced by the interaction effect of cultivar and seed tuber storage durations (Table 1). Tubers of both varieties that were stored for 6 or 7 months emerged earlier than those tubers of the same varieties stored for 2 months (Table 1). Vander Zaag and Van Loon (1987) reported that plants growing from seed tubers of different physiological age performed differently. According to Struik and Wiersema (1999) the length of time from planting to emergence depends on storage age of seed tubers.

Percentage of emergence was significantly ($P<0.05$) influenced by the interaction effect of cultivar and tuber storage period (Table 1). However, in the case of Zengena, 7 months old seed tubers showed significantly lower emergence percentage (72.77%) as compared to that of the other storage durations (Table 1). The low rate of plant establishment from old seed tubers is more explained by weak sprouts and low starch reserves for sprouts to develop in stems because of advanced seed tuber ages though moisture and depth of planting are also causes for low rates (Struik and Wieresema, 1999).

Table 1. Days to emergence and emergence percentage of potato as affected by the interaction effect of cultivar and seed tuber storage duration at Adet.

Treatments		Days to Emergence	Emergence (%)
Variety	Storage duration (months)		
Guassa	7	14.00g	84.88a
	6	14.00g	89.09a
	5	20.00f	92.73a
	4	22.67e	90.91a
	3	30.67c	85.46a
	2	36.00b	92.73a
Zengena	7	15.00g	72.77b
	6	14.67g	93.94a
	5	25.67d	87.31a
	4	25.67d	92.12a
	3	32.00c	87.27a
	2	45.00a	91.51a
Mean		24.61	88.39
Cultivar x Storage (5 %)		2.4	10.38
CV (%)		5.85	6.94

* significantly different at 0.05 probability level; Means followed by the same letter within a column are not significantly different at 0.05 probability level.

In favor of the current finding, Vander Zaag (1973) reported that physiologically old seed tubers shorten the time between emergence and senescence. Moreover, Eremeev and Joudu (2007) reported that plants coming from physiologically older seed tubers obvious signs of senescence started to appear earlier. Wurr (1982) also found that storage of potato seed tubers for long periods of time significantly shortens days to physiological maturity of the progeny crop.

Plant height

The analysis of variance indicated that plant height was significantly ($P<0.05$) influenced by cultivar (Table 3). Cultivar Zengena gave better plant height than that of Guassa. Differences in plant height due to seed tuber ages were not significant. However, as previously reported by Kumar and Knowles (1993), a 6 month storage period was optimal in terms of growth vigor and canopy structure. Reports also indicted that planting physiologically older seed tubers results in smaller plants with more stems and promotes earlier tuberization and senescence (Ewing, 1997). This is may be due to the same harvesting time that halts growth of tubers stored for short period.

Leaf area

The results showed significant ($P<0.05$) variation with respect to total leaf area per plant between cultivars and among the seed tuber storage durations (Table 3). Cultivar Guassa produced more leaf areas (3411.90 cm^2) per plant as compared to that of Zengena (2058.80 cm^2) (Table 2). The highest average leaf area per hill (3393.60 cm^2) was recorded from 6 months old seed tubers of both cultivars (Table 3). However, 7 months old seed tubers have produced lower leaf area (2921.2 cm^2). Similarly, growth characterization study of Mikitzel and Knowles (1990) showed that the production of more leaves in older seed tuber occurred at the expense of dry matter accumulation per leaf and resulted in greatly reduced leaf area per shoot and leaf. Similar report by Wieresema (1989) indicated that older seed tubers have longer sprouts and earlier emergence, canopy development and tuber initiation but may also show a lower leaf area or ground cover.

Table 2. Plant height, leaf area per plant, days to flowering and physiological maturity of potato as affected by the main effect of cultivar and seed tuber storage durations

Main effect	Plant height (cm)	Leaf area (cm^2)	Days to flowering	Days to physiological maturity
Variety				
Guassa	49.39b	3411.9a	61.55	109.89a
Zengena	61.90a	2058.8b	61.44	105.89b
LSD (5%)	3.9	492	ns	2.1
Storage duration				
7 months old	53.25	2921.2b	53.00d	97.50d
6 months old	58.57	3393.6a	53.67d	98.83d
5 months old	58.43	2218.3b	61.00c	106.83c
4 months old	52.78	2669.5b	63.00c	109.10c
3 months old	55.52	2587.4b	65.33b	113.33b
2 months old	55.33	2626.2b	73.00a	121.33a
LSD (5%)	ns	852.4	2.05	3.58
CV (%)	10.13	26.03	2.79	2.77

Ns,* non-significant and significantly different at $P<0.05$, respectively; Means followed by the same letter are not significantly different at $P<0.05$.

Main stem number hill^{-1}

Statistically significant ($P<0.05$) differences were observed between cultivars and among different seed tuber storage durations with respect to number of main stems hill^{-1} (Table 3). Guassa produced significantly higher number of stem hill^{-1} than Zengena. Seed tubers stored for six months resulted in significantly higher number of main stems per hill followed by seven months old tubers (Table 3). Seed tubers stored for 2, 3 and 4 months gave the lowest and comparable number of stems per hill (Table 3). In favor of this result, Kawakami (1952) reported that the difference in the number of main stems of different cultivars is due to the basic correlation between the age of seed tubers and the number of tubers those sprouted.

Biomass yield

A significant variation ($P<0.05$) in above ground and underground dry biomass was observed between cultivars and among seed tuber ages (Table 3). Guassa produced higher aboveground and underground dry biomass than Zengena (Table 3). Mikitzel and Knowles (1990) indicated that plants from old seed tubers displayed reduced shoot, root and leaf dry weights and these effects reflect altered dry matter partitioning and contributed to an overall change in plant morphology with advanced tuber age.

Table 3. Stem number per hill, aboveground dry biomass and underground dry biomass yield of potato as affected by cultivar and seed tuber storage duration.

Main effect	Stem number hill^{-1}	Aboveground dry biomass (g hill^{-1})	Underground dry biomass (g hill^{-1})
Variety			
Guassa	3.17a	64.95a	12.85a
Zengena	1.99b	58.02b	11.82b
LSD (5%)	0.40	2.44	0.97
Storage duration			
7 months old	3.50b	65.55b	11.47b
6 months old	4.40a	77.47a	16.64a
5 months old	2.27c	66.28b	12.06b
4 months old	1.95cd	56.90c	11.39b
3 months old	1.98cd	54.38c	11.21b
2 months old	1.40d	48.35d	11.23b
LSD (5%)	0.70	4.22	1.69
CV (%)	22.64	5.74	11.44

Ns,*: non-significant and significant at 0.05 probability level, respectively; Means of the same main effect within a column followed by the same letter are not significantly different at 0.05 probability level.

Tuber number hill^{-1}

Variety and seed tuber storage duration significantly ($P<0.05$) affected seed tuber number hill^{-1} (Table 4). Guassa produced significantly higher number of tubers per hill than Zengena (Table 4). The number of tubers increased with the increase in seed tuber age and the highest mean tuber number was observed for 6 months old seed tuber while the lowest was from 2 months old seed tuber (Table 4).

Average tuber weight

Statistically significant ($P<0.05$) differences were observed between the cultivars and among seed tuber storage durations with regard to average tuber weight (Table 4). However, the interaction effects of cultivar and seed tuber storage durations were found to be non-significant. Guassa gave higher average tuber weight than that of Zengena (Table 4). Six months stored seed tubers of both cultivars produced large tubers as compared to 7 months stored seed tubers (Table 4). Studies by Knowels *et al* (2003) showed a shift in tuber size distribution in relation to stem number per plant as affected by seed tuber age in storage.

Tuber specific gravity and dry matter content

Tuber specific gravity and dry matter content were not significantly ($P<0.05$) influenced by cultivar and their interaction effect with seed tuber storage durations. However, both parameters were significantly affected by seed tuber storage durations (Table 4). Tubers with the highest specific gravity (1.100 g cm^{-3}) and dry matter content (23%) were obtained from 6 months old seed tubers. This indicated that six months seed tubers are optimal for these cultivars to potatoes suitable for processing at Adet and similar environments.

Marketable and total tuber yield

Variety and seed tuber storage duration significantly ($P<0.05$) affected marketable and total tuber yield per hectare of potato. Variety Guassa consistently produced higher marketable (24.66 ton ha^{-1}), and total tuber yield (27.29 ton ha^{-1}) than Zengena (Table 5).

Table 4. Effect of cultivar and seed tuber storage duration on tuber number hill^{-1}, tuber weight, tuber specific gravity and dry matter at Adet

Main effect	Tuber number hill^{-1}	Average tuber weight (g)	Specific gravity (g cm^{-3})	Dry matter Content (%)
Variety				
Guassa	12.6a	83.84a	1.0850	19.54
Zengena	9.8b	74.21b	1.0867	19.94
LSD (5%)	1.47	9.07	ns	ns
Storage duration				
7 months old	14.0a	76.63b	1.0867b	21.83b
6 months old	14.7a	92.38a	1.1000a	23.00a
5 months old	11.0b	77.05ab	1.0850b	19.33bc
4 months old	10.0bc	78.50ab	1.0850b	18.50c
3 months old	9.2bc	79.67ab	1.0817bc	17.83c
2 months old	7.7c	69.93b	1.0767c	17.67c
LSD (5%)	2.5	15.71	0.008	2.65
CV (%)	19.01	16.60	0.62	11.23

*: significantly different at 0.05 probability level; Means of the same main effect within a column followed by the same letter are not significantly different at 0.05 probability level.

In the present study, the maximum marketable and total tuber yield were obtained from 6 month stored tubers. Meyling and Bodlaender (1981) reported that inter-varietal differences in tuber yield of potato cultivars were largely due to differences in dry matter production. Caldiz *et al.* (1996) also indicated that because of high rate of dry matter accumulation, plants coming from physiologically young seed tubers produce maximum tuber yield. Results of the present study were also supported by Kawakami (1962) who explained that seed tuber aging is physiological degeneration or loss of ability of a seed tuber to produce plants with high yield potential through its effect on tuber yield per plant.

Table 5 Effect of cultivar and seed tuber storage duration on marketable, unmarketable tuber yield and total tuber yield.

Main effect	Marketable yield (ton ha^{-1})	Total yield (ton ha^{-1})
Variety		
Guassa	24.66a	27.29a
Zengena	18.52b	20.55b
LSD (5 %)	2.7	2.7
Storage duration		
7 months old	17.90b	20.66b
6 months old	27.01a	30.30a
5 months old	20.45b	23.08b
4 months old	21.16b	23.01b
3 months old	21.89b	23.75b
2 months old	21.11b	22.72b
LSD (5%)	4.68	4.64
CV (%)	18.11	16.20

Ns,* non significant and significantly different at 0.05 probability level, respectively; Means of the same main effect within a column followed by the same letter are not significantly different at 0.05 probability level.

Conclusions

Results of the study showed that varieties responded differently to seed tuber storage durations for some of the parameters considered. It was observed that storage of seed tubers for 6 months significantly shortened days to emergence, flowering and maturity, increased stem and tuber number as compared to other storage periods. Irrespective of the cultivars, the highest tuber yield (30.3 ton ha^{-1}) was harvested from 6 months old seed tubers whereas lowest (20.66 ton ha^{-1}) was from 7 months old tubers though it was statistically non significant as compared to the remaining storage periods.. It is indicate that compared to 6 months old tubers, 7 months storage period resulted in 32% yield reduction. The highest specific gravity values (1.1000 gcm^{-3}) and tuber dry matter content of (23.67%) was recorded from 6 months stored tubers. As a conclusion, storing seed tubers of Guassa and Zengena and morphologically similar potato cultivars for six months can give optimum potato production for Adet and similar edaphic and climatic conditions.

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References

Bergel, H., 1980. Production, Marketing and Consumption of Potatoes in the Ethiopian highlands. Centre for Advanced Training in Agricultural Development, Institute of Socio-Economics of Agricultural Development, Technical University of Berlin.

Caldiz, D.O., Fernandez, L.V. and Struik, P.C., 2001. Physiological age index: a new, simple and reliable index to assess the physiological age of seed potato tubers based on haulm killing date and length of incubation period. *Field Crop Res.*69: 69-79.

Chase, R.W.,1995. Tuber set and its influencing factors. National Crisping Potato Industry Workshop, proceedings. Myer, A.J.(ed.) Publ Victoria Potato Research Group, Victoria.

Endale Gebre, Gebremedhin Woldegiorgis, Dagnachew Bekele and Berga Lemaga, 2008. Potato post-harvest management. pp. 113-129. In: Gebremedhin Woldegiorgis and Endale Gebre and Berga Lemaga (eds.). Root and Tuber Crops: Untapped Resources. Ethiopian Institute of Agriculture Research, Addis Ababa, Ethiopia.

Eremeev, J. and J. Joudu,2007. Effects of thermal shock and pre-sprouting on field performance of potato in Estonia. *Agronomy Research* 5:21-30.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research Second ed. John Wiley and Sons, Inc. USA. p. 680.

Goodwin, P.B.,A. Brown J.H. Lennard and F.L. Milthorpe, 1969. Effect of centre of production, maturity and storage treatment of seed tubers on the growth of early potatoes. *Agr.Sci. J.* 73:167-176.

International Potato Center (CIP), 1984. Potato for Developing World. Lima Peru. p. 148. Available on line at http://www.Potato 2008.org/en/world/Africa.html among Africa (FAOSTST data 2007). Accessed on 3/4/2009.

Knowles, N.R., Knowles, L. and Kumar, G.N.M., 2003. Stem number and tuber set relationship for Russet Burbank and Umatilla Russet potatoes in the Colombia Basin. *Potato Progress* 3(13).

Meyling, H.D.G. and K.B.A. Bodlaender,1981. Varietal difference in growth, development and tuber production of potatoes. *Neth. Agr. Sci. J.* 29 :113-127.

Mikitzel, U. and Knowles, N.R., 1990. Changes in respiratory metabolism during sprouting of aged potato-seed tubers. *Can. J. Bot*. 68:1619-1626.

SAS institute,2000. Statistical Analysis System. Version 9.00. SAS Institute Inc. Cary, North Carolina, USA.

Tesfaye Abebe and Yigzaw Desalegne, 2007. Review of crop improvement research achievements and future focus in parts of western Amhara Region. The case of Adet. In: Proceedings of the first Amhara Region Regional Workshop on Potato Research and Development: Achievements and transfer experiences and future directions. Bahir Dar, Ethiopia, 20-21 December 2007.

Vander plas,L.H.W.,1987. Potato tuber storage: biochemical and physiological changes. In: Bajaj, Y.P.S. Biotechnology in agriculture and forestry,3.potato. Berlin: Springer Varlag, pp. 109-135.

Wiersema,S.G.,1989. Comparative performance of three small seed tuber sizes and standard size seed tubers planted at similar densities. *Potato Res.* 32: 81-89.

LIVESTCOK RESEARCH

Assessment of beekeeping practices in Eastern Amhara Region with emphasis on improved beekeeping technologies

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Abstract

This study was conducted in *Gubalafto Wereda* of North Wolo Zone, Amhara Regional State, Ethiopia with the objectives of assessing beekeeping practices using improved beekeeping technologies. Purpesive sampling technique was employed to identify the sample respondents. About 40 representative sample respondent beekeepers that own improved box hive with honeybee colonies at present or lost in recent due to various reasons were selected from each of the three agro ecologies. Based on the sampling technique, 120 improved beekeeping technology users were selected. The data were collected using structured and semi-structured questionnaires to interview respondents individually and were analyzed using descriptive statistical procedure of SPSS Version 12 software. Major problems for promoting improved beekeeping technologies were identified in the study area. Percentage ranking revealed that incompleteness of the box hive package, prevalence of honeybee pests and enemies, shortage of bee forage, pesticide application, absconding of honeybee colonies, honeybee disease and lack of beekeeping skill were found to be the major challenges for the improved beekeeping technology usage in the Wereda in their decreasing order of importance. Because of lack of proper technological inputs, trained manpower and prevalence of different bee enemies, the beekeeper households have not been sufficiently benefiting from the sub sector. There still exist enormous opportunities and potentials to boost the production and quality of hive products. Hence, it is recommended that beekeeping extension, research and NGOs should enhance research and extension activities on full packaged provision of box hive technologies: honey extractor, queen excluder, foundation sheet, protective clothes and developing protection methods of honeybee enemies, development of bee forage, management of pesticide application and absconding of bees and economically important honeybee disease control The emphasis should also be given to developing a technologies from locally available materials to ensure sustainability. Organizing formers' visit to apiary demonstration sites is also equally important.

Key words: Bekeeping, improved technologies, North Wolo.

Introduction

Beekeeping is long standing and deep rooted household activity for rural communities of Ethiopia where millions of honeybee colonies are kept in traditional hives in backyard and/or in forest. Honeybee colony management practice is different at different geographical locations (Ayalew and Gezahegn, 1991; Girma, 1998). Amhara Regional State is endowed with varied agro ecological zones that are suitable for apiculture, sustaining about 917,460 honeybee colonies (CACC, 2003), which is a real reflection of the potentiality of the region. However, the level of beekeeping remained traditional where more than 90% of honeybee colonies are still kept in traditional hives, with various limitations.

In spite of introduction of improved beekeeping since 1965, the development has not traveled long distance in the region. The regional government has recently put beekeeping as one of development strategies to reduce poverty and to diversify farmers' income as well as to diversify national export commodities. As the result, the extension service has aggressively disseminated thousands of improved beekeeping equipment, like frame hives, Kenyan top bar hives and other accessories. Despite the attempt of disseminating improved beekeeping technologies by Wereda Agriculture Office and different NGOs in *Gubalafto Wereda*, still over 80% of honeybee colonies are kept in traditional hives, indicating the less adoption of improved beekeeping technologies, which calls for further investigated.

There was little or no feedback study about challenges and opportunities to use improved beekeeping technologies. However, beekeepers complain that they failed to obtain the expected honey yield using box hive technologies. Identification of bottle necks is important for policy makers, extension workers, researchers, and non-governmental organizations involving in beekeeping development programs and helps modify their strategies by providing the information about types of challenges and identifying opportunities to use further. Hence, the study was aimed at contributing much to generate appropriate information on factors affecting the use of improved beekeeping technologies.

So far, there is no compiled and reliable information on the challenges of using frame hives, overall beekeeping activities and other associated constraints. Therefore, this study was undertaken to identify bottlenecks and opportunities for using improved beekeeping technologies in *Gubalafto wereda*, Amhara Region.

Materials and methods

The study area

The study was conducted in *Gubalafto Wereda* of North Wollo Zone, Amhara National Regional State. Agro-ecologicaly it has *Dega* (highland, about 37 %), *Woynadega* (mid altitude, about 46%) and *Kolla* (lowland, about 17 %). In the highlands, the dominant honey plants are *Olea europea*, *Rosa abyssinica, Albizia gummifera, Guitozia abyssinica; Guizotia scabra* in the mid altitude, *Acacia abyssinica*, *Coffee arebica*, *Croton macrostachya*, *Guitozia abyssinica*; *Guizotia scabra*, *Trifolium species*, *Olea europea*, and *Vernonia amygdalina* and in lowlands, there are *Acacia abyssinica*, *Albizia gummifera* and *Croton macrostachya*. Generally, the topography of the woreda is rugged and chain of mountain terrains. The current rainfall either begins lately or quits early before the crops mature. The mean annual temperature of the area is 22 ^{O}C with the maximum and minimum averages of 25 ^{O}C and 7.5 ^{O}C, respectively. The livelihood of the people in the study areas is based on subsistence mixed farming system. Most of the sample households owned less than one hectare of land. About 5,803 honeybee colonies which account about 11% are kept in box hives (GWOARD, 2009).

Sampling procedure and data collection

Out of 32 *kebeles* that the *Wereda* has, about 20% was selected purpesively. Before commencing data collection, preliminary survey using a checklist (pre-testing questioner) was conducted to gather relevant information. Primary data were obtained from beekeeper household heads whereas secondary data were taken from the *Wereda* and Zonal Agriculture and Rural Development Offices and NGOs in the *Wereda.* The target sampling populations in the study wereda were farmer households who currently own honeybee colonies in the improved hives as well as those who recently lost their honeybee colonies from their improved hives due to various reasons. To collect qualitative and quantitative data on improved beekeeping technology usage, six rural *kebeles* two from each agro-ecological zone (highland, mid altitude and lowland) were selected. A total of 120 beekeeper sample households (40 beekeeper households each from highland, mid altitude and from lowland) were interviewed using semi structured questioner. The household selection was carried out from the list of farmers registered as members of the rural *kebeles* using improved beekeeping technologies.

The study was designed to address determinant factors of using improved beekeeping technologies; such as beekeeping activities experience, apiary site location, awareness on improved beekeeping technologies, trend of using improved beekeeping technologies and labor division for beekeeping. The study has also addressed areas of credit access and beekeeping extension service, honey yield of different beehive types, marketing of hive products, honeybee ecotypes and management, availability of improved beekeeping equipments, honeybee diseases, pests and predators, honeybee flora of the study area, herbicides, insecticides and poisonous plants which all affect the usage of improved beekeeping technologies..

Statistical analysis

The data were analyzed using Statistical Package for Social Science, SPSS version 12 software (SPSS, 2002) and cross tabulation.

Results and discussion

Improved beekeeping experience and sources of honeybee colonies

Most of the respondents (49.2%) started to use improved beekeeping technologies during 2003 and 2004. Different sources of honeybee colonies to start improved beekeeping technology were assessed and identified during the survey (Table 1). To start improved beekeeping, most beekeepers practiced transferring the honeybee colonies bought and/or owned in traditional hives to transitional and box hives. Some farmers have developed the skill of rearing/multiplying honeybee colonies as one of the main sources of obtaining additional colonies for the intermediate and modern beehives.

This is encouraging trend for beekeepers in the area rather than waiting accidental swarm coming to their hives hanged on trees.

Table 1. Year of commencement and sources of honeybee colonies to start improved beekeeping.

Year commencement and percentage of farmers utilizing improved beekeeping technologies			
2003	2004	2005	2006
16.7%	32.5%	22.5%	28.3%
Sources of honeybee colonies to start improved beekeeping tech. and %			
Transferring from traditional Hive	Caching intentional swarm	Purchasing established colony	From family
63.3%	10.0%	22.5%	4.2%

Honeybee colony holding

In general, the beekeeping business was practiced at a very small-scale level in the study area. The average total honeybee colony holding was 4.6 in highlands, 2.8 in mid altitude, and 2.7 in low lands. The total honeybee colony holding has positive correlation with altitude ($P<0.01$). The availability of honeybee colonies positively affected utilization of improved beekeeping technologies.

When improved Zander frame hive is considered; out of 73.3% of total respondents who own box hives with honeybee colonies, about 80.7% of them (73.3%) have only one frame hive with honeybee colonies (41% at mid altitude, 29.5% at highlands and 29.5% at lowlands), 11.4% have two honeybee colonies (more in highlands) and 7.9% have three or more honeybee colonies (more in mid altitude) in box hives. Some beekeepers (41.7%) have also empty frame hives. About 74% of those who have frame hives without honeybee colonies (57% at lowlands, 27% at high lands and 16% at mid altitude) have one empty frame hive, 22% have two (45% from lowlands, 36% from mid altitude) and only 4% have three frame hives without honeybee colonies (all from lowlands) because of absconding and death of the colonies due to different reasons (Table 2).

Table 2. Number and occupation of hive types per household.

	Traditional hives		Transitional hives		Improved box hives	
	With honeybee colonies	Without honeybee colonies	With honeybee colonies	Without honeybee colonies	With honeybee colonies	Without honeybee colonies
Mean	2.27	3.11	1.76	1.37	1.33	1.30
Std. deviation	1.73	3.49	1.03	0.72	0.80	0.54
Maximum	10	30	5	4	5	3

The high number of empty frame hives in the study area might be related to incidence of bee enemies like, bee-eater birds and wax moth. Moreover, unwise application of pesticides has also caused loss of honeybee colonies in the area. The cumulative effect of other factors has given the result of owning empty frame hives where honeybee colonies had either dead or absconded. The source of different hives is presented in the following table (Table 3).

Table 3. Source of different hives.

Source	Types of hives		
	Traditional hive	Transitional hive	Modern frame hive
Farmer	2.7	-	1.8
Own	85.7	77.6	1.8
Retailer	11.6	2.6	-
BOA	-	17.1	93.7
NGOs	-	2.6	0.9
Family	-	-	1.8

Trend of improved beekeeping technologies usage

According to the respondents, the trend of using improved beekeeping technologies over the last five years was generally decreasing, about 53.3% (48.4% from lowlands, 26.6% from highlands and 25% from mid altitudes in which one beekeeping cooperative is found). The reasons for decreasing the trend of improved beekeeping technology usage were low honey yield and frequent absconding of colonies from frame hives due to poor technical support, incomplete package supply, coldness of the hive in highland areas, drought, and high internal hive temperature due to absorption of heat from cover in lowland areas. Beeswax for example to make foundation sheet has only given once when the beekeepers take the frame hive from *Woreda* Office of Agriculture and Rural Development to transfer their colonies from different sources. Due to absence of foundation sheet supply during adding super and the presence of queen excluder, bees are neglected to go up to the added super. Even though the dissemination of framed box hive is highly appreciated, absence of full package technology supply has highly affected the effectiveness of improved box hive technology and acceptance by beekeepers.

Death of honeybee colonies by pesticides and unknown reasons, attack by predators and low productivity of these hives let the beekeepers unable to pay the loan of the hives. The respondents have also indicated that the price of the hive was unaffordable and the hive management was impractical for them. As the result, primary users of the frame hive technology have failed and informed other farmers as the new technology was unproductive for them. This has also played a great contribution for decreasing trend of using frame hive technology. The beekeepers as well as crop producers should be taught about importance of honeybees not only for honey production but also for crop pollination. To overcome the price effect as well as unproductiveness of box hives, increased use of transitional hives should be encouraged.

Labor source for different improved beekeeping activities

Even if beekeeping is socially the responsibility of male household heads, all sample improved beekeeping technology users in the area allow all physically able household members and other technical assistants to participate in the beekeeping activities accordingly. Consequently, women participation in beekeeping was limited compared to men as shown in Table 4.

Table 4. Improved beekeeping activities and labor participation.

Activities	Valid percentage of undertaken activities by				
	Household head	Wife	Children	Cooperatives	Development agent
Swarm catching	98.3	16.7	9.2	.8	.8
Colony Transferring	70.0	4.2	5.8	7.5	7.5
Colony Inspection	99.2	13.3	3.3	0	.8
Colony Feeding*	62.5	9.2	6.7	0	0
Honey harvesting	80.0	1.7	8.3	6.7	24.2
Honey extracting**	13.6	0	0	17.8	11.3
Apiary Sanitation	95.0	53.4	13.6		
Hive making•	82.5	25.0•			6.7
Hive sanitation	87.5	56.8	71.4		
Wax extraction	31.7	29.7			
Hive product selling©	92.5	31.4	3.4		

• Make traditional hive only © 7.6% do not sell honey, *37.5% do not practice colony feeding, **61.7% do not practice honey extraction. Sum of total percentage is more than 100% because of one activity is practiced in more than one household.

Access to credit and beekeeping extension

About 64.2% of improved technology users in the study area have access to credit to practice beekeeping activities whereas 35.8% have not used this access due to different reasons. About 46.5% have their own enough money to buy frame hive and accessories, 27.9% do not have awareness, 4.7% were not benefiting due to high interest rate of the loan, 9.3% discouraged due to late delivery of loan (out of the season of using for beekeeping purpose), 4.7% because of restrictive procedure and 7% due to personal problems. The utilization of credit service sharply declined from 2004 to 2007. This correlates with the decreasing trend of utilizing the improved beekeeping technologies in the study area. Thus, the Woreda Office of Agriculture and Rural Development (WOARD) has to create favorable conditions such as awareness creation on usage of loan, timely supply of loan, revising the interest rate and facilitating those who have their own money. Even if it is encouraging, much has to be done to facilitate utilization of credit service to practice improved beekeeping in efficient and productive way.

Summary of challenges to use improved beekeeping technologies

Currently beekeepers that are using improved beekeeping technologies are facing a number of interrelated challenges that limited productivity and production of honey from improved hives. The major identified challenges include: lack of input to insure correct harvesting and processing, inadequate extension services and lack of trained manpower (experts) at the *Wereda* level, aggressiveness of honeybee species, high price for improved equipment, bee poisoning, lack of good beekeeping management knowledge, limited cultivated bee forage, shortage of honeybee colonies, absconding of the colonies and challenge on marketing of extracted / strained honey.

Summary of opportunities for improved beekeeping

Though there are many challenges in the study area, there is still huge potential to increase honey production using improved beekeeping technologies to improve the livelihood of the beekeepers. Thus, the major opportunities are: availability of credit service, beekeeping training, bee flora, road access, experience of beekeepers, and proximity to research center, good rainfall distribution, market access and high market demand for honey and honeybee colonies and encouraging policy on improved beekeeping practices.

Conclusion

Even though there are adequate natural endowments and a long tradition and culture of beekeeping practices in the study area, the beekeeper households have not been sufficiently benefited from the sub sector mainly because of lack of proper technological inputs, trained manpower and prevalence of different bee enemies,. Yet, despite all the challenges currently facing the beekeeping sub sector, there are still enormous opportunities and potentials to boost the production and quality of hive products specially honey in the area.

There is availability of natural honeybee flora from forest and shrub covered areas as well as biannually cultivated crops.

Recommendations

The major areas of intervention required to ensure the beekeepers to benefit from apiculture are presented as follows:

- The Zander frame hives should be provided with its full packages and all the required accessories; if not, encouraging increased use of transitional hives which do not need much input but provid good amount of honey production. The queen excluder should be inserted on recommended time scale and better to use plastic queen excluder than aluminum queen excluder as the later damages wings of the bees. The top bars for transitional hive should be provided or materials should be made available to produce them locally.
- Establishing on-farm demonstration site and supporting with sufficient and regular training programs for farmers about beekeeping management (feeding, watering, inspection, transferring, supering, multiplying, honey and wax harvesting and handling, bee forage gardening) and providing necessary technical supports, since majority beekeepers have not participated on improved beekeeping demonstration.
- Creating awareness and means of saving honeybee colonies from insecticides applied on cereals, pulses, legumes, and horticultural crops during flowering, and finding the local or scientific prevention and control methods for bee pests; like bee-eater birds, honey badger, wax moths and others.
- Strengthening the established cooperatives and establishing new beekeepers cooperative to facilitate farmer-to-farmer training, honey, and wax collection, primary processing and marketing of hive products. In addition to buying, packing, and selling, the cooperatives should also be able to manufacture their own simple beekeeping equipment such as protective materials from locally available materials, frames, top bars, foundation sheet, and others not to wait the hand of BOARD office in the future.
- To sustain improved beekeeping technology, local crafts men manufacturing top bars specified top bar hives, swarm boxes, protective, veils, smokers, queen cages and other

equipment should be facilitated and trained in addition to training beekeepers and giving loan to start their own hives.

- The beekeeping experts at *Wereda* should get proper training on beekeeping management to provide appropriate training and technical assistance for development agents at grassroots level.
- In addition to natural honeybee floras, improved beekeeping program should also focus on selecting, propagating, and planting of honeybee flora preferably multipurpose.

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References

Ayalew Kassaye and Gezahegn Tadesse. 1991. Suitability Classification in Apicultural Development, Ministry of Agriculture, Addis Ababa, Ethiopia.

CACC (Central Agricultural Census Commission). 2003. Ethiopian Agricultural Sample Enumeration 2001/ 02 Results for Amhara Region. Statistical Reports on Livestock and Farm Implants (Part IV), Central Agricultural Census Commission, Addis Ababa, Ethiopia, pp 45-46.

Girma Deffar. 1998. Non-wood Forest Products in Ethiopia, EC-FAO Partnership Programme (1998-2000), Addis Ababa, Ethiopia.

GWOARD. 2009. Gubalafto *Weredea* Agriculture and Rural Development Office 2009.

On-farm demonstration of splitting queen rearing technique in Eastern Amhara Region, Meket woreda

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Abstract

The splitting technique was demonstrated in meket *woreda*, north wollo zone; where beekeeping activity is predominantly exercised by many farmers. By using this technique, all participant farmers have got on average new daughter colony of 1.09 per hive. The splitting technique has been highly accepted by beekeepers. Out of the total splitted colonies, 67% has adapted and 33% has absconded due to long lasted severe drought in the area during the experimental period. Thus, to encourage farmers and to scale up this technique, the government should focus on creating marketing opportunities for bee colonies produced by the beekeepers.

Key words: Honeybees, queen, rearing, splitting.

Introduction

The diversified agro climatic condition of the country, create environmental conditions conducive for the growth of over 700 species of flowering plants. The high proportion of Ethiopian plants is endemic to the country (Edwards, 1976). The ideal climatic conditions and diversified floral resources allow the country to sustain around 10 million honeybee colonies of which 7 million are kept in different hives by farmers and the remained exist in forest as wild colonies (EMA, 1981).

Beekeeping is the long standing practice in the rural communities of Ethiopia and it appeared as the history of the country (Kassaye, 1990). However, the type of beekeeping practiced in the country is largely traditional, which is being carried out in traditional hives of different types and it vary depending on the ecology and behaviors of the bees (Nuru, 2007).

At present, due to various factors, the populations of honey bee colonies are certainly in the state of continuous decline. As the result, it is becoming more difficult to obtain adequate swarms every year to expand the apiary (Nuru, 2007).

In highlands and mountainous areas of Ethiopia, the swarming tendency of the honey bee colonies is very low. As the result the price of the colony is very high and becoming a good source of income to beekeepers (Nuru, 2002). In these areas where reproductive swarming tendency is low, one of the major problems of apiculture is obtaining swarms either to start or to increase the existing stock. So in these areas, developing simple ways of colony multiplication skills such as splitting queen rearing would be very important. The technique has been proven to be efficient for local honey bee colonies (Nuru and Dereje, 1999). It has also been proven and became effective in western Amhara region and recommended to be done in different potential beekeeping districts of the region where there is promising bee forages and scarcity of the honey bee colonies (Adebabay, 2007).

Thus, it is justifiable to demonstrate the splitting queen rearing technique with regard to honey bee colony multiplication under farmers' condition in Eastern Amhara Region. Hence, the objective of this study was to demonstrate splitting queen rearing technique in Eastern Amhara Region under farmers' management condition.

Materials and methods

The study Area

The study was conducted in one of selected potential beekeeping woreda of North Wollo zone, Meket woreda, from which one kebele was purposely selected.

Sampling techniques and sampling size

As the experimental procedure is considered, nine farmers owning strong honey bee colonies in Kenyan top bar hives were purposively selected and intensive training on splitting queen rearing technique, standard top bar nucleus hives and protecting clothes were given for participants.

Nucleus hives were cleaned and smoked with wax and aromatic plants traditionally known and found around the farmers. Then, the actual splitting of the mother honey bee colonies was undertaken at night using strong torch consecutively by coaching the farmers on checking the presence of eggs and day old larvae, which is potential queen and absence of mother queen during transferring into nucleus hives. The nucleus colonies splitted were put at 100 meter to one kilometer far from the mother colony to avoid the risk of reuniting. At 9th to 10th days after splitting, the nucleus hive colonies were checked whether they have constructed and sealed queen cells. Then, by leaving the best queen cell, others were harvested and destroyed to control swarming. In order to check the safety of honey bee colonies, internal and external inspection was carried out in both mother and daughter colonies. At 12th to 13th days after emerging, the queen was checked for starting to lay eggs and the colony was returned to the normal backyard apiary site. When the colonies in the nucleus hives become populous, they were transferred in to the standard Kenyan top bar hives.

Data collection and statistical analysis

The data collected from the demonstration were: number of hive multiplied, number queens developed/hive, number of nucleus colony produced from each parent hive, number of colony adapted after splitting, number of colony abscond after splitting, and farmers' and extension workers' view about splitting queen rearing technique. The collected data were systematically analyzed and interpreted using descriptive statistics SPSS 12.0 version software (2003).

Results and Discussion

Out of the 11 mother honey bee colonies splitted by nine beekeepers, all have given extra one daughter colony and one has given two daughter colonies. Out of the honey bee colonies that gave one daughter colony, 70% of them have adapted and 30% have absconded whereas from the mother colony that gave two daughter colonies, one daughter colony has adapted and the second has absconded. When the total number is considered, twelve daughter queens have been developed from eleven mother colonies. Out of these, 67% has adapted and 33% has absconded due to long lasted strong drought in the area during experimental period (Table 1). The mean number of queens developed per hive was one and the mean number of nucleus colonies developed from parent hive was 1.09.

Table1. Number of honeybee colonies splitted, adapted and absconded.

	Number of mother colonies splitted	Number of daughter queens developed	Number of daughter colonies adapted	Number of daughter colonies abscond
Total	11	12	8	4
Mean per hive		1.09	67%	33%
Std. error of mean		0.091	0.141	0.152

After the completion of the experiment, field day was organized in Meket woreda at the experimental site kebele. During the field day, target beekeepers, other beekeepers, interested farmers, development agents from the woreda and socioeconomics and livestock researchers from Sirinka Agricultural Research Center have participated.

At the field day, farmers have reflected their opinion as splitting queen rearing has significant importance; they responded that while they have been living with honey bee colonies for long period, they wait intended wild natural swarm coming from abroad by hanging their traditional hive in the long forest trees or long trees around them which needs climbing force as well as gender issue and natural swarming from their hives to increase the existing honey bee colony stock as well to establish new apiary. The new technique has solved their long lasted problem of getting new honey bee colonies.

Continuing their opinion, in traditional bee keeping practice where new colonies are obtained by catching the swarmed colony during flowering period, much useful agricultural time for other farming activities such as weeding, harvesting, livestock keeping and others is wasted and is very tedious. The colony obtained by this method is also subjected to live in traditional hive which intern takes a lot of time to build combs and to become strong colony. Similarly, this method of getting queen by catching the wild swarmed colony takes a long period of time to develop. As a result it is rare to harvest honey from the new colony at the same year of colony catching. But from the new method of queen rearing technique done by splitting either strong transitional or modern hive simply by taking the strong colony of the two hives (transitional or modern); containing seven to ten top bar or frames having a comb with egg, day old larvae and small amount of worker bees to cover the brood comb during the on set of flowering season. As the draw back, farmers have complained as the technique reduces the honey yield at the first year of splitting, however, they have convinced as they can compensate the loss by the produced colony which can be sold or is potential honey producer in the followingyear. It is also possible to get little honey at second cropping period of the year. In this new technology, one can decide for which purpose to use the colony (either for production of colony or honey). The advantage of the new queen rearing method is that the queen is reared by the will of the beekeeper not by the natural process of swarming and it also alleviates the problem of pinching the queen abdomen, and killing the queen and helps to produce queen free of damage.

According to the farmers' expression, the splitting queen rearing technique can be undertaken in both high honey production potential and less honey production potential areas. The beekeepers who live in less honey production potential areas can supplement their income by selling only honey bee colonies which costs more than six hundred ETB; whereas those beekeepers living in high honey production potential areas can benefit from selling both colony and honey. The follower beekeepers who are out of the target participant farmers have also splitted their colonies by constructing nucleus hive from locally available materials. This shows that the technique is accepted by the farmers and it is very easy to be adopted by beekeepers.

Conclusions and recommendations

The result of this study indicated feasibility of rearing queens by splitting the colony under farmers' condition. The work needs further scaling-up across different honeybee production potential areas of the region by using strong mother colonies during onset of flowering season. The focus by the government should aim at creating marketing opportunity of honeybee colonies produced by the beekeepers using the technique.

References

Adebabay Kebede, Keralem Ejigu and Assaminew Tassew. 2007. Onfarm evaluation of colony splitting technique in Amhara region. In proceeding of the 2nd annual regional conference on completed livestock research activities, 14 to 16 September 2007. pp 64-70, Amhara agricultural research institute, Bahir Dar, Ethiopia.

Edwards, S. 1976. Some wild flowering plants of Ethiopia. Addis Ababa university press, Addis Ababa, Ethiopia.

EMA (Etiopian Mapping Agency). 1981. National atlas of Ethiopia. EMA, Addis Ababa, Ethiopia.

Kassye, A. 1990. (The honey bees Apis melifera of ethiopia). A morphographic study. MSc thesis, agricultural university of Norway, Norway.

Nuru Aadgaba and Dereje Wolteji. 1999. response of Ethiopian honey bee colonies to different queen rearing techniques. In proceeding of 7th Annual conference of Ethiopian society of animal production . 1999,pp 125-133, Addis Ababa, Ethiopia.

Nuru Aadgaba. 2007. Atlas of pollen grains of major honey bee flora of Ethiopia. Holleta bee research center, Holleta Ethiopia.

SPSS (Statistical package for social science). 2003. SPSS user's Guide 12.0, (SAS institute inc.)

On-farm reproductive performance of local ewes and their crosses with Awassi in the cool highlands of eastern Amhara region

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Abstract

The objective of this study was to evaluate reproductive performance of local ewes and their crosses with Awassi under farmers' management. The study was implemented in three villages (South Wollo, Menz and Chacha) in the cool highlands of the Amhara region, Ethiopia. Crossbred rams (75% Awassi x 75% Menz) were borrowed to a group of farmers and they agreed with signature to use a ram in rotation both within and among groups of farmers. Age at first lambing in Chacha (490.43 days) and Wollo (470.89 days) was significantly lower than in Menz (592.43 days) while the first two were not different ($p>0.05$) from each other. Local genotypes had significantly lower age at first lambing than Awassi x Local crossbred in all locations. Lambing interval was affected ($p<0.05$) by location and genotype of the ewe. The shortest lambing interval was found in Wollo followed by Chacha and Menz. Local breeds had shorter ($p<0.05$) lambing interval than Awassi crossbreds in all locations. Whereas, in south Wollo Corriedale x Local crossbred ewes had similar lambing interval with Local breeds. Ewe postpartum weight was significantly ($p<0.05$) affected by location, genotype and their interaction. The largest ewe postpartum weight was in Wollo (28.46 kg) followed by Chacha (27.12 kg) and Menz (23.87 kg). Number of lambs born per ewe was affected ($p<0.05$) by location and genotype. Wollo ewes had the highest number of lambs born per ewe (1.58) followed by Chacha (1.49) and Menz (1.39). Local ewes were able to produce higher number of lambs per year than Awassi x Local crossbred ewes. Number of lambs born per ewe per year of Corriedale x Local crossbred ewes in South Wollo was 1.66 which was similar ($p>0.05$) with Local ewes whereas higher ($p<0.05$) than AwassixLocal crossbred ewes. The variation in reproductive performance among locations and farmers indicated the importance of delineating crossbreeding areas depending on the exiting environmental situation and farmers' capacity. Developing appropriate exotic blood level for each area and devising alternative crossbreeding system that enables use of Local and Corriedale x Local crossbred ewes as dam line should also be taken into consideration.

Key words: Awassi, crossbred, ewe, local, reproductive.

Introduction

Short fat tailed sheep breeds (Menz, Wollo, Tikur and Farta) predominantly found in the cool highlands of eastern Amhara region has contributed about 20% and 60% of the total sheep population in the country and in the Amhara region, respectively (Solomon, 2008). The breeds are well adaptive to the environment and research result indicated that they are able to give three lambing in two years (Abebe, 1999; Tesfaye, 2008; Tesfaye, 2008). However, these sheep breeds have slow growth rate than other breeds with mature body weight of about 25 kg and very low twinning rate (Solomon, 2008); as a result, it is difficult to achieve fast return from them. Crossbreeding based on improved sire breed having better productivity is the most rapid way of improving productivity of local flocks.

Among many exotic breeds of sheep, Awassi sheep breed is an important genetic resource that plays a significant role in sheep industry as an improver breed in more than 30 countries besides the countries of its origin (Galal *et al.,* 2008). The Awassi sheep is a predominant dual-purpose, fat-tailed sheep breed of the Middle East. This sheep is well adapted to the harsh condition especially those related to scarcity of feed availability and high environmental temperatures. Similarly, Corriedale is another improved exotic sheep breed which was developed in New Zealand and Australia during the late 1800s' from crossing Lincoln Leicester rams with Merino females. The Corriedale is a dual-purpose sheep and was introduced to Ethiopia to improve meat and wool of local sheep breeds. A crossbreeding project using high grade Awassi and Corriedale sire is currently underway in the highlands of Ethiopia in three different locations to improve meat and wool production of native sheep breeds. Production performance is reflected by a combined effect of reproductive efficiency, growth rate and quality of the final product. Increasing the number of lambs marketed per ewe and per year is a major way to improve the efficiency of meat production in sheep. Evaluating the performance, particularly related to reproduction of crossbred animals at each stage of the project is essential. So far reproductive performances of crossbreds under farmers' situation are not evaluated. Thus, this paper is aimed at evaluating the reproductive performance of indigenous and crossbred ewes in different locations under farmers' management.

Materials and methods

Community-based sheep crossbreeding activity has been started and being implemented since 1998 in three villages, Chiro (Sowth Wollo) and, Sinamba and Chacha (North Shewa) administrative zone. The sites were selected based on their potential for sheep production and high dependency of farmers on sheep production. In this crossbreeding scheme, high grade exotic crossbred (3/4 Awassi x 1/4 Menz and ≥3/4 Corriedale x ≤1/4 Menz) rams were used to cross the indigenous sheep breeds of village flocks. The Awassi crossbred rams were distributed in all sites while Corriedale crossbred rams were distributed only to the Chirro site. The crossbred rams were borrowed to a group of farmers in selected villages. A group of farmers agreed with signature to use a ram in rotation both within and among groups. Farmers were responsible for the use and care of a ram given to them. An enumerator was recruited and trained for data collection and to facilitate ram utilization. A research team from the research center visited the area in three months interval to monitor and evaluate the progress. Unwanted ram lambs (local and crossbred having lower blood level than the distributed rams) were castrated or disposed before breeding age in order to control indiscriminate mating, while crossbred ewe lambs were maintained and backcrossed with the improved ram. Data on pedigree, birth, growth, reproduction and off take were collected regularly. All sheep were de-wormed twice a year against internal parasites. Vaccination was also carried out for common diseases based on the recommendations.

Data on reproductive performances collected from a total of 71 farmers (26 in Chiro, 18 in Chacha and 27 in Sinamba) were used in this analysis. Data were collected from 1998 to 2004. During the crossbreeding process, crossbred having different blood levels were produced. For the analysis of the reproduction data, genotype of the sheep was categorized as Local, Awassi x Local and Corriedale x Local crossbred. Crossbred ewes having 37.5% and above exotic blood level were considered as crossbred and those ewes having less than 37.5% exotic blood level were excluded from the analysis as they were few in number. Data on reproductive performance were analyzed using GLM procedure of SAS version 9.1 (SAS, 2003). In the analysis, genotype and location were fitted as class variables and the reproductive performances as dependant variable. Within location analysis was also implemented for all locations by fitting genotype as class variable. When significant, means were separated using adjusted Tukey-Karmar test.

Results and discussion

Age at first lambing, lambing interval, ewe postpartum weight and number of lambs born per ewe per year by location, genotype and by genotype within location are presented in Table 1. Age at first lambing was significantly ($p<0.05$) affected by location, genotype and the interaction of the two. Age at first lambing in Chacha (490.43 days) and Wollo (470.89 days) was significantly lower than in Menz (592.43 days) while the first two were not different ($p>0.05$) from each other. Local genotypes had significantly ($p<0.05$) lower age at first lambing than Awassi x Local crossbred in all locations. In South Wollo, age at first lambing of Corriedale x Local crossbred ewes was found in between Local and Awassi x Local crossbred ewes with no clear separation of means. They were not different ($p>0.05$) from both Local and Awassi x Local crossbred ewes.

Lambing interval was affected ($p<0.05$) by location and genotype of the ewes. The shortest lambing interval was found in ewes of Wollo followed by Chacha and Menz. Local breeds had shorter ($p<0.05$) lambing interval than Awassi crossbreds in all locations. Whereas, in south Wollo Corriedale x Local crossbred ewes had similar lambing interval with Local breeds.

Ewe postpartum weight was significantly ($p<0.05$) affected by location, genotype and their interaction. The largest ewe postpartum weight was in Wollo (28.46 kg) followed by Chacha (27.12 kg) and Menz (23.87 kg). Ewe weight at postpartum for Locals and Awassi x Local crossbreds was 24.5 and 27.8 kg, respectively. Generally, Awassi x Local crossbred ewes had higher weight at postpartum than locals.

Within location comparison also indicated that Awassi x Local crossbreds had higher ewe postpartum weight than their local contemporaries in all locations. In South Wollo, post partum weight of Corriedale x Local crossbred ewe was found in between local and Awassi x Local crossbred ewes.

Number of lambs born per ewe was affected ($p<0.05$) by location and genotype. Wollo ewes had the highest number of lambs born per ewe (1.58) followed by Chacha (1.49) and Menz (1.39). When considering the genotype, Local ewes produced higher number of lambs per year (1.57) than Awassi x Local (1.34) crossbred ewes. Number of lambs born per ewe per year of Corriedale x Local crossbred ewes in South Wollo was 1.66 which was similar ($p>0.05$) with Local ewes, whereas higher ($p<0.05$) than Awassi x Local crossbred ewes. Again the number of lambs born per ewe for Awassi x Local ewes in South Wollo was similar ($P>0.05$) with Local ewes in Chacha and Menz. In all locations, age at first lambing, lambing interval, ewe postpartum weight and number of lambs born per ewe per year varied from farmer to farmer (result not presented here). We also observed that farmers in South Wollo gave more attention for their sheep.

Discussion

Age at first lambing for local breeds in all location and Corriedale x Local and Awassi x Local crossbreds in South Wollo were in the range of 446.2 to 528.6 days. This generally seemed to be similar with that reported in tropical traditional systems which are between 446 and 572 days (Galina *et al.,* 1996) and improved breeding conditions between 431 days and 572 days (Armbruster *et al.,* 1991). Lambing interval found in this study for local, Awassi x Local and Corriedale x Local crossbred ewes ranged from 228 to 252 days is fairly comparable with that of Mexican Black belly and Pelibuey breeds which are 230 and 254 days, respectively (Galina *et al.,* 1996) and Menz sheep breed 253 days (Mukasa-Mugerwa *et al.,* 1994).

Table 1. Least square means (SE) of the effect of location and genotype of the reproductive performance in three locations under farmers' management.

Effect	N	LI (days)	N	AFL (days)	N	EPPWT	N	NLBEY
Location		*		*		*		*
Chacha	984	258.01(2.80)^{a}	139	490.43(7.96)^{a}	2194	27.12(0.13)^{a}	906	1.49(0.02)^{a}
Wollo	739	242.33(2.61)^{b}	61	470.89(12.16)^{a}	1682	28.46(0.22)^{b}	667	1.58(0.02)^{b}
Menz	1259	274.09(2.80)^{c}	177	592.43(7.76)^{b}	2329	23.87(0.16)^{c}	1243	1.39(0.16)^{c}
Genotype		*		*		*		*
Local	2716	243.26(1.09)	265	479.20(6.16)	5504	24.50(0.05)	2567	1.57(0.01)
Awassi	145	285.64(4.55)	112	556.64(9.09)	443	27.80(0.18)	137	1.34(0.03)
CV (%)		21.88		17.31		14.86		19.83
Within location comparison								
Chacha		*		*		*		*
Local	904	242.69(1.80)	91	456.86(8.79)	1961	25.92(0.08)	833	1.57(0.01)
Awassi	80	290.49(6.04)	48	656.31(15.19)	233	28.32(0.22)	73	1.31(0.27)
CV (%)		21.91		17.48		13.06		20.09
Menz		*		*		*		*
Local	1223	259.12(1.16)	133	528.55(8.74)	2194	21.53(0.07)	1207	1.47(0.30)
Awassi	36	304.83(9.39)	44	724.95(14.44)	135	24.95(0.27)	36	1.24(0.27)
CV (%)		21.64		17.99		14.68		20.44
Wollo		*		*		*		*
Local	589	228.32(2.12)^{a}	41	446.22(14.12)^{a}	1349	26.00(0.13)^{a}	527	1.66(0.01)^{a}
Corriedale	121	229.73(4.67)^{a}	32	491.47(15.98)^{a,b}	258	29.82(0.30)^{b}	112	1.65(0.03)^{a}
Awassi	29	252.03(9.53)^{b}	30	518.10(16.10)^{b}	75	31.73(0.56)^{c}	28	1.51(0.06)^{b}
CV (%)		22.37		14.61		18.09		18.24

N = number of observation, LI = Lambing interval, AFL = age at first lambing, EPPWT = ewe post partum weight, NLBEY = number of lambs born per ewe per year; * = significant at $p = 0.05$, means with different subscript within a column are statistically different ($p<0.05$).

Number of lambs born per ewe per year found in this study for Awassi x Local crossbred ewe in Menz and Chacha area was lower than the value reported for Mexican Black belly and Pelibuey breeds (1.37 and 1.55, respectively) (Galina *et al.,* 1996). However Local breeds in Menz and Chacha and Awassi x Local in South Wollo gave comparable results; Local and Corriedale x Local sheep genotypes in South Wollo gave higher result from the above report.

Generally, reproductive performance is affected by both genetic and environmental factors. In this study, Local breed had better age at first lambing, lambing interval and number of lambs born per ewe per year than Awassi x Local crossbred ewes in all locations. However in South Wollo, Corriedale crossbreds showed comparable performance with Local ewes. Regarding location, ewes in South Wollo showed better performance than ewes in Menz and Chacha. For example, lambing interval for Awassi x Local crossbred ewes in South Wollo (252 days) was comparable with Local breed in Chacha and Menz 243 and 259 days, respectively. This performance could allow three lambing in two years which is a character of productive ewes in terms of lambing interval. This pointed out that in better environment and management Awassi x Local crossbred ewes could also perform comparable to Local breeds in terms of reproductive performance. Better performance in South Wollo might be due to the combined effect of Local genotype, better environment and good farmers' management. Genetic potential for early puberty reported for Awassi ewe lambs in Baghdad (424 days) has suggested the breed's good potential for reproduction (Younis et. al., 1978). In contrast to this, in unimproved Awassi flocks, the ewes lamb for the first time at the age of two years or more (Epstein, 1982). This wide range of variability in reproduction performance indicated the higher effect of management on this trait which is also reported by many authors (Kremer *et al.,* 2009; Mokhtari *et al.,* 2010). Furthermore, low heritability for reproductive traits had been reported in many literatures (Mokhtari *et al.,* 2010; Selvaggi *et al.,* 2010) indicating that more focus should be given on improving the environment like ewe nutrition before mating, during late pregnancy and early lactation for the improvement of reproductive performance. Inbreeding depression is higher for traits of low heritability than the highly heritable traits.

Thus, the use of limited number of crossbred rams in this project might also contribute for the lower reproductive performance of crossbred ewes. However the effect of inbreeding in reproductive performance needs further investigation.

Conclusions

Local breed had better age at first lambing, shorter lambing interval and higher number of lambs born per ewe per year than Awassi x Local crossbred ewes in all locations. However, in South Wollo, Corriedale crossbreds showed comparable performance with Local ewes. Regarding location, ewes in South Wollo showed better performance than ewes in Menz. This study revealed that in better environment and management, Awassi x Local crossbred ewes could also perform as comparable as Local breeds in terms of reproductive performance. The variation in reproductive performance among locations and farmers observed in this study indicated that the importance of delineating crossbreeding areas and developing appropriate exotic blood level for each area. Furthermore, devising alternative crossbreeding system which allows the use of pure Local and Corriedale x Local crossbred genotypes as dam line is imperative for the success of the crossbreeding program.

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References

Abebe Mekoya. 1999. Husbandry practice and productivity of sheep in Lalo-mama Midir woreda of central Ethiopia. An M.Sc thesis presented to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia. 99p.

Armbruster, T., Peters, K.J., Hadji–Thomas, A. 1991a. Sheep production in the humide zone of West Africa: III – Mortality and productivity of sheep in improved production systems in Cˆoted'Ivoire. J. Anim. Breed. Genet. 108, 210–220.

Epstein H. 1982. The FAO/UNEP Consultation on Animal Genetic Resources Conservation and Management, held in 1980. WORLD ANIMAL REVIEW, A quarterly journal on animal health, production and products no. 44–1982.

Galal S., Gürsoy O., Shaat I. 2008. Awassi sheep as a genetic resource and efforts for their genetic improvement—A review. Small Rumin. Research 79: 99–108.

Galina M.A., Morales R., Silva E., Lopez B. 1996. Reproductive performance of Pelibuey and Blackbelly sheep under tropical management systems in Mexico. Small Rumin. Res. 22:3 l-37.

Kremer R., Barbato G., Rista L., Rosés L., Perdigón F. 2009. Reproduction rate, milk and wool production of Corriedale and East Friesian×Corriedale F1 ewes grazing on natural pastures. Small Ruminant Res. doi:10.1016/j.smallrumres.2009.12.009.

Mokhtari M.S., Rashidi A., Esmailizadeh A.K. 2010. Estimates of phenotypic and genetic parameters for reproductive traits in Kermani sheep. Small Rumin. Res. 88: 27–31.

Mukasa-Mugerwa, E., Negussie, A. and Said, A.N. 1994. Effect of postweaning level of nutrition on the early reproductive performance and productivity indices of Menz sheep. J. Appl. Anim. Res., 5: 53-61.

SAS (Statistical Analysis System). 2003. SAS for windows, Release 9.1. SAS Institute, Inc., Cary, NC, USA.

Selvaggi M., Darioa C., Peretti V., Ciotola F., Carnicella D., Dario M. 2010. Inbreeding depression in Leccese sheep. Small Rum. Res. 89: 42–46.

Solomon Gizaw. 2008. Sheep resources of Ethiopia: genetic diversity and breeding strategy. PhD thesis, Wageningen University, The Netherlands.

Tesfaye Ashagre. 2008. Performance of Menz sheep under traditional management system in Dessie Zuria districts of South Wollo, Amhara region. A thesis submitted in partial fulfillments for the requirements for the Master of Science degree in livestock production and pastoral development. Mekele, Ethiopia. 151pp.

Tesfaye Getacherw. 2008. Characterization of Menz and Afar indigenous sheep breeds of smallholders and pastoralists for designing community-based breeding strategies in Ethiopia. A Thesis Submitted to the Department of Animal Sciences, School of Graduate Studies. Dire Dawa, Ethiopia. 138pp.

Younis, A.A., El-Gaboory, I.A., El-Tawil, E.A. and El-Shobokshy, A.S. 1978. Age at puberty and possibility of early breeding in Awassi ewes. J. Agric. Sci. 90:255-260.

Comparative evaluation of traditional herb and conventional treatment of ovine foot rot

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Abstract

The study was conducted from May, 2009 to July, 2009 to evaluate the effect of traditional herb, *Amaranthus angustifolius* (Aluma) and combination of Aluma and lemon, and conventional drugs, antibiotic spray and formalin for the treatment of foot rot. Eighty three infected sheep were selected and identified from seven different flock affected by foot rot, and randomly divided into six groups by considering an equal distribution of foot rot lesion score for each group: These were (i) 14 affected animals which were treated with Aluma, (ii) 14 animals which were treated with Aluma without pairing (iii) 14 similarly affected animals which were treated with Aluma in combination with Lemmon, (iv) 10 sheep which were treated with antibiotic spray, (v) 15 sheep which were treated with formalin, and (vi) 16 sheep which were left untreated (control). All treatments were repeated every week for three month duration. Sheep feet were inspected and foot rot lesions were scored at the beginning and end of the treatments. In addition sheep were inspected three times 30 days apart on Days 30, 60 and 90, and response to treatments were recorded. On day-30 the least square mean comparison for treatment response revealed that antibiotic spray had the best result of all treatments ($p < 0.05$) and the combination of Aluma and lemon resulted in the second successful recovery which significantly differ from the rest ($P<0.05$). There were no significant differences ($P>0.05$) in lesion score of treatment groups before treatment. A significant ($p<0.0001$) effect on lesion score was seen at the end of treatment period and Least square mean comparison revealed that Antibiotic spray, the combination of Aluma and lemon and Aluma alone had low foot rot lesion score withno significant ($P>0.05$) difference among them but differ significantly from other treatment groups. In conclusion the combination of Aluma and lemon with 2:1 ratio appears to have similar effect with antibiotic and offer better approach for use in the field than formalin in the treatment of foot rot. The juicy preparation or ointments of indigenous medicinal plants especially Aluma may play a direct role in the sustainable treatment and control of foot rot infections.

Key words: Aluma, antibiotic, formalin, lemon, foot rot.

Introduction

Foot rot is a specific disease of sheep, which under suitable environmental conditions is highly contagious. The prevalence in highly susceptible sheep approaches 100% (Martin and

Aitkin, 2000). The on-farm sheep characterization study existing records in selected villages and model farmers around Chacha indicated that lameness, swelling between claws of sheep locally called 'Choqe' during wet season (July-September) following the rains is the major health problem reducing sheep productivity in the area. It is maintained in a flock in the feet of chronic carriers. According to the diagnostic survey carried out around Chacha the pair wise ranking of major sheep diseases on the basis of morbidity and mortality incidences showed 'Choqe' ranked second next to respiratory disease complex. The disease is contagious and transmitted from infected animal to healthy flock horizontally (through communal grazing, common housing etc). Out breaks of foot rot result from the occurrence of host, environmental and microbial factors. These predisposing factors are triggered due to poor housing management (muddy floor without regular cleaning regime), which is favorable for the direct transmission of bacterial infection in the flock.

Many farmers use treatment methods that are appropriate for resolving advanced cases of foot rot, rather than preventing early cases from becoming more severe (Wassink and Green, 2001; Wassink *et al*., 2003). Treatment programs have included vaccines, which provide some protection for approximately a 12-week period or less (Lambell, 1986; Schwartzkoff *et al*., 1993; Hunt *et al*., 1994), antibiotics, which provide temporary relief, foot bathing using zinc sulfate with a surfactant by walking or soaking for up to 60 min with and without paring (reviewed by Abbot and Lewis, 2005). Paring provides exposure of infected tissues to zinc sulfate and may improve the efficacy of a walk-through topical treatment (Skerman *et al*., 1983; Bagley *et al*., 1987).

In recent years, the cost of conventional medicines for use in animals has escalated and they have thus become unaffordable to most livestock raisers (Njoroge and Bussmann, 2006). Traditional remedies and practices, the ethno-veterinary medicines (EVMs), are now sometimes the only available alternative to expensive or unavailable modern forms of healthcare (Luseba and Van der Merwe, 2006). The World Health Organization (WHO, 2002 cited by Kiringe 2006) attributed the popular use of traditional medicine among rural communities to it being affordable, readily accessible and culturally acceptable.

The easiest and most rational solution to the problem is to develop acceptably effective drugs from reasonably inexpensive sources for use as supplements to commercial drugs. Veterinary traditional medicine provides a shortcut to this end, and is more readily accessible for scientific investigation than its counterpart, traditional human medicine. Therefore, the objectives of this study were: to evaluate the effectiveness of herbal medicine on treatment of foot rot, to determine the statues of foot rot with different treatment options, and to determine whether breed differences existed in response to exposure and treatment of foot rot.

Materials and methods

The study area

Chacha area is known for its livestock potential in general and sheep rearing in particular. The area is characterized for its large communal grazing throughout the year. The grazing area is marshy and water logged during the wet season. The soil is black vertisol, which is habitat for anaerobic microorganisms. Sheep husbandry practices are traditional like elsewhere in Ethiopia (mixed livestock species are grazing during daytime and housed at night, there is no regular veterinary service, no feed supplement and poor housing management).

Study animal

Foot rot infected sheep including all age groups, indigenous and Menz x Awassi breeds which are formerly distributed to the area.

Material and methods

A thorough ethical consideration like non-fatal nature of the disease, thus avoiding situations in which an animal’s life is at risk as a result of faulty treatment were undertaken before the field validation of the treatments. The researchers and farmer also discussed the treatments and the farmer approved them for his sheep.

Eighty three infected sheep were selected and identified from seven different flock affected by foot rot, and randomly divided into six groups by considering an equal distribution of foot rot lesion score for each group: These were (i) 14 affected animals which were treated with Aluma, (ii) 14 animals which were treated with Aluma without pairing (iii) 14 similarly affected animals which were treated with Aluma in combination with Lemmon, (iv) 10 sheep which were treated with antibiotic spray, (v) 15 sheep which were treated with formalin, and (vi) 16 sheep which were left untreated (control). Foot trimming was combined with all treatments except treatment group (ii) so the impact of trimming on recovery was not elucidated.

All treatments were repeated every week for three month duration. The antibiotic spray was Cyclospray composed of chlortetracycline HCL. The dosage and application was upon instruction of the manufacturer (Farvet Laboratories B.V., The Netherlands). The juice of Aluma was applied over the treatment area until evenly coloured. The combination of Aluma and Lemmon were in 2:1 ratio. Formalin concentration of 5% was used for foot bathing. Sheep feet were inspected and foot rot lesions were scored on two occasions, at the beginning (before commencement of different treatments) and at the end (after completion of the treatments). A standard scoring system was used to grade the severity of foot rot lesions in this experiment. According to this system, Score 0= a normal foot Score 1= moisture, reddening of the skin, hair loss of the skin between the toes Score 2= mild inflammation and tissue damage of the soft horn of the inner wall Score 3 = under-running and moderate tissue damage of the inside wall and the sole Score 4= under-running and more severe tissue damage extending to the outer edge of the sole Score = very severe tissue damage with under running extending to deep layers of the outer wall and the toe (Morcombe, 2008).

In addition sheep were inspected three times 30 days apart on Days 30 (first treatment response), 60 (second treatment response) and 90 (third treatment response), and these response to treatments were recorded. Infection is defined as inflammation of the horny and laminar structures of the foot, which often included pus discharge, or the presence of lesions. Response to treatment was recorded and scored as 3-completely healed (no inflammation or lesions observed), 2-recovered (some lesions were observed), 1-partially recovered (prevented from getting worsen and some sign of healing) and 0-no change at all (still infected). Lesion score and response to treatment were noted by a single observer along the whole period of experiment.

Plant material preparation

Herbaceous plant, *Amaranthus angustifolius* locally called 'Aluma', was used in this study. Identification was based on the available botanical literature (A Glossary of Ethiopian Plant Names by Wolde Michael Kelecha, 2nd edition, March 1977, Addis Ababa). The plant was collected from Debrebirhan research center and the study area. The leaf and stem part of the green plant before flowering was used to make juice. The juice was prepared mainly by soaking crushed plant material in water (infusion). Then the juice was applied as dressing for foot rot lesions.

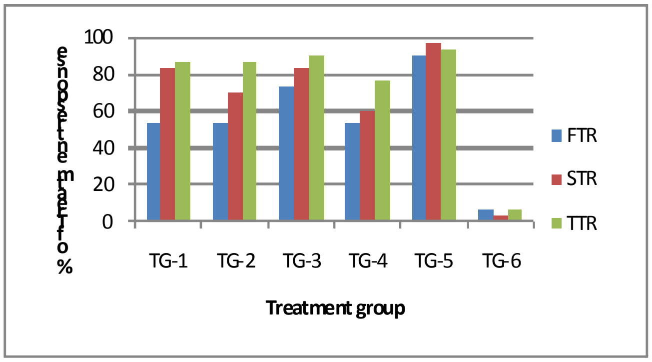
Statistical analysis

Data entry was performed in Microsoft office Excel 2007 and data were exported to SAS 9.0 (SAS institute, Inc., Cary, NC, USA) for analysis. The analysis was performed using GLM procedure and compared by Least square mean ($P<0.05$). Least squares means were separated by the PDIFF option which requests that P-values for differences of the LS-means be produced.

Results

Response to treatment

Fig. 1 shows mean percentage of treatment response after 30, 60 and 90 days of treatment, on Day 30 (FTR), 60 (STR) and 90 (TTR) of the study there were significant differences ($P < 0.0001$) among treatment groups in mean of treatment response.



TG-treatment group; FTR-first treatment response; STR-second treatment response and TTR-third treatment response

Fig. 1. Mean percentage of treatment response after 30, 60 and 90 days of treatment.

Referring Table 1, on day-30 the least square mean comparison for treatment response revealed that TG–5 had the best result of all treatments which is significantly different ($p<0.05$) and TG–3 resulted in the second successful recovery which significantly differed from the rest. TG-2, 1 and 4 had similar LS mean and better result than the control. Similarly on day-60 TG-5 had still best response which significantly differs ($p<0.05$) from the rest. TG-3 and 1 again had the second successful treatment response and were not significantly different ($p>0.05$) each other. TG-2 and 4 had similar treatment response ($p>0.05$). At the final phase of treatment, i.e., on day-90 of the experiment, TG-5 had only significant difference ($p<0.05$) from TG-4 and the control.

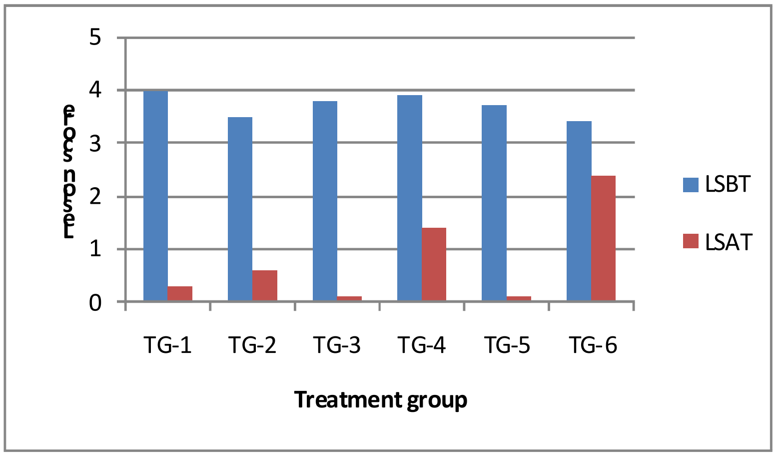
Table 1. Least square means (±SE) of treatment response of the TGs.

TG	FTR	STR	TTR
1	1.79 (0.13) c	2.57 (0.11) b	2.86 (0.09) a
2	1.79 (0.13) c	2.14 (0.11) c	2.79 (0.09) a b
3	2.29 (0.13) b	2.64 (0.11) b	2.86 (0.09) a
4	1.73 (0.12) c	1.87 (0.10) c	2.53 (0.09) b
5	2.90 (0.15) a	3.00 (0.13) a	3.00 (0.11) a
6	0.00 (0.12) d	0.00 (0.10) d	0.00 (0.09) c

Different letters denotes significant differences ($p<0.05$); TG-treatment group; FTR-first treatment response; STR-second treatment response and TTR-third treatment response.

Lesion score

Fig. 2 illustrates foot rot lesion score before & after treatment, there were no significant differences in lesion score of TG before treatment at P<0.05. A significant effect of TG on lesion score was seen at the end of treatment period (p<0.0001) and Least square mean comparison revealed that TG –5, 3 and 1 had low foot rot lesion score with no significant difference among them but differ significantly from other TG. TG-4 had higher lesion score compared to other TG except the control (Table 2).



LSBT-lesion score before treatment; LSAT-lesion score after treatment

Fig. 2. Foot rot lesion score before and after treatment.

Table 2. Least square means (± SE) of lesion score after treatments.

TG	Lesion score
1	0.36 (0.12) a
2	0.71 (0.12) b
3	0.14 (0.12) a
4	1.47 (0.11) c
5	0.00 (0.14) a
6	2.44 (0.12) d

Different letters denotes significant differences (p<0.05).

Effect of genotype, age and sex

There were no significant association (p>0.05) between breed, age & sex and recovery from foot rot. Foot score was also similar between different breeds, sex and age (Tables 3 and Table 4).

Table 3. ANOVA showing relation between age, sex, breed and treatment response.

Dependent variable	Source	DF	Mean Square	F Value	Pr > F
	TG	4	3.03670175	10.77	<.0001
FTR	Age	1	0.48555304	1.72	0.1946*
	sex	1	0.11601997	0.41	0.5237*
	Breed	1	0.08180623	0.29	0.5922*
	TG	4	2.42886628	12.16	<.0001
STR	Age	1	0.23883104	1.20	0.2787*
	sex	1	0.02456464	0.12	0.7271*
	Breed	1	0.01543718	0.08	0.7820*
	TG	4	0.37367669	2.49	0.0529*
TTR	Age	1	0.23624302	1.57	0.2147*
	sex	1	0.14635680	0.97	0.3276*
	Breed	1	0.17527496	1.17	0.2844*

**Not significant at p<0.05.*

Discussion

Medicinal plants have been used in the treatment of various ailments throughout human history. It is important to determine the appropriate use of medicinal plants through scientific validation. Testing should be performed on traditional treatments in order to confirm the effectiveness, as well as to determine the safety in live organisms (Matos, 1995).

Given that enormous number of variables that exist under field conditions and the fact that most of the farmers considered medicinal plants inferior to modern drugs that are produced in factories and are sold in pharmacies, formal controls were not possible up to the end of experiment, but, under this protocol of validation, the efficacy of different treatments on foot rot infected animals was being recorded.

Table 4. ANOVA showing relation between age, sex, breed and lesion score.

Dependent variable	Source	DF	Mean Square	F Value	Pr > F
LSBT	TG	4	0.44631855	1.42	0.2382*
	Age	1	0.35092762	1.12	0.2948*
	sex	1	0.06416339	0.20	0.6529*
	Breed	1	0.29663237	0.94	0.3351*
LSAT	TG	4	4.27317756	23.22	<.0001
	Age	1	0.60418224	3.28	0.0751*
	sex	1	0.01796694	0.10	0.7558*
	Breed	1	0.11773871	0.64	0.4270*

**Not significant at P<0.05; LSBT-lesion score before treatment; LSAT-lesion score after treatment.*

Despite the study is still in its preliminary stages and the treatments have been tried on very few animals, there were significant differences among treatment groups in mean treatment response. Sheep received antibiotic spray with pairing showed best recovery of all and those treated with the combination of Aluma and Lemmon had better treatment response than others including the formalin group. When the day of treatment advances, effectiveness of the treatment with antibiotic spray, Aluma and lemmon and Aluma alone became closely similar. This shows that the need for repetition of treatments with Aluma to get better result. Sub-clinical infection of the inter-digital skin, persisting for a period of weeks, has been suspected in some studies and was, in one report, associated with treatment with a formalin footbath (Thomas, 1957). In our experiment, Aluma appears to offer better approach for use in the field than formalin in the treatment of foot rot. In addition it had no detectable odour and without any sign of irritation.

Recovery or response rate to all treatments was similar among breeds and there was no significant association between lesion score and breed. This result is in agreement with conclusion of Burke and Parker (2006) which describes the response to foot rot eradication appeared to be similar among breeds examined.

Conclusions

While field trials are considered the best method for validation, (confidence had to be built up first in the local community for trying out the treatment in a prescribed manner and also to ensure detailed and exact documentation. In the present experiment, the combination of Aluma and lemon with 2:1 ratio appears to have similar effect with antibiotic and offer better approach for use in the field than formalin in the treatment of foot rot. There were no adverse effects found in the experimental sheep treated with Aluma against foot rot. Considering the above findings, it can be concluded that in the treatment of foot rot in sheep herbal preparation may be used especially in the form of juice or ointment. Herbal preparations are inexpensive, easily available, easy to prepare and so juicy/ointments of indigenous medicinal plants especially Aluma may play a direct role in the sustainable treatment and control of foot rot infections. The potential value of Aluma, supported by recent result, needs to be investigated and quantified further, taking into account the difficulties that have already been identified here. Furthermore, active compounds need to be identified and the mechanisms of its action understood, in order to achieve efficient regimes for its use in foot rot treatment and control.

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References

Abbot, K.A., Lewis, C.J. 2005. Current approaches to the management of ovine footrot. Vet. J. 169:28–41.

Anjaria, J. 1996. Ethinoveterinary pharmacology in india: post, present and future. In: C.M.McCorkle, E., Mathhias and T.W.Schillhorn Van Veen (eds), Ethinoveterinary Research and Development, Intermediate Technology Publications, London, UK, 137-147.

Bagley, C.V., Healey, M.C., Hurst, R.L. 1987. Comparison of treatments for ovine foot rot. J. Am. Vet. Med. Assoc. 191:541–546.

J.M. Burke and C.F. Parker. 2006. Effect of breed on response to foot rot treatment in mature sheep and lambs. Small Rum. Res. 71:165–169.

Kiringe, J.W. 2006. A survey of traditional health remedies used by the Masai of Southern Kaijiado district, Kenya. Ethnobotany Research and Applications 4:61–73.

Luseba, D. and Van der Merwe, D. 2006. Ethnoveterinary medicine practices among Tsonga speaking people of South Africa. Onderstepoort J. Vet. Res. 73:115–122.

Lambell, R.G. 1986. A field trial with a commercial vaccine against foot-rot in sheep. Aust. Vet. J. 63:415–418.

Matos, F.J.A. 1995. A validac¸ ão de novas drogas e plantas medicinais. Rev. Bras. Farm. 76:90–92.

Martin W.B. and Aitken I.D. 2000. Diseases of sheep. 3rd ed., 254-257.

Morcombe, P. 2008. Benign footrot in sheep and goats. In farm note (Western Australian agricultural authority, Department of agriculture and food), farm note 330 which replace farmnote 76/2005.

Njoroge, G.N. and Bussmann, R.W. 2006. Herbal usage and informant consensus in Ethnoveterinary management of cattle diseases among the Kikuyus (Central Kenya) J. Ethnopharmacology, 108:332–339.

Schwartzkoff, C.L., Lehrbach, P.R., Ng, M.L., Poi, A. 1993. The effect of time between doses on serological response to a recombinant multivalent pilus vaccine against footrot in sheep. Aust. Vet. J. 33:202–206.

Hunt, J.D., Jackson, D.C., Brown, L.E., Wood, P.R., Stewart, D.J. 1994. Antigenic competition in a multivalent footrot vaccine. Vaccine 12:457–464.

Shodhini (A network of women health activities, New Delhi). 1997. Touch Me, Touch Me Not: Women, Plants and Healing, (Kali for Women, New Delhi, India.

Skerman, T.M., Green, R.S., Hughes, J.M., Herceg, M. 1983. Comparison of footbathing treatments for ovine footrot using formalin or zinc sulphate. N. Z. Vet. J. 31:91–95.

Stewart, D.F. 1954a. The treatment of contagious footrot in sheep by the topical application of chloromycetin. Aust. Vet. J. 30:209–212.

Thomas, J.H. 1957. The eradication of contagious footrot of sheep. Aust. Vet. J. 33:263-266.

Wassink, G.J.; Green, L.E. 2001. Farmers practices and attitudes towards foot rot in sheep. Veterinary record, v.149 (16), pp. 489-490.

Wassink, G.J., Grogono-Thomas R., Moore, L.J., Green, L.E. 2003. Risk factors associated with the prevalence of footrot in sheep from 1999 to 2000. Vet. Record, 152:351-58.

Wolde Michael, K. 1977. A Glossary of Ethiopian Plant Names. 2nd edition, Addis Ababa, Ethiopia.

Estimation of live body weight from linear body measurements for Farta Sheep

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Abstract

A study to develop regression models for prediction of body weight from other linear body measurements was conducted in Estie, Farta and Lai-Gaint districts, South Gondar, Amhara region. Records on body weight (BW) and other linear body measurements (Body Length (BL), Wither Height (WH), Chest Girth (CH), Pelvic Width (PW) and Ear Length (EL)) were taken from 941 sheep. Non-linear, simple linear and multiple linear regression models were developed using Statistical Package for Social Sciences (SPSS version 12.0). For the multiple linear regressions, step-wise regression procedures were used. Predicting models were developed for different age, sex and for the pool. Positive and significant ($P<0.01$) correlations were observed between body weight and linear body measurements for all sex and age groups. Among the four linear body measurements, heart girth had the highest correlation coefficient (except ear length) in all age and sex groups which is followed by body length, height at wither and pelvic width. Heart girth was the first variable to explain more variation than other variables in both sex and age groups. The models developed had a coefficient of determination of 0.26 to 0.89; the highest coefficient of determination was depicted for male while the lowest was for dentition groups having two permanent incisors. Regression models in general were poor for the dentition groups above one. Heart girth alone was able to estimate weight with a coefficient of determination of 0.77, for both sexes and the pool. The coefficient of determination of the fitted equations (in general) decreased as the age of sheep advances indicating that the fitted equations can predict weight for younger sheep with better accuracy than for older ones. Therefore, for ease of use and simplicity at field condition, it is possible to use heart girth alone as a predicting tool.

Key words: Body weight, Farta, linear body measurements, regression model.

Introduction

Farta breed of sheep is one of the sheep breeds found distributed in the south Gonder zone of the Amhara National Regional State, Ethiopia. These sheep are kept mainly for meat production (sale and slaughter) under the traditional management systems (Shigdaf *et al.*, in press). There is no any specialized breed improvement program designed for this sheep. Genetic improvement of its live weight is required to increase meat yield from this breed.

Body measurements are simple and easily measured variables for estimating live weight although it is unlikely to be as accurate as direct measurement of live weight due to error in location of reference points and anatomical distortions produced when animal change position or posture or muscle tone (Sowande and Sobola, 2007). Body measurements have been used to evaluate breed performance and to characterize breed of animals. Strong linear and geometric relationships between live weight and chest girth have been reported in the literature (Benyi, 1997; Fasae *et al*., 2005; Mengistie *et al*., 2010).

Estimation of the relationship between body measurements in sheep may help provide means for predicting traits which are not normally and easily measured under field conditions. In a breeding programme where improved live weight is the overall breeding objective, other body measurements having strong correlation to live weight must be considered (Sowande and Sobola, 2007). There is paucity of information on the relationship between live weight and body measurements of Farta sheep. This study was undertaken to obtain prediction equations for estimating live weight of Farta sheep from five body measurements for the purpose of breed characterization.

Materials and methods

The study area

The study was conducted in Estie, Farta and Lai-Gaint districts of south Gondar zone where Farta sheep is distributed. Farta district is located about 100 km north-east of Bahir Dar, capital of the Amhara National Regional State. Farta lies within an altitude range of 1920 4135 m a.s.l. The district receives an average annual rainfall of 900-1099 mm and a mean-range temperature of 9-25^{0}C (Farta District OoARD, annual report). The second district, Lai-Gaint, is located 175 km from Bahir Dar and lies between an altitude ranges of 1300-3500 m.a.s.l. Lai-Gaint receives an annual average rainfall of 600-1100 mm and mean minimum and mean maximum temperatures of 9 and 19 ^{O}C, respectively. The third district, Estie , is located 157 km northwest of Bahir Dar city having an altitude range of 1500-4000 m a.s.l. The minimum and maximum mean annual rainfall of the area is 1307-1500 mm and the mean annual minimum and maximum temperature is 8.3 ^{O}C-25 ^{O}C.

Study animals and management

Study animals considered were Farta sheep. They are short fat tailed; wooly under coat; medium sized; commonly white (37.5%), brown (27.5%) and black with brown belly (15%), white/brown with brown/white patches; males are horned. Sheep were managed under traditional systems; the main feed resources were natural pasture (communal and private grazing land), crop residue, improved forage, and crop aftermath.

Data collection

Data on weight and other linear body measurements were collected from 941 sheep, with different age/dentition and sex groups. Age was estimated based on dentition groups (0PPI - sheep with milk teeth (>about 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above). For dentition group 0PPI, sheep approaching to one year of age (physical estimation) were used.

The live weight of an animal was taken using the Salter scale (50 kg capacity with 200 gram precision). Linear body measurements (heart girth, wither height, body length, pelvic width and ear length) were taken using flexible metal tape (3 meter length) to the nearest 0.5 cm after restraining and holding the animals in an unforced position. The reference points taken were: heart girth - the circumference of the chest posterior to the forelegs at right angles to the body axis; wither height - the highest point measured as the vertical distance from the top of the shoulder to the ground (bottom of forelegs); body length - horizontal length from the point of shoulder to the pin bone; pelvic width - horizontal distance between the extreme lateral points of the hook bone (*tuber coxae*) of the pelvis; and ear length - length of the external ear from its root to the tip.

Statistical analyses

Statistical analyses were carried out using SPSS Software version 12.0 (SPSS, 2003) General Linear Model (GLM) procedures, and linear and nonlinear regression procedures. Sex and dentition were considered as fixed effects. Live weight was regressed on other body measurements for sexes, dentition groups and for the pool. In the multiple regression equation, prediction equations were developed using a stepwise elimination procedure. The following models were used for data analysis:

$Y_{ij} = \mu + S_i + T_j + (ST)_{ij} + e_{ij}$ (GLM) Model 1

W = a + bG (Simple linear) Model 2

$W = a + b1G + b2G^2$ (Quadratic) Model 3

W = a + b1G1 + b2G2 +….+ bnGn (Multiple linear) Model 4

Where; Y_{ijk} = The observation on body weight and other linear body measurements, W = The observation on live weight of the animal, μ = Overall mean, S_i = Fixed effect of sex (i = Female, Male), T_k = Fixed effect of dentition (k = 0, 1, 2, 3, 4), $(ST)_{jk}$ = the interaction effect of sex with dentition, a = Intercept, b= Regression coefficient of weight on body measurements, G = Body measurements, n = n^{th} number of body measurement, e_{ijk} = effect of random error.

Results and discussion

Body weight and linear body measurements

The mean body weight and linear body measurements of Farta sheep are presented in Table 1. The overall mean body weight, wither height, body length, chest girth, pelvic width and ear length obtained in the present study was 26.2±0.32 kg, 64.3±0.34 cm, 55.6±0.35 cm, 70.9±0.44 cm, 12.8±0.11 and 9.35+0.12 cm, respectively. There was a significant difference ($p<0.05$) in body measurements (except ear length) between sexes and dentition groups.

Correlation between weight and linear body measurements

The Pearson's correlation of linear body measurements with weight and with each other is presented in Table 2. There were significant and positive relationships between body weight and other linear body measurements and with each other. Chest girth had the highest correlation coefficient (r = 0.43-0.87; $p<0.01$) with body weight in both sexes and all dentition groups which is followed by wither height and body. Ear length has almost no correlation with body weight (inconsistent relationship). Good correlation coefficients between body weight and chest girth were also reported for Menz and Washera sheep (Mengistie *et al*., 2010).

Table 1. Body weight and linear measurements of Farta sheep as affected by sex and dentition.

Variables	N	BW (kg)	WH (cm)	BL (cm)	CG (cm)	PW (cm)	EL (cm)
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	941	26.20±0.32	64.31±0.34	55.59±0.35	70.86±0.44	12.79±0.11	9.35±0.12
Sex		***	***	***	*	NS	NS
Female	800	23.82±0.19	62.16±0.20	54.30±0.20	69.76±0.26	12.83±0.06	9.67±0.07
Male	141	28.58±0.62	66.46±0.65	56.89±0.67	71.96±0.84	12.76±0.22	9.03±0.24
Dent		***	***	***	***	***	NS
0PPI	315	15.82±0.23^{a}	56.54±0.24^{a}	48.45±0.25^{a}	58.91±0.31^{a}	10.66±0.08^{a}	9.23±0.09
1PPI	64	26.02±0.70^{b}	65.12±0.74^{b}	55.36±0.76^{b}	72.25±0.95^{b}	13.00±0.25^{b}	9.40±0.27
2PPI	61	28.33±0.65^{c}	65.39±0.68^{c}	56.33±0.71^{b}	73.30±0.88^{bc}	12.78±0.23^{b}	9.44±0.25
3PPI	74	29.75±0.83^{cd}	66.83±0.87^{cd}	59.01±0.90^{c}	73.67±1.13^{bc}	13.69±0.29^{c}	8.93±0.32
4PPI	427	31.09±0.98^{d}	67.67±1.03^{d}	58.82±1.07^{c}	76.15±1.33^{c}	13.84±0.35^{c}	9.75±0.38
Sex*Dent		***	**	NS	NS	NS	NS
Female*0PPI	204	15.35±0.27	55.78±0.28	48.11±0.29	58.95±0.37	10.64±0.09	9.36±0.10
Female*1PPI	55	23.43±0.52	62.25±0.55	54.06±0.57	69.83±0.71	12.79±0.18	9.74±0.20
Female*2PPI	50	25.73±0.55	63.43±0.58	55.66±0.60	72.60±0.75	13.38±0.19	9.88±0.21
Female*3PPI	68	26.53±0.47	64.50±0.50	56.53±0.51	72.84±0.64	13.39±0.17	9.61±0.18
Female*4PPI	423	28.09±0.19	64.85±0.20	57.15±0.20	74.56±0.25	13.93±0.06	9.76±0.07
Male*0PPI	111	16.29±0.37	57.29±0.39	48.78±0.40	58.88±0.50	10.68±0.13	9.11±0.14
Male*1PPI	9	28.62±1.30	68.00±1.37	56.66±1.42	74.66±1.77	13.22±0.46	9.05±0.50
Male*2PPI	11	30.92±1.18	67.36±1.24	57.00±1.28	74.00±1.60	12.18±0.42	9.00±0.45
Male*3PPI	6	32.96±1.60	69.16±1.68	61.50±1.74	74.50±2.16	14.00±0.57	8.25±0.62
Male*4PPI	4	34.10±1.96	70.50±2.06	60.50±2.13	77.75±2.65	13.75±0.70	9.75±0.76

NS: Not significant (P>0.05), *P<0.05, **P<0.01, ***P<0.001; BW - Body Weight; CG - Chest Girth; BL - Body Length; PW - Pelvic Width; WH - Wither Height; EL - Ear length; 0PPI - sheep with milk teeth (>about 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2 PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above

Strong and positive correlations between body weight and other linear body measurements have also been reported by different scholars (Sowande and Sobola, 2007). The high correlation coefficients between body weight and linear body measurements for all age groups suggest that either of these variables or their combination could provide a good estimate for predicting live weight of Farta sheep.

Prediction of weight using body measurements

Regression models developed are presented in Figures 1, 2, 3, 4 and Table 3. Different regression models were developed for different sexes, dentition groups and for the pool with different coefficient of determinations. The regression equations developed had different coefficient of determination for different age groups. This might be because of the difference in growth and proportion of conformational traits at different ages. This tends to infer that at different ages different conformational traits may more successfully predict weight.

Chest girth was the first variable to explain more variation than other variables in both male and female Farta sheep. However, using of chest girth was less reliable in predicting the body weight at 1, 2 and 3PPI dentition groups. In these age groups, height at withers and body length accounted for the greatest amount of variation in body weight. The correlations between body weights and body measurements in pooled data were higher than those at different age groups. This might be due to more or less similar environmental influence at different age groups (Thiruvenkadan, 2005).

The coefficient of determination of the fitted equations (in general) decreased as the age of sheep advances indicating that the fitted equations can predict weight for younger sheep with better accuracy than for older ones. The highest coefficient of determination was obtained when the equations were fitted for the pool (for all age group).

Table 2. Correlation coefficients between body weight and linear body measurements of Farta sheep by age and dentition groups.

Parameter	Measurements	WH	BL	CG	PW	EL
Overall	BW	0.78**	0.78**	0.87**	0.73**	0.12**
	WH		0.75**	0.72**	0.63**	0.19**
	BL			0.66**	0.65**	0.21**
	CG				0.72**	0.11**
	PW					0.16**
Dentition						
0PPI	BW	0.75**	0.68**	0.78**	0.60**	0.17**
	WH		0.62**	0.60**	0.51**	0.16**
	BL			0.44**	0.45**	0.23**
	CG				0.58**	0.15**
	PW					0.11*
1PPI	BW	0.64**	0.41**	0.50**	0.35**	-0.02^{NS}
	WH		0.57**	0.31*	0.24^{NS}	0.18^{NS}
	BL			-0.01^{NS}	0.21 ^{NS}	0.25*
	CG				0.30*	-0.22^{NS}
	PW					0.11^{NS}
2PPI	BW	0.51**	0.47**	0.43**	-0.00^{NS}	-0.27*
	WH		0.44**	0.19^{NS}	-0.2^{NS}	-0.12^{NS}
	BL			0.02^{NS}	0.06^{NS}	0.03^{NS}
	CG				0.21^{NS}	-0.24^{NS}
	PW					0.21^{NS}
3PPI	BW	0.46**	0.62**	0.50**	0.49**	-0.03^{NS}
	WH		0.52**	0.14^{NS}	0.13^{NS}	-0.06^{NS}
	BL			0.10^{NS}	0.33**	0.01^{NS}
	CG				0.27*	0.06^{NS}
	PW					0.07^{NS}
4PPI	BW	0.35**	0.45**	0.64**	0.23**	0.00^{NS}
	WH		0.44**	0.25**	0.18**	0.18**
	BL			0.12**	0.22**	0.14**
	CG				0.16**	-0.03^{NS}
	PW					0.07^{NS}
Sex						
Female	BW	0.75**	0.76**	0.86**	0.71**	0.11**
	WH		0.73**	0.70**	0.62**	0.20**
	BL			0.62**	0.62**	0.20**
	CG				0.69**	0.09**
	PW					0.14**
Male	BW	0.86**	0.83**	0.87**	0.71**	-0.00^{NS}
	WH		0.79**	0.78**	0.62**	0.01^{NS}
	BL			0.67**	0.62**	0.09^{NS}
	CG				0.70**	0.00^{NS}
	PW					0.03^{NS}

***P<0.01; *P<0.05; NS Not significant; BW - Body Weight; CG - Chest Girth; BL - Body Length; PW - Pelvic Width; WH - Wither Height; EL - Ear length; 0PPI - sheep with milk teeth (>about 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2 PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above.*

BW = -34.61+0.93WH

BW = -26.576+0.9288BL

$BW = -53.86+1.58WH-0.0053WH^2$

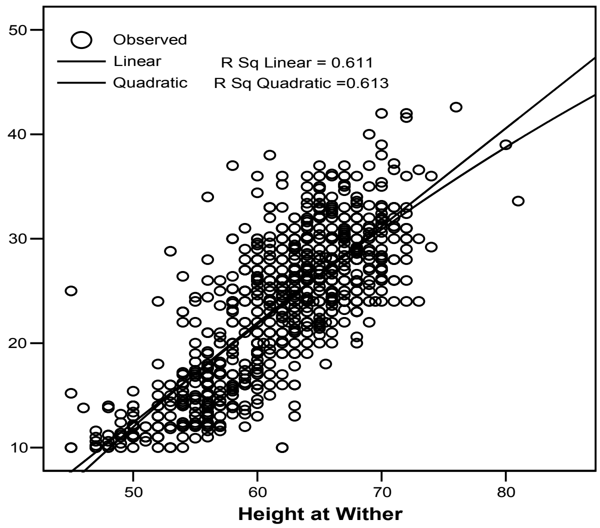

Figure 1. Estimation of weight using height at wither.

$BW = -65.519+2.4207BL-0.0141BL^2$

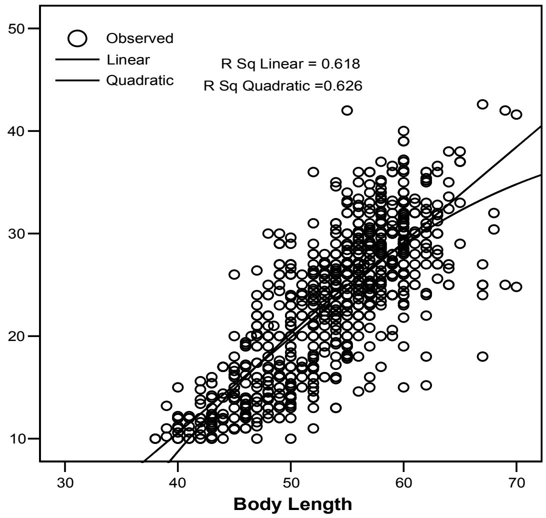

Figure 2. Estimation of weight using body length.

$BW = -23.738+0.6866CG$

$BW = -19.173+20.5459CG+0.0011CG^2$

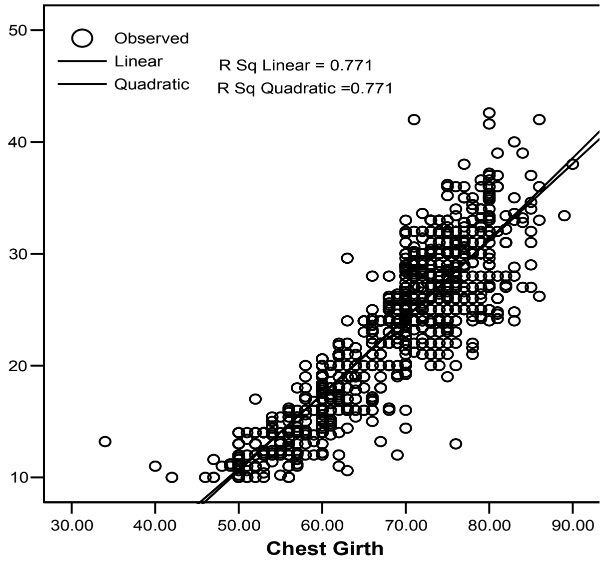

Figure 3. Estimation of weight using chest girth.

$BW = -8.3203+2.5127PW$

$BW = -50.880+9.4674PW-0.2767PW^2$

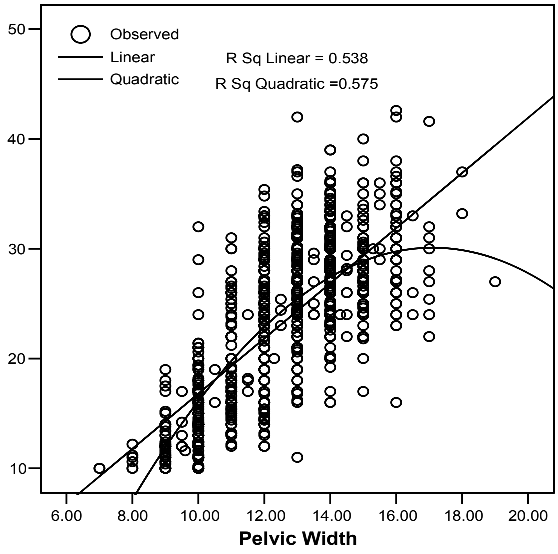

Figure 4. Estimation of weight using pelvic width.

Table 3. Linear and Multiple linear regression equations for predicting body weight from linear body measurements for sex and dentition groups.

Age	Model	B0	X1	X2	X3	X4	X5	R2	R2 Change	SE
Dentition										
0PPI	CG	-11.482	0.461					0.625	0.625	2.316
	CG+BL	-20.777	0.353	0.324				0.765	0.140	1.837
	CG+BL+WH	-24.781	0.286	0.228	0.224			0.802	0.038	1.686
	CG+BL+WH+PW	-24.815	0.269	0.218	0.214	0.194		0.806	0.003	1.675
1PPI	WH	-17.747	0.665					0.416	0.416	3.740
	CG+WH	-30.006	0.269	0.558				0.516	0.100	3.432
2PPI	WH	-6.071	0.510					0.259	0.259	3.181
	CG+WH	-21.420	0.271	0.442				0.376	0.117	2.945
	CG+BL+WH	-35.729	0.287	0.414	0.286			0.469	0.093	2.741
3PPI	BL	-7.121	0.600					0.396	0.396	3.099
	CG+BL	-32.775	0.385	0.557				0.588	0.192	2.578
	CG+BL+PW	-34.245	0.341	0.495	0.610			0.624	0.036	2.481
4PPI	CG	-16.677	0.601					0.411	0.411	3.192
	CG+BL	-35.765	0.556	0.392				0.549	0.139	2.794
Sex										
Females	CG	24.306	0.694					0.755	0.755	3.273
	CG+BL	-34.503	0.516	0.416				0.830	0.076	2.722
	CG+BL+PW	-34.108	0.478	0.381	0.319			0.834	0.004	2.691
	CG+BL+PW+WH	-36.183	0.452	0.331	0.288	0.113		0.838	0.003	2.667
	CG+BL+PW+WH+EL	-35.454	0.448	0.336	0.294	0.119	-0.124	0.838	0.001	2.663
Males	CG	-23.534	0.691					0.767	0.767	3.598
	CG+BL	-35.569	0.455	0.525				0.877	0.110	2.625
	CG+BL+WH	-38.688	0.365	0.381	0.269			0.893	0.016	2.453
Pooled										
	CG	-23.686	0.686					0.771	0.771	3.32
	CG+BL	-34.038	0.497	0.433				0.846	0.076	2.72
	CG+BL+WH	-36.822	0.456	0.358	0.156			0.852	0.006	2.67
	CG+BL+WH+PW	-36.399	0.428	0.335	0.149	0.255		0.855	0.002	2.65
	CG+BL+WH+PW+EL	-35.404	0.424	0.341	0.154	0.265	0.255	0.856	0.001	2.64

[2]Dependent Variable: BW (Body weight) - Body Weight; CG - Chest Girth; BL - Body Length; PW – Pelvic Width; WH - Wither Height; EL - Ear length. [1]Dentition 0PPI - sheep with milk teeth (> 9 months); 1PPI - sheep with 1 pair of permanent incisor (PPI); 2PPI - sheep with 2 PPI; 3PPI - sheep with 3 PPI; 4PPI - sheep with 4 PPI and above.

Conclusion

Body weight and other body measurements were significantly correlated with each other. From the result, it can be concluded that using linear body measurements can be a simple method for estimating body weight of Farta sheep. Body weight had higher association with heart girth. Therefore, use of heart girth as highly correlated variable in the regression equation on total body weight can result in more reliable prediction of body weight. Since body measurements had high correlation with body weight, this may be used as selection criteria in Farta sheep.

References

Benyi, K. 1997. Estimation of liveweight from chest girth in pure and crossbred West African goats. Tropical Animal Health and Production, 29, 124–128.

Fasae, O. A., Chineke, A. C. and Alokan, J. A. 2005. Relationship between some physical parameters of grazing Yankasa ewes in the humid zone of Nigeria. Archivos de Zootecnia, 54, 639–642.

Mengistie Taye, Girma Abebe, Solomon Gizaw, Sisay Lemma, Abebe Mekoya and Markos Tibbo. 2010. Traditional management systems and linear body measurements of Washera sheep in the western highlands of the Amhara National Regional State, Ethiopia. Livestock Research for Rural Development 22 (09).

Sowande O. S. and Sobola O. S. 2007. Body measurements of west African dwarf sheep as parameters for estimation of live weight. Trop Anim Health Prod. DOI 10.1007/s11250-007-9116-z.

Thiruvenkadan A K. 2010. Determination of best-fitted regression model for estimation of body weight in Kanni Adu kids under farmer's management system. Livestock Research for Rural Development 17 (7).

Growth and carcass characteristics of old Menz ewes supplemented with different levels of concentrate feed

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Abstract

Supplementation of old ewes with different level of concentrate feed was conducted at Debre Berhan Agricultural Research Center aiming to assess the effect of feeding levels on ewe body condition, carcass characteristics and market price. A total of 55 old ewes (6 to 9 years old) culled from the ongoing Menz sheep selection program were used for the experiment. Sheep were allocated into five treatment groups randomly after stratifying by age and initial live weight. Treatment groups were grazing only, grazing + supplemented with 150, 300, 450 and 600 g day^{-1} concentrate feed. The experiment was conducted for 90 days from April to June, 2010. Concentrate supplementation had significantly improved ($p<0.05$) final weight average daily gain, ewe body condition at slaughter, carcass characteristics and market price of old ewes. Ewes supplemented with 150 g day^{-1} were higher ($p<0.05$) in final live weight, average daily gain and carcass weight than ewes maintained on grazing only and not different ($p>0.05$) from other supplemented groups. Feeding was also improved ($p<0.05$) the carcass characteristics of old ewes. Supplementation of an old ewe with 150 g day^{-1} concentrate feed gave both biologically and economically optimum level to condition old ewes before marketing which gave net benefit of 55.00 ETB over the non-supplemented group. Ewes culled from the breeding could be an additional source of income in the traditional sheep production system. Thus, instead of keeping unproductive old ewes for longer period of time in the flock, it is advisable to condition and sell them at reasonable price.

Key words: Carcass, concentrate, ews, supplementation.

Introduction

Traditional sheep production is an important component of the Ethiopian agriculture. Sheep production is considered as the main source of income for the family in the cool highland areas where crop productivity is low due to land degradation and frost. Despite their importance, the performance of the sector is very low due to insufficient feed and nutrition, health problem and unimproved breeding practices. In Menz sheep flocks, the proportion of ewes takes the largest share (Abebe, 1999; Tesfaye, 2008) than other classes of sheep; and ewes are mainly maintained for the purpose of breeding. Research results indicated that ewe productivity is higher at middle age. Productivity of Horro ewe is reached maximum between 2 and 3 years age; productivity slightly reduced at 6 years and dramatically reduced after 6 years of age (Solomon *et al.,* 1996; Solomon and Gemeda, 2000). Ewe of 1st and 7th parity produces lighter lambs than the ewes of middle age in Afar sheep (Yibrah, 2008). In flock of farmers in Menz area, about 15% of the available breeding ewes are having 7 and above parity (Tesfaye, 2008). Keeping of such old ewes for longer period of time in the flock has reduced productivity of sheep due to their poor reproductive performance. Furthermore, these classes of sheep compete for the available feed resource. Thus, promoting the sale of ewes before the decline of their productivity will certainly improve the productivity of sheep farming. Generally, old ewes are sold at lower price in the market because of their poor body condition due to age and poor feeding situation. Acceptance of meat from old ewes is also low due to less tenderness. Thus, the aim of this study was to assess the effect of supplementation of concentrate feed levels on body condition, carcass characteristics and market price of old Menz ewes.

Material and methods

The experiment was conducted at Debre Berhan Agricultural Research Center from April to June 2010 for 90 days. A total of 55 old ewes, 6 to 9 years old culled from the ongoing selection program were used for the experiment. Sheep were allocated into five treatment groups randomly after stratifying by age and initial live weight. Treatment groups were grazing only, grazing+supplemented with 150, 300, 450 and 600 g day-1 concentrates feed. The concentrate feed was bought from Addis Ababa (Kality feed processing plant) and the feed had 21% crude protein and 14 MJ/kg metabolizable energy on dry matter basis. All animals were grazed together during the day and supplemented groups were provided their corresponding amount of concentrate feed individually twice a day at 10:00 am and 4:00 pm local time. All sheep had access to water twice a day just after supplementation time

Initial live weight, fortnightly weights and body condition scores were recorded for each animal. Body Condition scoring was done subjectively using five scoring scales from 1 (emaciated) to 5 (obese or extremely fat). At the end of the feeding trial all ewes were slaughtered for carcass evaluation. After bleeding and removal of digestive tract and non-carcass components, hot carcass weight was recorded. Tail was removed from the hind quarter. Dressing percentage was calculated on hot carcass weight basis and expressed as proportion of final weight before slaughter. Fat thickness and rib eye muscle area were measured at the longissimus between 11th and 12th rib using plastic ruler and planimeter, respectively. Sensory carcass evaluation was employed using panelist selected purposely from the employees of the research center based on their relative local experience of meat tasting. For carcass sensory evaluation, the five treatment groups were categorized in to three groups (animals maintained on grazing only, grazing + medium level of concentrate supplement and grazing + high level of concentrate supplement). Ewes supplemented with 150 g day^{-1} and 300 g day^{-1} were grouped as medium and ewes supplemented with 450 g day^{-1} and 600 g day^{-1} grouped as high level of supplement. Carcasses of three ewes were randomly selected for sensory evaluation from each of the three treatment groups. Three carcasses from young ram lambs of about yearling age were used as check. Small cube, about 1 cm^3 of meat from different carcass cuts (leg, loin and shoulder) and small piece of ribs from an animal were cooked on local charcoal until the internal temperature of the meat reached 70 ^{O}C. Then, the cooked meat from a ewe was offered to a panel of 8 evaluators. The panelist scored 1 to 6 (less preferred and most preferred) for each of tenderness, juiciness, taste and overall acceptance. Between the two consecutive tastes, a panelist took a piece of bread and small amount of water to reduce the possible carry over effect.

Live weigh and carcass data were analyzed fitting a general linear model of SAS (2009), by fitting concentrate level as main effect and initial live weight as co- variant. The co-variable was kept in the model only when significant. Carcass sensory evaluation data were analyzed using mixed model procedure of SAS (2009) by fitting feed level as fixed factor and panelist as random factor. Least square means were separated using adjusted Tukey–Kramer test. Partial budget and sensitivity analysis were employed to assess profitability and sensitivity of the recommendations with fluctuations in feed cost and sheep price. Ewe’s price was estimated by three local experienced people at the end of feeding trial.

Feed cost and animal treatment cost were considered as a variable cost in the analysis since the other costs (like labor) were similar for all treatment groups.

Results and discussion

Least square means (SE) of initial weight, final weight, average daily gain and body condition score of old ewes supplemented with different levels of concentrate feed are presented in Table 1. Supplementation had significantly improved final weight, average daily gain and ewe's body condition at slaughter. Supplemented groups were not different from each other in final weight and body condition score at slaughter. Body condition score was also improved by supplementation. During the 90 days of feeding, old ewes in supplemented group gained live weight in the range of 40.44 g to 64.59 g day^{-1}. However ewes in the non-supplemented group gained 8.08 g day^{-1}. Old ewes maintained with grazing only had lower ($p<0.05$) body condition score than the supplemented group. And the entire supplemented groups were not different from each other. The improvement of final body weight and body condition due to concentrate supplementation obtained in this study is in agreement with the result obtained for Horro old ewes (Ulfina *et al.,* 2000). In all cases, ewes supplemented with 150 g day^{-1} were higher than the non-supplemented groups and similar with other supplemented groups. This result showed that supplementation of culled breeding ewes with small amount of concentrate feed (150 g day^{-1}) for 90 days improved their final weight and body condition.

Carcass weight, dressing percentage, tail weight, fat thickness and rib eye muscle area of old ewes supplemented with different levels of concentrate feed are presented in Table 2. Carcass weight, tail weight and fat thickness were significantly improved by supplementation. Ewes in supplemented group had produced 3 to 4 kg more carcass than the non supplemented group. Supplementation of 150 g day^{-1} concentrate feed was higher than the non supplemented group and was not different from the other supplemented group. Thus supplementation of 150 g day^{-1} concentrate feed considered as optimum level of supplement for old ewe. Dressing percentage and rib eye muscle area were not affected ($p<0.05$) by feeding.

Table 1. Initial weight, final weight, average daily gain and body condition score of ewes supplemented with different levels of concentrate feed.

Feed level	N	Initial weight (kg)	Final weight (kg)	Average daily gain (g)	Body condition score
Grazing	10	29.28(1.11)	9.19(0.60)^{a}	8.08(5.17)^{a}	1.94(0.23)^{a}
Greazing + 150	10	28.38(1.12)	32.50(0.65)^{b}	40.44(5.80)^{b}	3.24(0.25)^{b}
Greazing + 300	11	28.59(1.07)	33.19(0.64)^{b}	54.90(5.77)^{bc}	3.27(0.25)^{b}
Greazing + 450	11	28.57(1.o7)	33.53(0.58)^{b}	63.43(5.47)^{c}	3.71(0.25)^{b}
Greazing + 600	10	28.65(1.12)	34.68(0.58)^{b}	64.59(5.17)^{c}	3.67(0.23)^{b}

N = Number of observations. Means with different letter within a column are different at p = 0.05.

Table 2. Carcass weight, dressing percentage, tail weight, fat thickness and rib eye muscle area of ewes supplemented with different levels of concentrate feed.

Feed level	N	Carcass weight (kg)	Dressing percentage (%)	Tail weight (kg)	Fat thickness (cm)	REM area (cm^{2})
Grazing	10	12.20(0.67)^{a}	42.73(1.23)	336.25(64.09)^{a}	0.38(0.09)^{a}	12.04(0.49)
Greazing + 150	10	15.20(0.72)^{b}	45.17(1.31)	602.86(68.51)^{b}	0.73(0.09)^{b}	11.43(0.49)
Greazing + 300	11	15.31(0.67)^{b}	46.22(1.23)	686.50(64.09)^{b}	0.78(0.09)^{b}	11.25(0.49)
Greazing + 450	11	16.30(0.67)^{b}	47.59(1.23)	677.50(64.09)^{b}	0.72(0.10)^{b}	11.57(0.51)
Greazing + 600	10	16.02(0.63)^{b}	45.59(1.16)	788.89(60.43)^{b}	0.92(0.10)^{b}	10.96(0.49)

N = number of observations. Means with different letters within a column are different at $p \leq 0.05$.

Carcass tenderness, Juiciness, taste and overall acceptance are presented in Table 3. Supplementation improved ($p<0.05$) the carcass characteristics of old ewes. Mean comparison of carcass sensory evaluation is presented in Figure 1. Carcass from ram lams which was used as check was higher ($p<0.05$) in tenderness than ewes in all treatment groups. However carcass from supplemented ewes was tenderer than carcass from the non-supplemented ewes.

Table 3. Carcass sensory evaluation score.

Feed level	N	Tenderness	Taste	Juiciness	Overall acceptance
Grazing only	3	3.12(0.10)	3.39(0.11)	2.88(0.11)	3.30(0.12)
Medium feed	3	3.49(0.10)	3.59(0.11)	3.04(0.11)	3.64(0.12)
High feed	3	3.57(0.10)	3.73(0.11)	3.15(0.11)	3.73(0.12)
Check	3	3.93(0.10)	3.60(0.11)	3.32(0.11)	3.73(0.12)

N = Number of observations. Values in parenthesis are standard errors.

Carcass from all treatment groups showed similar taste except carcass from high level supplemented group was higher than carcass from the non-supplemented group (Figure 1). In overall acceptance, carcass from the non-supplemented ewe was less ($p<0.05$) accepted than carcass from supplemented group. Generally this result showed that carcass from supplemented group had better acceptability than the carcass from the non-supplemented group. The effect of age on meat quality and its improvement through better feeding is in agreement with other studies (Plessis and Hoffman, 2007; Maria *et al.,* 2011).

Economic analysis

The economic data from the center generated from five treatments (1 control (farmers' practice) and other 4 treatments) fed for 90 days, and accordingly the feed quantity were converted into monetary terms based on the market price. In all cases, labor cost was not considered since there is no labor allocated for these practice only. The economics of old ewes fattening showed that treatment 2 (grazing + 150 g concentrate) was the best which gained a net return of 313.36 ETB. Net benefit over the control was 55 ETB. The marginal rate of return (MMR) for the selected treatment is 139%, this means that for every 1 Birr invested in concentrate feed and medication, farmers can recover the 1ETB and obtain an additional 1.39 ETB.

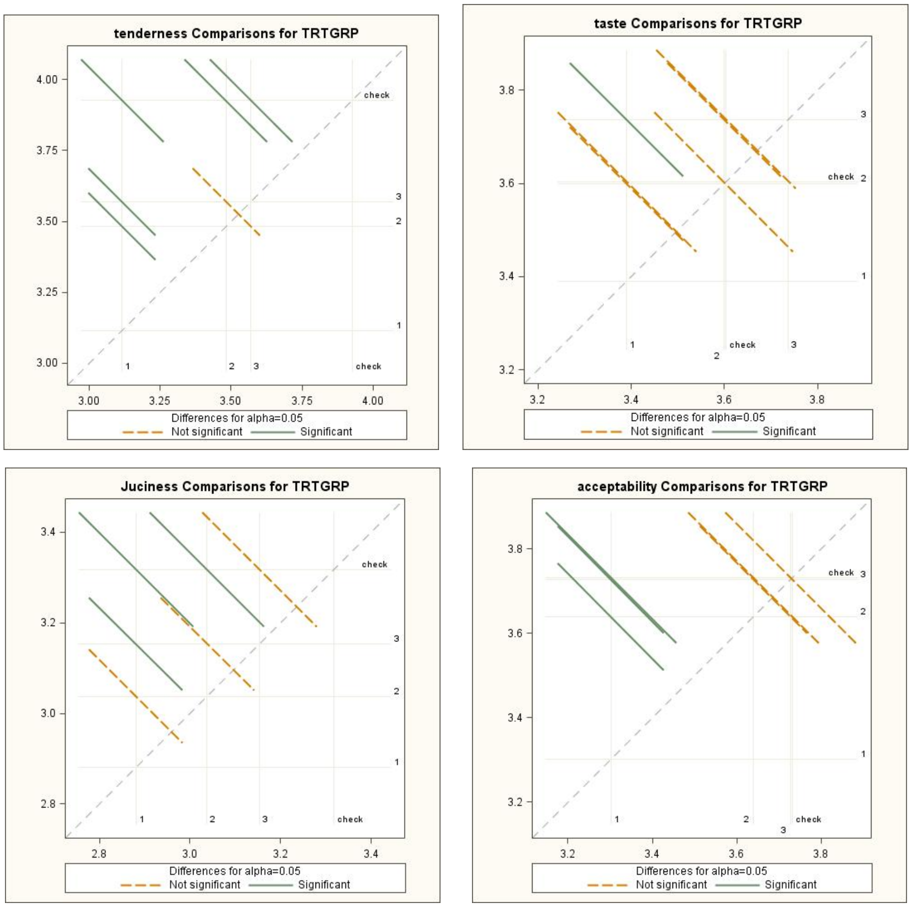

Figure 1. Mean comparison of carcass sensory evaluation for tenderness (above left), juiciness (lower left), taste (above right) and overall acceptance (lower right) of carcass obtained from ewes in different feeding level and check (young un-fattened male sheep). TRTGRP = treatment group; 1 = grazing only, 2 = medium level of feed, 3 = high level of feed. Values in x and y axis are sensor evaluation scores.

Sensitivity analysis was done to confirm to what extent the result will sustain to the variables or bad expectations. That is, assuming changes towards the worse in input and output prices or in some aspects of the enterprise that lead to a decrease in the volume of the production. Profitability of fattening practice would result in a positive net benefit for the study area up to 5% output price reduction and a 5% input price increment from current estimated average output price and input price levels (Table 4).

Table 4. Partial budgeting and Sensitivity analysis for old ewes fattening.

	Treatments				
Description	T1	T2	T3	T4	T5
Selling price (ETB/head)	258.33	353.54	368.75	378.96	386.48
Average medical cost (ETB/head)	0.4	0.4	0.4	0.4	0.4
concentrate cost (ETB/head)	0	39.78	79.56	119.34	159.12
total cost (ETB/head)	0.4	40.18	79.96	119.74	159.52
Net return (ETB/head)	257.93	313.36	288.79	259.22	226.96
Net return over the control	-	55.43	30.86	1.29	-30.97
marginal rate of return (MRR), %	-	139.34	D	D	D
Sensitivity analysis					
+5% fattening cost (ETB/head)	0.42	42.19	83.96	125.73	167.49
-5% selling price (ETB/kg)	245.41	335.86	350.31	360.01	367.16
Net benefit (ETB/head)	244.99	293.67	266.35	234.29	199.66
Marginal rate of return (MRR), %	0	53.82	D	D	D
+10% fattening cost (ETB/head)	0.44	44.20	87.96	131.71	175.47
-10% selling price (ETB/kg)	232.49	318.17	331.88	341.06	347.83
Net benefit (ETB/head)	232.06	273.99	243.92	209.35	172.36
Marginal rate of return (MRR), %	-	48.93	D	D	D

*T1 = Grazing(G); T2 = G+150g concentrate; T3 = G+300g concentrate; T4 = G+450g concentrate and T5 = G+600g concentrate D = Dominated.

Conclusion

Ewes culled from the breeding could be an additional source of income in the traditional sheep production system. Instead of keeping unproductive old ewes for longer period of time in the flock, it is advisable to condition and sell at reasonable price. Supplementation of 150 g day^{-1} concentrate feed gave both biologically and economically optimum level of supplementation to condition old ewes which give a net benefit of 55.00 Ethiopian Birr over the non-supplemented group.

References

Abebe Mekoya. 1999. Husbandry practice and productivity of sheep in Lalo-mama Midir woreda of central Ethiopia. An M.Sc. thesis presented to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia, 99 pp.

Maria Cristina Bressan, Erika Cristina Rodrigues, Lizandra Vercezi Rossato, Eduardo Mendes Ramos, Luis Telo da Gama. 2011. Physicochemical properties of meat from Bos taurus and Bos indicus. R. Bras. Zootec., 40:.6, p.1250-1259.

Plessis I. Du. and Hoffman, L.C. 2007. Effect of slaughter age and breed on the carcass traits and meat quality of beef steers finished on natural pastures in the arid subtropics of South Africa . South African Journal of Animal Science 37:3.

SAS (Statistical Analysis System), 2009. SAS for windows, Release 9.2. SAS Institute, Inc., Cary, NC, USA.

Solomon Abegaz and Gemeda Duguma, 2000. Genetic and phenotypic parameters of growth, reproductive and survival performance of Horro sheep at Bako Agricultural Research Center. Research Fellowship Report. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

Solomon Abegaz, Thwaites, C.J. and Goshu Mekonnen. 1996. The relationship of ewe productivity with body weight and age of Horro ewes. In: proceedings of the 4th Ethiopian Society of Animal Production (ESAP). pp. 75-80.

Tesfaye Getachew. 2008. Characterization of Menz and Afar Indigenous sheep breeds of smallholders and pastoralists for designing community-based breeding strategies in Ethiopia. An M.Sc. thesis presented to the School of Graduate Studies of Haromaya University, Dire Dawa, Ehiopia, 138 pp.

Ulfina Galmessa, Solomon Abegaz, Gemeda Dhuguma, Fiqiru Terefe, Girma Aboma and Solomon Gizaw. 2000. Response of aged Horro ewes to pre-market supplementary feeding. Livestock production and the improvement-Implication for sustainable livelihood. Proceedings of the 7th annual conference of the Ethiopian Society of Animal Production held in Addis Ababa, Ethiopia. 26-27 May 1999. Pp. 96-103.

Yibrah Yacob, 2008. Environmental and genetic parameters of growth, reproductive and survival performance of Afar and Blackhead Somali sheep at Werer Agricultural Research Center, Fellowship report submitted to International Livestock Research Institute (ILRI) and Ethiopian Institute of Agricultural Research. Ethiopia. 70p.

On-farm evaluation of mixture of noug seed cake and wheat bran supplementation for fattening of oxen in Bahir Dar Zuria district

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Abstract

Fattening trial of draught oxen was conducted at two rural kebeles (Robit Bata and Sosetu Yenesa) in Bahir Dar Zuria district to evaluate the contribution of mixture of noug seed cake and wheat bran supplementation compared to farmers' feeding practice on body weight changes and economic return. Final body weight and average daily gain (ADG) from 1-45 days were significantly ($p<0.05$) higher for the concentrate supplemented oxen. Though body weight gain, ADG from 1-15 days and 1-75 days were higher for the supplemented oxen, the differences were not statistically significant. Economic analysis showed significantly ($p< 0.05$) higher gross and net return from supplemented oxen than non-supplemented oxen. Therefore, in areas where industrial by-products (noug seed cake and wheat bran) could be purchased in relatively low price, fattening of draught oxen through concentrate supplementation could generate better income from increased body weight and improved body condition of the animals.

Key words: Draught, fattening, supplementation.

Introduction

Ruminant productivity in Sub-Saharan Africa is limited due to the low nutritive value of feeds available for the animals (Van Soest, 1982). The most abundant feeds in Sub-Saharan Africa are over mature natural grasses and crop residues which are limited both in quantity and quality during the dry season resulting in low growth rates (Soller *et al*., 1986; Goe, 1987). Of all ruminants, cattle have been the most important livestock in the provision of draught power and meat in the highlands of Sub-Saharan Africa (ILCA, 1981).

Despite high cattle population in the region, animal performance and return obtained has been low mainly due to poor nutrition. One of the likely ways of alleviating the problem of insufficient meat production is that of increasing productivity through improved feeding management. Traditional cattle fattening is common in the mixed crop livestock system. As the management and feeding practices are traditional, cattle fattening takes long time and the animal's productivity is low. Hence there is a need to adopt improved feeding practices to make the traditional fattening practice effective and profitable. Thus, this study was initiated with an objective of evaluating weight gain and economic return of fattening oxen through supplementation of mixture of wheat bran and noug cake.

Materials and methods

The study area and farmers selection

The trial was conducted in two rural *kebeles,* Robit Bata and Sosetu Yenesa, in Bahir Dar Zuria district. Ten volunteer farmers with better fattening experience and have participated in the study.

Experimental animals and feeding management

A total of ten draught oxen (six in supplemented and four in non supplemented group) were used for this experiment. The oxen selected were dewormed for internal parasites before the commencement of the trial and monitored for their health status during the experimental period. There were two treatments, i.e. concentrate supplemented (49.5% noug cake + 49.5% wheat bran + 1% salt + Basal feed/hay) and non-supplemented (farmers fattening practice). The supplemented group was offered 3 kg day^{-1} concentrate feed during the period of the experiment in addition to natural pasture hay used as basal diet. One kilogram concentrate feed costs 2.10 ETB. Participant farmers in the non supplemented group fed their fattening oxen hay/crop residues and local brewery by-product when available. The oxen were offered water twice daily.

Data collection and statistical analysis

Data on initial and final body weights and price of oxen were collected. The average initial body weights for supplemented and nonsupplemented groups were 326.4 kg and 289.9 kg, respectively. Body weights of oxen were taken every two weeks to know the live weight change of the oxen during the experiment. Body weight of the oxen was estimated from heart girth (HG) measurement using a prediction equation of $Y = 4.81HG - 432.73$ (r =

0.81, $p<0.001$, n = 573) developed for Boran cattle (Nicholson and Sayers, 1987). The feeding trial was conducted for 75 days after 15 days acclimitization period. Analysis of data on body weights and price of oxen was carried out using the General Linear Model (GLM) procedure of SPSS (2007). Treatment was included as classification variable, while initial body weight was included as covariate in the model when it was significant. The statistical model used was as follows:

$Y_{ij} = \mu + t_i + b + (Inwt_{ij} - Inwt) + e_{ij}$

Where, Y_{ij} = the observation on weight gain, price of animal

μ = the overall mean

t = the effect of treatment

b = linear regression of initial body weight (Inwt) on subsequent body weight gains

e_{ij} = Effect of random error

Partial budget analysis

The partial budget analysis was based on the calculation of the total cost of the basic ration (hay) and supplemented feed (concentrate) and considering averages of initial and selling price of oxen. Partial budget analysis was employed to compute average cost of production, gross and net income from sale of oxen in each treatment group. Costs (medicament, labor) that were similar in each treatment group were not included in the analysis.

Results and discussion

The oxen showed body weight gain during and at the end of the trial. The difference in average initial body weight between supplemented (326.4 kg) and non supplemented groups (289.9 kg) was not statistically significant. At the end of the experiment, weight of the supplemented oxen was 366 kg with an average weight gain of 39.6 kg, while that of the non-supplemented group was 318.4 kg with an average weight gain of 28.5 kg. Final body weight and ADG from 1-45 days were significantly ($p<0.05$) higher for the concentrate supplemented oxen. Though weight gain, ADG from 1-15 days and 1-75 days were higher for the supplemented oxen, the differences were not significant (Table 1).

Table 1. Least square means of initial body weight, final body weight and average daily gain (ADG) at different days for fattening oxen.

Parameter studied	Supplemented(N=6)	Non-supplemented(N=4)	Level of sig.
Initial heart girth (cm)	153.5 ± 4.08	150.3 ± 5.0	NS
Initial body wt (Kg)	326.4 ± 13.53	289.9 ± 14.12	NS
Final heart girth (cm)	166.7 ± 2.65	155.3 ± 3.24	*
Final body wt (Kg)	366 ± 9.41	318.4 ± 11.56	*
Body weight gain (Kg)	39.6 ± 13.6	28.5 ± 16.7	NS
ADG from 1-15 days (Kg)	1.07 ± 0.38	0.07 ± 0.46	NS
ADG from 1-45 days (Kg)	0.72 ± 0.12	0.15 ± 0.17	*
ADG from 1-75 days (Kg)	0.57 ± 0.09	0.31 ± 0.11	NS

* = Sig ($p<0.05$), NS = Not significant

Similar fattening trial conducted by Adane and Ashenafi (2005) at Adamitulu Agricultural Research Center using Arsi draught oxen supplemented with 2 kg noug seed cake to teff straw showed 46.5 Kg weight gain in 90 days fattening period among the other treatments. The group of animals fed on this ration gave the highest average net return (344 ETB) per animal. Tesfaye *et al.* (2002) in a study conducted at ILRI (International Livestock Research Institute), Debre Zeit research station also reported that supplementation of wheat bran had a significant effect on final body weight in highland zebu oxen fed teff straw as basal diet. The average body weight gain was 459 g/day for medium level of supplementation (2.75 kg/head/day) which performed better in terms of feed conversion efficiency and cost of dry matter per kg body weight.

The difference in estimated initial average price of supplemented (1900 ETB) and non-supplemented (1662 ETB) oxen was not statistically significant (Table 2). Average selling price of supplemented oxen was 3775 ETB, while the nonsupplemented group was 2575 ETB. Economic analysis showed significant ($p<0.05$) difference on gross and net return between supplemented and non-supplemented oxen. The supplemented animals had a gross return of 1875 ETB, while the non supplemented group had a gross return of 913 ETB. Net return was 1065.00 and 463.00 ETB for supplemented and non-supplemented groups, respectively (Table 2).

Table 2. Partial budget analysis for fattening oxen supplemented with mixtures of noug seed cake and wheat bran.

Parameter studied	Supplemented (N=6)	Nonsupplemented (N=4)	Level of significance
Average initial price of oxen	1900.00	1662.00	NS
Average selling price of oxen	3775.00	2575.00	*
Gross return	1875.00	913.00	*
Costs	810.00	450.00	
Concentrate feed	472.50	-	
Hay	337.50	450.00	
Net return	1065.00	463.00	*

* = Sig ($p<0.05$), NS = Not significant.

Conclusion and Recommendation

Economic analysis showed significantly higher gross and net return from supplemented oxen. Therefore, in areas where industrial by-products (noug seed cake and wheat bran) could be purchased in relatively low price, fattening of draught oxen through concentrate supplementation could generate better income from increased body weight and improved body condition of the animals.

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References

Adane Hirpa and Ashenafi Mengistu. 2005. Economics of different supplement options to teff straw for fattening Arsi oxen. Asfaw Yimegnuhal and Tamrat Degefa (Eds). Proceedings of the 12th Annual conference of the Ethiopian Society of Animal Production (ESAP), August 12-14, 2004. ESAP, Addis Ababa, 410 pp.

Goe, M.R. 1987. Animal traction on smallholder farms in the Ethiopian highlands. PhD dissertation. Department of Animal Science, Cornell University, Ithaca, New York.

ILCA (International Livestock Centre for Africa). 1981. Animal traction in Sub Saharan Africa. ILCA Bulletin 14, Addis Ababa, Ethiopia.

Nicholson M.J. and. Sayers A.R.. 1987. Relationships between body weights, condition score and heart girth changes in Boran cattle. Trop. Anim. Hlth Prod. (1987) 19, 115-120.

Soller, H., Reed, J.D., and Butterworth, M.H. 1986. Intake and utilization of feed by work oxen. ILCA Newsletter Vol. 5 No. 2, Addis Ababa, ILCA.

Statistical Procedures for Social Sciences (SPSS). 2007. (Version 16.0). Statistical Procedures for Social Sciences (SPSS) INC, Chicago, USA.

Tesfaye Wolde Michael, P.O. Osuji, Asfaw Yimegnuhal and Alemu Yami. 2002. Effect of wheat bran supplementation on feed intake, body weight change and retained energy in the carcass of Ethiopian highland zebu (*Bos indicus*) oxen fed teff straw as basal diet. Proceedings of the 9th Annual conference of the Ethiopian Society of Animal Production (ESAP), August 30-31, 2001. ESAP, 433pp.

Van Soest, P.J. 1982. Nutritional ecology of the ruminant. O and B books, Corvallis, Oregon.

Phenotypic characteristics of Farta sheep in Amhara Region, Ethiopia

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Abstract

A study to describe the physical body characteristics of Farta sheep was undertaken in south Gonder zone of the Amhara Regional State, Ethiopia. Three districts (Estie, Farta and Lai-Gaint) were selected purposively based on sheep population and accessibility. Both qualitative and quantitative measurement data were collected on 920 (557 Female and 363 male) and 667 (634 Female and 33 male) sheep, respectively. The descriptive statistical procedures of SPSS version 16 was used to describe the qualitative traits. GLM procedure of SPSS version 16 was used to analyze body measurements. Three coat patterns (plain (54.9%), spotted (29.5%) and patchy (15.6%) were observed. White (35.38%), brown (13.94%), mixture of brown and white (Goseme; 16.19%) and mixture of white, brown and black (11.39%) were dominant coat color types. Straight head profile (73.2%) had high proportion followed by convex head profile types (26.4.51%). All Farta sheep in the study area (100%) had horizontal ear form. Most (57.6%) of the rams were horned while most females (91.6%) were polled. Out of the horned rams, 57.1% had curved horn shape with backward orientation. About 62.3% of the horned ewes had curved horn shape with back ward orientation. Farta sheep are short fat tailed (100%). The tail is curved up ward at the tip (55.6%) and the remaining was twisted (33.7%) and straight and tip down ward (10.6%). Almost all Farta sheep had no toggle (94.35%), no wattle (98.4%) and ruff (100%). The overall weight, height at withers, heart girth and body length obtained were 24.13kg, 61.69 cm, 70.39 cm and 54.32 cm, respectively. Results on body weight and linear measurements showed age-dependent sexual differences. Males appeared longer and heavier ($P<0.001$) than females at all age categories. The body measurements of younger animals were less than ($P<0.001$) those of older age groups.

Key words: Body weight, characterization, Farta sheep, phenotypic.

Introduction

Ethiopia's sheep population estimated at 23.6 million (CSA, 2004), is the third largest in Africa with more than 18 breeds or populations (DAGRIS, 2004). Major sheep breeds found in Ethiopia are Begayit, Farta, Horro, Abergelle, Menz, Begi-Degu, Arsi, Ille, Tukur, Bonga, Afar, Dangila and Black Head Somali (formerly known as Black Head Ogaden) sheep breeds. Farta sheep breed is found in South Gondar Zone of Amhara Regional State.

Sheep contribute a substantial amount to the farm household as income, mutton and non-food products (manure, skins and coarse wool). The awareness in recognizing the value and the contribution of small ruminant production to a stable and sustainable food production in Tropical Africa has grown quite substantially in the last decade. Such positive development efforts need to be supported through appropriate research and development activities to enhance productivity of locally available breeds by minimizing the prevailing production constraints. Despite the wide traditional importance, availability of large population and genetic resource, the attention given to the improvement of this sub sector is inadequate.

There seems to be a greater awareness of the need to identify, characterize, preserve and improve indigenous breeds which are thought to have some valuable attributes that could be used at present or sometime in the future. Therefore, the objective of the study was to describe and document the phenotypic characteristics of Farta sheep in the study area.

Materials and methods

Site selection and description of the study area

The study was conducted in south Gondar, Amhara region. Three districts namely Esite, Farta and Lai-Gaint and six peasan associations (Pas), two PAs from each district, were selected purposively based on their high number of the targeted sheep population, potential of sheep production and road accessibility.

Farta district is located about 100 km north-east of Bahir Dar, capital of the Amhara National Regional State. Farta lies within an altitude range of 1920-4135 m a.s.l. The district receives an average annual rainfall of 900-1099 mm and a mean-range temperature of 9-25 ^{0}C (Farta District OoARD, annual report). The second district, Lai-Gaint, is located 175 km from Bahir Dar and lies between an altitude ranges 1300-3500 m.a.s.l. Lai-Gaint receives an annual average rainfall of 600-1100 mm and mean minimum and mean maximum temperature of 9 and 19 ^{O}C, respectively. The third district, Esite district, is located 157 km North West of Bahir Dar city having an altitude range of 1500-4000 m a.s.l. The minimum and maximum mean annual rainfall perception of the area is 1307-1500 mm and the mean annual minimum and maximum temperature is 8.3 ^{O}C – 25 ^{O}C.

Data collection

For phenotypic characterization of Farta sheep, the following sampling procedures were used. For qualitative trait 667 mature Farta sheep of both sexes and for quantitative trait 920 sheep at all age stage were selected randomly from purposely selected PAs to obtain information on physical characteristics of the sampled sheep. This number of sheep was taken based on the minimum standard set by FAO (2005) to undertake characterization. For breed phenotypic characterization, a total of 48 variables were selected from the FAO (2005) sheep breed descriptor list. The selected qualitative characters included: sex, dentition, coat pattern, coat color type, hair type, head profile, horn shape, horn orientation, presence/absence of wattle, presence/absence of ruff, presence/absence of toggle, tail type, tail shape and ear form. The quantitative character include: body weight, body length, height at wither and heart girth.

Data analysis

The raw data collected from the formal survey were entered, cleaned, managed and analyzed using SPSS Version 16 for descriptive statics.

Results and discussion

Effect of sex and location on phenotypic traits

The phenotypic characteristics of Farta sheep in the study area were observed and recorded for female and male separately (Table 1).

The analysis of chi-square test of the phenotypic traits for the effect of sex and location showed that coat color pattern, coat color, hair type, head profile, ear form, horn shape, horn orientation, tail type and tail shape had no significant (P>0.05) variation due to sex and location. This indicates that dilution of the breed with other type of breed was insignificant. However, the presence/absence of horn had significant (P<0.05) variation due to the difference in sex.

Table1. Chi-square test of the phenotypic traits for the effect of districts and sex.

Traits	Source of variation	P-value
	Districts	0.623
Coat color pattern	Sex	0.736
	Districts	0.431
Coat color	Sex	0.292
	Districts	0.321
Hair type	Sex	0.094
	Districts	0.135
Head profile	Sex	0.832
	Districts	0.724
Ear form	Sex	0.532
	Districts	0.083
Presence/absence of horn	Sex	0.724
	Districts	0.246
Horn shape	Sex	0.329
	Districts	0.573
Horn orientation	Sex	0.493
	Districts	0.634
Tail type	Sex	0.391
	Districts	0.215
Tail shape	Sex	0.342

Phenotypic characteristics

Coat pattern, coat color and hair type of Farta sheep

Screening was made for coat pattern (plain, spotted and patchy) and color (Black, white, spotty and brown) in 634 Farta sheep from Esite, Farta and Lay Gaint of the study areas (Table 2). Nearly 54.9% of the sheep in overall study area had plain coat pattern distribution which is followed by spotted and patchy coat pattern with proportion of 29.5% and 15.6%, respectively.

Table 2. Farta sheep coat pattern, coat color and hair type distribution in the study districts.

Character	Attribute	Female (N=634)		Male (N=33)		Overall (N=667)	
		N	%	N	%	N	%
Coat color Pattern	Patchy	101	15.9	3	9.1	104	15.6
	Plain	345	54.4	21	63.4	366	54.9
	Spotted	188	29.7	9	27.3	197	29.5
Coat color	Brown	88	13.88	6	18.18	93	13.94
	Brown with black/white head	50	7.88	2	6.06	52	7.8
	Mixture of brown and black	103	16.25	4	12.12	108	16.19
	White	223	35.17	13	39.39	236	35.38
	Mixture of white and black	29	4.57	3	9.09	32	4.79
	Black	45	7.1	3	9.09	48	7.2
	Black with white/brown head	20	3.15	2	6.06	22	3.29
	Mixture of Brown, white and black	76	11.99	0	0	76	11.39
Hair type	Coarse	613	96.7	32	97	645	96.7
	Smooth	21	3.3	1	3	22	3.3
Head profile	Concave	3	0.5	0	0	3	0.4
	Convex	160	25.2	16	48.5	176	26.4
	Straight	471	74.3	17	51.5	488	73.2
Ear Form	Horizontal	634	100	33	100	667	100
Horn	Present	53	8.4	14	42.4	67	10.0
	Absent	581	91.6	19	57.6	600	90
Horn sheep	Curved	33	62.3	8	57.1	41	61.2
	Spiral	8	15.1	6	42.9	14	20.9
	Straight	12	22.6	0	0.0	12	17.9
Horn orientation	Back ward	34	64.2	12	85.7	46	68.7
	Lateral	19	35.8	2	14.3	21	31.3
Tail type	Short fat	634	100	33	100	667	100
Tail shape	Curled	359	56.6	12	36.4	371	55.6
	Straight	68	10.7	3	9.1	71	10.6
	Twisted	207	32.6	18	54.5	225	33.7
Toggle	Present	11	1.7	0	0	11	1.6
	Absent	623	98.3	33	100	656	98.4

N = Number of observations

In overall study area, coat color types of plain white had high proportion of frequency than the others which followed by the coat color that had a mixture of white and Brown. Coat color types of plain white, brown and black in Farta sheep were 35.38%, 16.19% and 7.2 %,.respectively. This is strongly supported by the preference of farmers for white and brown to the black color for which the farmers are exerting some kind of selection for the preferred ones. The mixture of brown and white (*Goseme)* and black and white (*Arbete*) accounted 16.19% and 4.79%, respectively. Brown with white or black head (*Yekeye bora*) and black with white or brown head (*Ytekure bora*) had a proportion of 7.8% and 3.29% respectively. A mixture of white, brown and black coat color of Farta sheep accounted 11.39% out of the total sampled size.

Head profile and Ear Form

In the study area, straight head profile (73.2%) had high proportion frequency than the other types of head profile which is followed by convex and concave head profile types with proportion of 26.4% and 0.4%, respectively. All Farta sheep in the study area (100%) had horizontal ear form.

Horn Sheep and orientation

The presence and the absence of horn in Farta sheep were dependent on sex variation. Most (57.6%) of the rams were horned whereas the rest (42.4%) were polled. Out of the horned rams, 57.1% had curved horn shape and the remaining 42.1% had spiral horn shapes. Out of the total horned, 85.7% of the rams had back ward oriented and the remaining 14.3% had laterally oriented horns. Most (91.6%) of the ewes were polled whereas the rest of the ewes (8.4%) were horned. Out of the horned ewes, 62.3% had curved horn shape and the remaining 22.6% and 15.1% had straight and spiral horn shape. Out of the total ewe having horn, 64.2% of the ewe had back ward oriented and the remaining 35.8% had laterally oriented horns.

Tail types and shape, toggle, ruff and wattle

Farta sheep breed is a fat tailed. All (100%) of the breed are short fat tailed. In more than half of the sampled sheep, the tail was curved up ward at the tip (55.6%) and the remaining was twisted (33.7%) and straight tip down ward (10.6%). Almost all Farta sheep had no toggle (98.4%), wattle (100%) and ruff (100%). Figures 1 and 2 showed Farta sheep grazing at communal grazing land.

Figure1. Farta sheep grazing on a communal grazing land.

Body weight and linear body measurements

The Mean ± Standard Deviation (SD) of body weight and linear body measurements of Farta sheep by sex and age groups are shown in Table 3.

Table 3. Body weight and Linear body measurements of Farta sheep by sex and age groups (Means ± SD).

Age group	Sex	n	BW(kg)	HW (cm)	BL(cm)	HG(cm)
0PPI	Male	93	17.8±5.41a	57.85±7.85a	49.71±6.81a	61.69±8.85a
	Female	136	14.4 ±6.88b	54.28 ±6.4b	46.49 ±6.41b	56.75 ±7.98b
1PPI	Male	64	25.00±4.64c	62.70±1.3c	55.60±5.9c	71.10±8.6c
	Female	103	20.46±4.49d	60.34±3.8d	51.17±4.11d	67.59 ±6.01d
2PPI	Male	73	28.22±3.9e	67.80±3.99e	58.5±3.17e	74.10±3.70e
	Female	91	23.7±2.89f	62.27±8.47f	55.42±2.88fh	71.34±5.06fh
3PPI	Male	51	31.07±5.71g	71.00±7.94g	61.00±3.00g	78.00±5.29g
	Female	97	26.47±3.33hj	64.36±3.39hj	56.56±3.96hfj	72.78±4.55hfj
4 PPI	Male	82	34.1±6.93i	74.00±4.24i	64.00±0.00i	81.00±4.24i
	Female	130	27.12±4.14jh	65.65±5.78jh	57.4±4.25jh	73.58±5.06jh
Overall	Pooled	920	24.13±4.63	61.69±5.32	70.39±4.61	54.32±5.97

HW = Height at withers; HG = Heart Girth BL = Body length; BW = Bodyweight; n =No. of observations, 0PPI = those with zero pairs of permanent incisor, 1PPI = those with one pairs of permanent incisor, 2PPI = those with two pairs of permanent incisor, 3PPI = those with three pairs of permanent incisor, 4PPI = those with four pairs of permanent incisor and wear out), Values within a column having different superscripts differ significantly (p<0.05).

Males were higher than females in terms of body weight, height at withers, girth length and body length across all age categories (P<0.05). This result agrees with the conclusion by Tobbo *et al.* (2004) stated that male sheep generally grow faster and are heavier with superior body conformational measurements than female sheep. Body weight and linear body measurements were significantly ($P<0.05$) differed among the age group zero, one, two, three and four in male Farta sheep. In female Farta sheep, body weight and height at withers were not significantly ($P>0.05$) different between age groups three and four. In female Farta sheep body length and heart girth were not significantly ($P>0.05$) different between age groups two and three and also among three and four. The results obtained on body weight and linear body measurements of Farta sheep were higher than the report of Tesfaye (2008) for Menz sheep but lower than the report of Mengiste (2008) for Washera sheep. On the basis of body size and height at withers, Farta sheep can be classified as a medium sized breed according to one of the sheep description criteria suggested by FAO (1986).

Conclusion

Except the presence and the absence of horn, the other qualitative traits had no significant variation in Farta sheep due to differences in sex and districts. Farta sheep breed is a short fat tailed with a majority of curved up ward at the tip. The coat color pattern varied from plain, patchy and spotted with high proportion of plain coat. The major coat color types were plain white, a mixture of white and brown (*Goseme*) and plain brown. The majorities of Farta sheep have a long coarse hair. The predominant head profile observed is straight head with low proportion of convex. The ear form observed was horizontal. Almost all ewes were polled whereas the majorities of the rams were horned. The rams have a horn shape markedly from spiral through curve to straight. The predominant horn orientation was observed back ward which is followed by lateral. Almost all the sheep were not toggle. Ruff and wattle were not totally observed in the sampled Farta sheep. Males were higher than females in terms of body weight, height at withers, girth length and body length. In general, the Farta sheep can be classified as a medium size breed type.

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References

CSA. 2004. (Central Statistical Authority). Agriculture Sample survey Statistical bulletin. Addis Ababa, Ethiopia.

DAGRIS. 2004. Domestic Animal Genetic Resources Information System (DAGRIS). (eds Ed Rege, Workneh Ayalew, Ephrem Getahun). ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. (http://dagris.ilri.cgiar.org/dagris/, accessed on 15-Apr-2006).

FAO. 1986. Animal Genetic Resources Data Banks Descriptor lists for cattle, buffalo, pigs, sheep and goats. FAO Animal Production Health Paper 59/2: 150 pp.

FAO. 2005. Genetic characterization of livestock populations and its use in conservation decision making, by O. Hannotte & H. Jianlin. In Ruane, J. and Sonnino, A.(Eds). The role of biotechnology in exploring an protecting agricultural genetic resources, pp. 89–96. Rome. (www.fao.org/docrep/009/ a0399e/a0399e00.htm) accessed on 12/06/2007).

Mengistie Taye. 2008. On-farm Performances of Washera Sheep at Yilmanadensa and Quarit Districts of the Amhara National Regional State, MSc Thesis. Hawassa University, Awassa, Ethiopia.

Tesfaye Ashagre. 2008. Performance of Menz sheep under traditional management system in Dessie Zuria district of South Wollo, Amhara region, MSc Thesis. Mekelle University, Mekelle, Ethiopia.

Quality parameters of skin from Menz, Awassi X Menz and Washera sheep breeds for leather production

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Abstract

This study aimed at assessing the influence of crossbreeding on physical characteristics of leather considering that important leather characteristics can be affected when exotic breeds are introduced to improve meat production in native breeds. Sheep skin (n = 72) from three different genotype and three feeding levels were evaluated for their grade at pickling stage and physical characteristics of crust leather. Sheep genotypes were Menz and Washera, and half-bred Awassi x Menz sheep. The feed levels were grazing; grazing + 400 g day^{-1} concentrate feed supplement and grazing + 600 g day^{-1} concentrate supplement. At raw stage all skin was graded between 1 and 3 (best to medium) however at pickling stage no skin was graded between 1 and 3 rather graded as poor quality (5A and above). Tensile strength and single edge tear force was affected by sheep genotype. Awassi x Menz crossbred sheep had similar ($p>0.05$) tensile strength with the indigenous Menz sheep, whereas lower ($p<0.05$) than Washera sheep breed. Menz sheep had similar ($p>0.05$) tensile strength with Washera sheep. Both sheep genotype and feeding level had no effect ($p>0.05$) on elongation at break. Menz sheep had similar ($p>0.05$) single edge tear force with its Awassi crosses and other indigenous Washera sheep. In contrary to the tensile strength, Awassi x Menz crossbred sheep had higher ($p<0.05$) single edge tear force than Washera sheep breed. Single edge tear force and skin thickness were increased as feed level increased. Tear resistance was not affected ($p<0.05$) by genotype and feeding. This study confirmed that there is no evidence of supporting the suspected inferiority of skins from crossbred sheep. All the three sheep breeds studied produced leathers with physical characteristics compatible with the quality standards required by the leather industry. Thus, introduction of Awassi sheep and its inheritance to 50% could not result in a significant decrease in leather quality. Further investigation should be done for the exotic inheritance of above 50% in order to quantify if there is a loss of quality at that higher Awassi blood levels.

Key words: Genotype, feeding, leather, skin.

Introduction

Because of abundant and renewable resource base in Ethiopia due to large livestock population, the leather industry is an important strategic sector for the economic and industrial development. Abundant livestock resource, less production cost and increasing demand for leather and leather goods show that the leather processing will continue to be a major industry for Ethiopia (Mahmud, 2000; Mammo, 2000). Small ruminant improvement program in Ethiopia has primarily based on meat production. However, semi-processed skins and hides in the form of pickled, wet-blue and finished leather and leather products constitute the most important export products of the livestock sub-sector. Indigenous sheep breeds particularly those from the Ethiopian highlands are reputed to have one of the best quality skins for leather products having fine natural qualities of clarity, thickness, flexibility, strength, and compact texture (Mahmud, 2000). Skins of tropical sheep are generally thicker than those obtained from the layered structure of skins of finer-wool breeds like Merino which gives them a poor reputation. It is hypothesized that importing exotic genotype for meat and milk production in native breeds might also negatively affect important leather characteristics. Skins from Awassi x Menz crossbred sheep are either sold at lower prices or are rejected completely. There is, however, no scientific proof for or against the alleged inferiority of skins from Awassi x Menz crossbred sheep. Thus, it is indispensable to investigate the quality of the skins of indigenous and crossbred sheep breeds to ensure their true value and incorporate in evaluating and designing crossbreeding programs.

Materials and methods

Animal management

Sheep skin (n = 72) from three different genotype and three feeding levels were evaluated. Sheep breeds were indigenous Menz and Washera, and half-bred Awassi x Menz sheep. The feed levels were grazing; grazing +400g day^{-1} concentrate feed supplement and grazing +600 g day^{-1} concentrate supplement. Indigenous Menz and Washera sheep breed were purchased from local markets in Menz and Gojjam areas, respectively.

Awassi X Menz crossbred sheep were purchased from Amed Guya Sheep Breeding and Multiplication Center. Feeding was started in July 2009 and was conducted for 90 days. At the beginning of feeding, Menz and Awassix Menz crossbred sheep were at about 15 months old while Washera sheep was at about 9 months old. Before the beginning of the feeding, all sheep were treated against internal and external parasites. Then from each breed, sheep were allocated randomly into three feeding levels after stratifying by their live weight. All animals were managed similarly during the day and sheep in supplemented group received their corresponding amount of supplement feed after grazing. Supplement feed was provided for each animal individually using individual feeding trough for 90 days. Initial weight, slaughter weight and average daily gain of sheep are presented in Table 1.

After the 90 days feeding trial, all sheep were slaughtered at Debre Berhan Agricultural Research Center and the skins were flayed by local slaughter men. All skins were washed with cold water and salted on the flesh side of a skin. On the next day, part of the skin (n = 25) 3 skins from each treatment were selected randomly and submitted to Mojo tannery and the remaining skins (n = 45) 5 skins from each treatment were submitted to Ethiopian Leather and Leather Products Technology Institute (ELPTI) for skin grading and physical characteristics test, respectively.

Table 1. Initial, slaughter weight and average daily gain of sheep by genotype and feed level.

Genotype/feed level	N	Initial weight (kg)	Slaughter weight (kg)	Average daily gain (g)
Awassi X Menz				
Low	8	26.84	32.91	76.74
Medium	8	27.13	39.63	130.21
High	8	27.19	41.69	144.10
Menz				
Low	8	19.71	22.84	41.67
Medium	8	20.19	28.0	67.59
High	8	21.25	28.53	75.00
Washera				
Low	8	19.63	23.50	56.25
Medium	7	20.75	29.75	87.04
High	7	20.83	31.33	90.74

N = number of animals.

Skin grading and physical test

Skin size, presence of defects on skins and quality grading were done at Mojo tannery. Size of the skin classified as medium, large and extra large based on subjective assessment. Skin quality was graded in 1 to 5 scales where 1 is the best and 5 are the poorest considering sheep ked infestation and size. At ELPTI skin processing was performed according to the following main steps: soaking, liming, washing, fleshing, trimming, deliming, pickling, tanning, blastification, sammying, neutralization, re-tanning, drying and smoothing. After tanning the leather were conditioned based on ISO 2419:2005 and sampling for test was done based on the procedure of ISO 2418:2005. Environmental test condition was at temperature of $20\underline{+}2\ ^0C$ and relative humidity of $65\underline{+}5\%$. Samples were taken parallel to the back bone and perpendicular to the back bone.

Physical test gives an indication of the strength as well as the amount of the leather could be stretched before the upper grain layers crack, which will cause damage to the surface of leather. The following physical tests were implemented ELPTI.

Tensile strength: Tensile strength is defined as the force required for the breaking of a dumbbell-shaped leather sample on the Instron machine. The sample is held firmly in two clamps. These two clamps move apart at a steady speed of ± 100 mm min^{-1}. As they move apart, the force required to stretch the leather is measured automatically. At some point, the leather sample breaks. The force required to break the sample is called the tensile strength of the leather and is measured in Newtons. For each test, samples cut along as well as across the length of the skin were used. Tensile strength was measured based on ISO 3376:2000 procedure.

$$Tensile\ strength\ (N/mm^2) = \frac{Measured\ breaking\ load\ (N)}{(Thickness\ (mm) X\ Width\ (mm))}$$

Elongation at break: This is measured during the tensile strength test described above. At the point of breaking, the leather has also been stretched. The percentage stretch is called the elongation at break. It is defined as the percentage stretch of the dumbbell shaped leather sample before it broke.

$$Elongation\ at\ break\ (\%) = \left(\frac{Length\ at\ break\ (mm) -\ Initial\ length\ (mm)}{Initial\ \ length\ (mm))}\right) X\ 100$$

Tear resistance: The test for slit tear strength involved a rectangular leather sample with a small slit cut in it. The sample was then pulled apart by a clamp attached to its base and another clamp inserted through the slit. The point at which the slit starts to tear was defined as the slit tear strength. The slit tear strength was expressed in relation to average leather thickness.

$$Tear\ resistance\ (N/mm) = \left(\frac{Force\ at\ tear\ \ (N)}{Skin\ thickness\ (mm)}\right)$$

Single edge tear force (N): This is the highest load reached at tear. Measured using ISO 3377-2:2002 procedure.

Data analysis

Descriptive statistics were implemented using SPSS to summarize the proportion of skin defect, size and grade by genotype. Fisher's exact test was used to test the association of skin defect, size and grade with genotype. Data on tensile strength, percent elongation, single edge tear, skin thickness and tear resistance was analyzed using GLM procedure in SAS by fitting breed and feeding level as class variable. The interaction of the two was not significant so that excluded from the model. When significant, means were separated using Tukey Kramer test.

Results and discussion

Sheep skin defect due to sheep ked by genotype before and after pickling are presented in Table 2. There was significant ($P<0.05$) association between sheep ked infestation and genotype before pickling. Less proportion of sheep ked infestation was observed for Awasi X Menz crossbred sheep. The on-station management at Amedguya Sheep Breeding and Multiplication Center might contribute for less proportion of sheep ked infestation. However, there was no association ($p>0.05$) between sheep ked infestation and genotype after pickling. This is due to the fact that ked infestation becomes more evident at pickling stage.

Table 2. Number of skin and percentage in bracket for sheep ked infestation before and after pickling by genotype.

	Before pickling		Fisher's exact test	After pickling		Fisher's exact test
Genotype	Sheep ked	No ked	p value	Sheep ked	No ked	p value
Awassi x Menz	2(22.2)	7(27.8)	0.013	8(88.9)	1(11.1)	1.00
Menz	8(88.9)	1(11.1)		8(88.9)	1(11.1)	
Washera	6(75.0)	28(25.0)		8(100)	0(0.00)	
Overall	16(61.5)	10(38.5)		24(92.31)	2(7.69)	

Sheep skin size of Awassi xMenz crossbred and Menz sheep are presented in Table 3. There was association ($p<0.05$) between size and genotype. Large size skin was obtained from crossbred sheep. Washera sheep skin was not considered in this analysis as the age of Washera sheep at slaughter was 6 months less than the other two breeds.

Table 3. Number of skin and percentage in bracket for skin size by genotype.

	Size		Fisher's exact test
Genotype	Large	Extra large	p value
Awassi x Menz	0(0.00)	9 (100)	0.02
Menz	5(55.6)	4(44.4)	
Overall	5(27.8)	13(77.2)	

The results of skin grade at pickled stage are presented in Table 4. Out of the total (n = 25) skins most of the skins (87.5%) were graded as poor quality (5A and above), and 37.5% were rejected due to poor quality. There was no association between genotype and grade ($p>0.05$). At raw stage all skin was graded between 1 and 3 (best to medium) however at pickling stage no skin was graded between 1 and 3. Sheep ked was noted as the major reason for the downgrading of the skin. This was also reported by Tefere and Abebe (2007) that they found hides and skin problems caused by lice, keds, ticks and mange mites are among the major pre-slaughter defects that cause downgrading and rejection. The price of skin in international market is highly influenced by size and grading quality of semi-processed skin (Tefera and Abebe, 2007). As the proportion of ked increased the grade of sheep and goat skin decreased (Tefera and Abebe, 2007). Thus, controlling or treating external parasite in farmers' sheep flock should be given highest attention.

Table 4. Number of skin and percentage in bracket for skin grade by genotype.

	Grade				Fisher's exact
Genotype	4	5A	5B	R	test p value
Awassi x Menz	1(11.1)	6(66.7)	0(0.00)	2(22.2)	0.287
Menz	1(11.1)	4(44.4)	0(0.00)	4(44.4)	
Washera	2(28.57)	4(57.14)	1(14.29)	0(0.00)	
Overall	4(25.0)	14(87.5)	1(6.25)	6(37.5)	

Tensile strength, percent elongation, single edge tear and tear resistance by genotype and feed level are presented in Table 5. Tensile strength was affected by sampling direction. Better result was obtained for parallel direction. This is in agreement with (Snyman and Jackson-Moss, 2000; Oliveira *et al.,* 2007). Tensile strength obtained in this study ranged from 16.11 to 18.84 N/mm^2 was in agreement with 10 South African sheep breeds ranged from 11.86 to 22.56 N/mm^2 (Snyman and Jackson-Moss, 2000), higher than 12.8 N/mm^2 reported for sheep breed in Germany (Rehbein *et al.,* 2000) and lower than 20 to 29.42 N/mm^2 reported for the Brazilian sheep breeds (Oliveira *et al.,* 2007). Tensile strength was influenced ($p<0.05$) by genotype of the sheep. Awassi X Menz crossbred sheep had similar ($p>0.05$) tensile strength with the indigenous Menz sheep where as lower ($p<0.05$) than Washera sheep breed. Menz sheep had similar ($p>0.05$) tensile strength with Washera sheep. Tensile strength was not affected ($p>0.05$) by feeding.

Elongation at break was also affected by sampling direction. The vertical direction gave the best result and this was also in agreement with (Oliveira *et al.,* 2007; Snyman and Jackson-Moss, 2000). Both sheep genotype and feeding level had no effect ($p>0.05$) on elongation at break. The value of elongation at break 65.88 % obtained in this study was found to be in the acceptable range of 40 to 80 % by the standard of the Brazil leather industry (Oliveira *et al.,* 2007).

Single edge tear force was affected ($p<0.05$) by genotype and feeding level. Menz sheep had similar ($p>0.05$) single edge tear force with its Awassi crosses and other indigenous Washera sheep. In contrary to tensile strength, Awassi X Menz crossbred sheep breed had higher ($p<0.05$) single edge tear force than Washera sheep breed. Single edge tear force was increased as feed level increased. Sheep in high feeding level had higher single edge tear force than sheep in low feeding level (grazing only). Sheep in medium feeding level had similar single edge tear force with sheep in low and high feeding level. Skin thickness was increased as feed level increased. Tear resistance was not affected ($p<0.05$) by genotype and feeding.

Tear resistance of 15.01 to 15.99 N/mm obtained in this study was lower than Brazilian and South African sheep breeds (Snyman and Jackson-Moss, 2000; Oliveira *et al.,* 2007) however, it was in agreement with the result from sheep breed in Germany (Rehbein *et al.,* 2000).

In this study, Washera sheep breed was evaluated in average of 6 months less than Menz and Awassi_Menz crossbred sheep. Tensile strength of ostritches skin was increased at rate of 0.43 N/mm^2 per month up to the age of 14 months (Cloete *et al.,* 2004) and it was also observed that there is a trend of increases in skin physical characteristics of goat skins up to 24 months age (Wang and Attenburrow, 1993). With this fact the superiority of Washera sheep skin in tensile strength even at lower age indicated that the breeds ability of providing skin with highest value of tensile strength. Our result on physical test parameters was comparable with hair Dorper sheep breeds of South Africa which is known as the most popular and required in leather industry.

Table 5. Physical characteristics of leather produced from different genotype and feeding level.

Genotype/feed level	Thickness (mm)	Tensile strength (N/mm^2)			Elongation at break (%)			Single edge tear force (N)			Tear resistance
		parallel	vertical	average	parallel	vertical	average	parallel	vertical	average	
Genotype		*	*	*	NS	NS	NS	*	*	*	NS
A x M	1.23^{a}	18.15^{a}	13.99^{a}	16.11^{a}	51.49	81.17	66.34	23.92^{a}	15.61^{a}	19.79^{a}	15.99
Menz	1.18^{a}	20.15^{ab}	15.69^{ab}	17.92^{ab}	51.40	80.73	66.00	22.22^{a}	13.10^{b}	17.66^{ab}	15.02
Washera	0.99^{b}	21.97^{b}	15.93^{b}	18.94^{b}	49.77	80.82	65.29	17.34^{b}	13.07^{b}	15.21^{b}	15.53
Feed level		NS	NS	NS	NS	NS	NS	*	*	*	NS
Low	1.02a	20.60	15.55	18.07	49.12	80.71	64.85	18.52^{a}	12.41^{a}	15.47^{a}	15.01
Medium	1.17b	20.24	14.81	17.53	49.60	84.38	67.00	21.79^{ab}	14.34^{ab}	18.06^{ab}	15.69
High	1.21c	19.42	15.25	17.38	53.95	77.64	65.78	23.22^{b}	15.04^{b}	19.13^{b}	15.85
R2 (%)	41.64	26.10	19.64	27.93	14.24	5.55	3.40	35.17	30.13	39.21	6.75
CV (%)	14.48	14.54	12.92	11.69	11.82	14.94	8.42	23.27	18.87	18.22	13.64
SE	0.04	0.75	0.51	0.58	1.55	3.12	1.43	1.27	0.68	0.83	0.55

* = significant at p = 0.05, NS = not significant at p = 0.05 and means with different subscript within a column are statistically different (p<0.05).

Conclusion and recommendation

This study confirmed that there is no evidence of supporting the suspected inferiority of skins from crossbred sheep. All the three sheep breeds studied produced leathers with physical characteristics compatible with the quality standards required by the leather industry. Thus, introduction of Awassi sheep and its inheritance to 50% could not result in a significant decrease in leather quality. Further investigation should be done for the exotic inheritance of above 50% in order to quantify if there is a loss of skin quality at that higher Awassi blood levels.

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References

Cloete, S.W.P., S.J. van Schalkwyk, L.C. Hoffman and A. Meyer. 2004. Effect of age on leather and skin traits of slaughter ostriches. South Afr. J. Anim. Sci. 34:2.

Mahmud, A. 2000. Development potential and constraints of hides and skins marketing in Ethiopia. In: R.C. Merkel, G. Abebe and A.L. Goetsch (eds.). The Opportunities and Challenges of Enhancing Goat Production in East Africa. Proceedings of a conference held at Debub University, Awassa, Ethiopia from November 10 to 12, 2000. E (Kika) de la Garza Institute for Goat Research, Langston University, Langston, OK pp. 127-138.

Mammo Muchie. 2000. Leather processing in Ethiopia and Kenya: lessons from India. Technology in Society 22: 537–555

Oliveira, R.J.F., Costa, R.G., Sousa, W.H., Medeiros, A.N., Dal Montea, M.A.B., Aquino, D., Oliveira, C.J.B. 2007. Influence of genotype on physico-mechanical characteristics of goat and sheep leather. Small Rumin. Res. 73:181–185

Rehbein, S., Oerte, H. l, Barth, D., Visser, M., Winter, R., Cramer, L.G., Langholff, W.K. 2000. Effects of Psoroptes ovis infection and its control with an ivermectin controlled-release capsule on growing sheep 2. Evaluation of wool production and leather value Veterinary Parasitology 91:119–128

Snyman, M.A. and Jackson-Moss, C., 2000. A comparison of the leather produced from skins of ten different South African sheep breeds. Grootfontein Agric. 2(2), 17-21.

Tefera Sertse and Abebe Wossene. 2007. Effect of ectoparasites on quality of pickled skins and their impact on the tanning industries in Amhara regional state, Ethiopia. Small Rumin. Research 69:55–61

Wang, Y.L. and Attenburrow, G.E. 1993. Strength of Brazilian goatskin leathers in relation to skin and animal characteristics. J. Soc. Leather Techn. and Chem. 75:55-60.

Dry season supplementation of urea-molasses block and urea treated straw for milking cows under village conditions of North Shoa

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Abstract

On-farm verification of urea molasses block (UMB) and urea treated straw (UTS) supplementation for crossbred dairy cows were conducted at dairy co-operatives of Kabigizaw, around Debre Birhan, North Shoa. The experiment was conducted in the dry season where the available pasture was not enough to support any production. Milk yield data were taken daily, while milk samples for the constituents were taken before and at the middle of the experimental period. The data were analyzed using SAS (2002) GLM procedure. In terms of milk yield, the control group was significantly lower than ($P < 0.05$) the supplemented groups and no significant difference ($P>0.05$) was obtained among the supplemented groups (UTS, UMB and the commercial concentrate). However, the partial budget analysis revealed that the supplementation was not economically feasible. No significant difference ($P>0.05$) was obtained among the supplemented and un-supplemented dairy cows in any of the considered milk constituents.

Key words: Dairy, milk, supplementation, UMB, UTS.

Introduction

In the central highlands of Ethiopia, natural pasture grazing and crop residues constitute the major portion of ruminant nutrition. However, these feeds are low in crude protein (Seyoum *et al*., 2007) even unable to satisfy the maintenance requirement of the animal. Reduction in milk production and weight losses of animals during the dry season is a common feature of the area, and brings a substantial economic loss to farmers. Studies indicated that when ammonia concentration in the rumen falls below 200 mg/liter, the rumen micro-organisms are inefficient and are likely respond to dietary NPN supplement particularly to urea molasses blocks (Pedrok and Leng, 1989). To attain this N level, a diet should contain 11-14% CP (2% N). Urea treatment improves the CP content of crop residues from 3 to 4% to a level of 7 to 9 % which fulfill the minimum requirement for adequate intake, digestive activity and live weight maintenance (Chriyaa *et al*., 1997).

Result from Selale area showed an increase in milk yield (0.5-2.0 liters) from dairy cows fed urea treated straws (Reherahie, 2001).

Among the many options tested so far to improve the feed value of crop residues, UMB and UTS are used widely in developing countries. The use of UMB for supplementing crop residues based diet has been well documented by (Sansoucy, 1995; Garg *et al*., 1998; Singh and Singh, 2003) and has the potential to increase production (Leng *et al*., 1991; Singh and Singh, 2003; Mirsa and Reddy, 2004), increase dry season milk supplies and increase household income (Garg *et al*., 1998; Patel, 2002; Singh and Singh, 2003). In India, providing of UMB with a concentrate of 30% CP produced 20 - 25 liters of milk per day from Friesian cow fed straw as main diet (Kunju, 1986). Results showed replacement of 40% of concentrates, with UMB and bypass protein maintained milk yield and increased farmers' net income (Leng *et al*., 1991). On-farm experiment conducted in Uttaranchal, India indicated that feeding of UMB increased milk production by 37% in buffaloes and 34% in local cows, without any effect on body weight and animal health (Singh and Singh, 2003). The present study was conducted to verify the response of crossbred dairy cows supplemented with urea molasses blocks and urea treated straws on milk yield and its composition in the dry season.

Materials and methods

Location

The experiment was conducted at Kabigizawu Kebele, Basona-Werana Woreda, North Shewa Zone. Debre Birhan is located 130 km North of Addis Ababa at 9^{o} 36'N and 39^{o}38'E. The study area is located 13 km from Debre-Birhan on the way to Addis Ababa. The area is characterized by mixed crop livestock production system. Barley, wheat, and faba bean are the major crops grown in the area, among livestock cattle and sheep are the dominant species. Due to the intervention made by the governmental and non-governmental organization a good number of Holliston-Freisian cross bred dairy cows are found in the area. There is no taboo that hinders selling of fresh milk and milk products in all villages. Dairy cooperatives of the area collect fresh milk from the members and sell back to big milk processing plants and any unsold milk will be processed by the cooperatives.

Animals and treatments

A thorough training was given to all volunteered farmers, how to prepare and utilize UMB and UTS. Due to lack of enough number of lactating cows that could be assigned for each treatment in the dry period, the experiment was run in a single 4 X 4 Latin square design in switchover arrangement. Four treatments and four periods were used. The treatments were,

1. Control (farmers practice)
2. UMB
3. UTS
4. Commercial concentrate

Feeds and feeding

Barley straw was treated with urea (4%) and molasses (10%) under airtight conditions for 30 days and aerated overnight before feeding. Six kilogram of UTS was given per cow daily. Concentrate mix which is composed of 43% Noug cake, 55% wheat bran and 2% salt was given daily as a supplement to treatment 3 (UTS) at a rate of 2.5kg for maintenance and 0.5kg for every liter of milk produced. The amount had been adjusted based on the previous week milk yield. The (supplements) UMB and UTS were given to the milking cows in the evening. The control group gets what the farmer usually gives to his cow, and was recorded.

The urea molasses blocks was made according to the recommendation given by Alemu, (2007) and contains 40% fermentable molasses, 25% wheat bran, 10% urea, 10% noug cake, 5% salt and 10% cement. A block with an average weight of 8 kg was made manually and dried under shade. During the adaptation period, the animals were allowed to lick the block for 2-3 hours per day thenafter overnight throughout the experimental period. Every morning each block was weighed to calculate the amount licked in the previous night. Three kilo gram of concentrate mix was provided per cow per day along with UMB.

All cows had access to water once a day and grazed eight hours per day. Commercial concentrate was bought from Kality Feed Processing Plant and had a crude protein and TDN of 17% and 72%, respectively. Animals in treatment 4 received concentrate at the rate of 2.5 kg for maintenance and 0.5kg for every liter of milk produced. The amount had been adjusted based on the previous week milk yield.

Data collection and analysis

The experimental period was divided in to four periods and each cow was randomly assigned to one of the four treatments over these periods. Each period had 15 days adaptation period and 6 days actual data collection period and between periods, there was 5-days gap to avoid any carryover effect. Record on milk yield, feed offered and leftover was taken daily during 6 days of experimental period. Morning and evening milk was summed up to obtain each day milk yield. Milk samples for analysis were also taken from the morning and evening milk. At the end of the experiment, a thorough discussion was made with the participant farmers to assess their perception towards the experiment. Milk constituents were analyzed in collaboration with Ethiopian Dairy and Meat Training Institute. The GLM procedure of SAS (2002) was used to analyze the milk yield and its composition. The economic data for dry period supplementation of UMB and UTS was generated from the record collected in the study areas, on 4 cows for 99 days during dry seasons. Period, cow and treatment were used as a class2 variables and the model used was:

$$Yijkl= \mu + Ti + Rk + Cl + \Sigma ijkl$$

Where, Yjikl= observation on subject j with treatment i, period k, column l,

μ = the overall mean

Ti = the fixed effect of treatment *i*

R*k* = the effect of row (period) order k

C*l* = the effect of column *l* (animal)

Σijkl = the random error

Results and discussion

The mean milk yield and major milk constituents (protein, fat and total solid %) are shown on Table 1. A significant ($P<0.05$) milk yield difference was observed among the treatment groups. The control group had significantly ($P<0.05$) lower milk yield than the supplemented groups. However no significant ($P>0.05$) milk yield difference was noted within the supplements (UTS, UMB and commercial concentrate). Milk yield increased by 1.1 liter (30.3%) from feeding of UTS and by 1.25 liters (34.4%) from UMB supplementation which was in agreement with the range 0.5–2 liters reported by Reherahie, (2001). Hossain *et al*. (2002) also reported that cow fed urea treated rice straw as a basal diet gave 0.67 kg more milk yield than the cow fed untreated rice straw as a basal diet.

Table 1. The effect of urea molasses straw treatment and urea molasses block on milk yield and major milk constituent.

Variables	Control	UTS	UMB	Commercial concentrate	N	P-value	SE	R^2	CV%
Milk yield	3.63^b	4.73^a	4.88^a	5.26^a	4	0.0472	0.632	0.86	13.66
Milk protein, %	3.60	3.36	3.66	3.61	4	0.517	0.292	0.77	8.22
Milk fat, %	2.45	3.32	2.45	3.18	4	0.086	0.492	0.94	17.3
Total solid %	11.09	11.66	11.07	11.65	4	0.461	0.665	0.88	5.85

Superscript with the same letter means no significant difference.

In the current study, the average milk yield, fat %, protein % and % total solid were 4.62, 2.85, 3.56, and 11.37 liters, respectively. No significant ($P>0.05$) difference was observed among treatments in major milk constituents. The result is in agreement with Rehrahie (2001) who obtained no difference in milk composition either fed with urea treated barley or Teff straw. The participant farmers were eager in using UMB and/or UTS supplement as it increased milk yield. No side effect was reported by any of the farmers' due to UMB feeding; the only problem mentioned was the unavailability and high cost of molasses and cement, respectively. The partial budgeting and sensitivity analysis is indicated on Table 2. Though there is significant increase in milk yield due to supplementation, the partial budgeting and sensitivity analysis shows that supplementation was not economical in this study.

Table 2. Partial budgeting and Sensitivity analysis.

Description	Control	UMB	UTS	Concentrate
Average daily milk yield (lt/cow)	3.63	4.88	4.73	5.26
Selling price (Birr/lt)	4.00	4.00	4.00	4.00
Gross benefit (Birr/cow)	14.52	19.52	18.92	21.04
Average daily input cost (Birr/cow)	0	5.60	7.11	11.20
Average daily medical cost (Birr)	0.17	0.17	0.17	0.17
Total daily cost (Birr/cow)	0.17	5.77	7.28	11.37
Net benefit (Birr/cow)	14.35	13.75	11.64	9.67
marginal rate of return (MRR) %		-10.71	-139.74	-48.17

Conclusion and recommendations

The study verified that supplementation of urea treated straws and urea molasses block improved milk yield. However, the partial budget analysis revealed that supplementation was not economically feasible. Currently it is not advisable to use urea treated straw and UMB. However, the technology might be reconsidered when the input costs get lowered and /or price of milk increased.

Reference

Alemu Yami. 2007. How to make urea molasses blocks (UMB) and feed to sheep and goats. USAID Technical Bulletin No. 1. pp 8.

Chriyaa A, Moore K. J and Waller S.S. 1997. Intake, digestion and nitrogen balance of sheep fed shrub foliage and medic pods as a supplement to wheat straw. Animal Feed Science and Technology 65:183-196.

Kunju, P.J.G. 1986. Urea molasses lick: An approach to increase the utilization of crop residues. National dairy development board. Anand, india, 4. In: Rice straw and related feeds in ruminant ration, pp:261-274.

Garg, M.R, Mehta, A.K and Singh, D.K. 1998 Advances in the production and use of urea molasses mineral blocks in India. World Animal Review 90 (1): 22-27

Hossain, M.S., Haque, M.N., Aziz, S.A., Mazzumder, M.S., Ali, M.L. and Elahi, A.T. 2002. Effect of urea molasses straw treatment on the productive and reproductive performance of indigenous cows under the village condition of Bangladish. Pakistan Journal of Biological Science 5: 997-999.

Leng R.A, Preston T.R, Sansoucy R. and Kunju P.J.G. 1991. Multinutrient block as a strategic supplements for ruminants. World Animal Review 67 (1): 11-19

Misra, A.K and G. S. Reddy. 2004. Effect of urea molasses mineral block supplementation on milk production in crossbred cows. Sharma K, Pattanaik A K, Narayan D and Das A (Eds) 2004. New dimensions of animal feeding to sustain development and competitiveness. Proceedings of Vth Biennial Conference, held at NIANP, Bangalore, India, 263pp.

Patel, I. 2002 A case study on adoption of urea molasses mineral blocks. In: Rangnekar D and Thrope W (editors) 2002. Smallholder dairy production and marketing-Opportunities and constraints. Proceedings of a South-South workshop held at NDDB, Anand, India and ILRI, Nairobi, Kenya. 538pp.

Perdok, H. and Leng, R.A. 1989. Rumen ammonia requirements for efficient digestion and intake of straw by cattle. In: Nolan J.V., Leng R.A. and Demeyer (eds), The Roles of Protozoa and Fungi in Ruminant Digestion. Penambul Books, Armidale, Australia.

Rehrahie Mesfin. 2001. Biological and economical evaluation of feeding urea treated Teff and Barley straw based diets to crossbred dairy cows in the highlands of Ethiopia, MSc Thesis, Swedish University of agricultural science, Uppsala 2001.

Sansoucy, R. 1995. New developments in the manufacture and utilization of multinutrient blocks. World Animal Review 82: 78-83.

Seyoum Bediye, Zinash Sileshi and Dereje Fikadu. 2007. Chemical composition of and nutritive values of Ethiopian feeds. Research report 73, Ethiopian institute of agricultural research (EIAR), Addis Ababa, Ethiopia. pp24

Singh, P.R. and Singh, M. 2003 Effect of UMMB supplementation on milk production in buffaloes and cows: an on farm trial. Indian J. Animal Nutr. 20 (10): 1-5.

Identifying indigenous feed resources and their nutritive value in North Gondar Zone of Amhara Region

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Abstract

A study was conducted to identify indigenous feed resources and asses the current uses, abundance and their quality in selected Woredas (Metema, Gondar Zuria, Dembia, Debark and Dabat) of North Gondar, Amhara Region. Each 'woreda' were selected from North Gondar Zone as representative of kola, woynadega and dega Agro-ecologies. Eighty seven feed types were identified and collected. Representative samples of a total of eighty seven feed samples from Kola, Weynadega and Dega (20, 36 and 31) were collected from September to October (wet season). The feeds were classified into browse, herbaceous, and grass feeds. The feeding systems used by farmers include cut and carry, direct browsing/grazing and hay making. Chemical analysis of Metema feeds showed that 20% of the feeds have the potential to be used as a protein supplement as they contain more than 20 percent crude protein (CP). The study showed that feeds which have greater than 20 percent CP are 19 and 16 percent for Dembia and Gondar zuria, and Debark and Dabat respectively.

Key words: Feed, nutritive value.

Introduction

Livestock production can play a vital role in the livelihood of the farmers not only during bad production years, but also during normal years. One of the limiting factors to animal production in Ethiopia is nutrition (Tsige-yohannes, 1998). As a result of the low standard of feeding, the present level of productivity for all classes of animals is very low. Maximization of productivity and the contribution of the animal genetic resource to small farms depend to a very large extent on the availability of the total feed resources and on the efficiency of utilization of animal feeds (Seyoum and Zinash, 1989). Even if natural pasture and crop residues are the major feed resources, they are poor in quality and do not last long enough to sustain livestock production for the most part of the year in North Gondar particularly during the dry season. To cope up with problem of dry season feed shortage which could not even support the animal maintenance requirement, farmers traditionally divert to drought tolerant indigenous browse, herbaceous and grass feeds.

However, there is no much scientific information about these indigenous feed resources. Thus, this study was conducted to fill the knowing gap of concerning abundance, nutritive value and utilization of indigenous feeds in selected woredas of North Gondar, Amhara Region.

Materials and methods

Based on three agro-ecologies, *woredas* of North Gondar were clustered as '*kola'(hot)*, '*weyinadega'(medium)* and '*dega' (cold)* purposively. The study was conducted in North Gondar Zone of the Amhara Region at Metema , Dembia and Gondar Zuria and Dabat and Debark representing '*kola'*, '*weyinadegaand* '*dega', respectively.* Rapid survey integrated with focus group discussion was used for primary data collection process. Representative samples of available indigenous feed resources were collected from September to October (wet season) during on-farm data collection in support of key-informant farmers in each site where samples were taken.

A total of 87 feed samples from '*Kolla'* (low altitude), '*Weynadega'* (mid altitude) and '*Dega'* (high altitude), 20, 36 and 31, respectively, were stratified based on type of feed and agro-climatic zones. Samples of the same feed types were bulked together on agro-ecology bases and then thoroughly mixed and sub-sampled. The samples were dried in an oven at 65^{o}C for 72 hours and ground in wily mill to pass through 1mm sieve and allowed to equilibrate at room temperature for 24hours. Feed analysis was done at Holeta Agricultural Research Center for Dry matter, Ash and CP using the method of AOAC (1990). NDF, ADF and ADL were analyzed by the method of Van soest (1982).

Results and discussion

Identified feed resources and their chemical compositions

The result of the study in Tables 1 to Table 3 showed that indigenous feed resources were identified in their common names, scientific names, cutting time/availability for feeding, mode of feeding, means of propagation, parts of the species eaten and livestock types feeding. The study showed that feed resources are classified into browses, herbaceous plants, and grasses. Browse feeds resources are relatively green throughout the year. As a result, they are harvested (used) during the critical period of feed shortage (April to May) in all study areas. Herbaceous and grasses are used throughout the year according to their availability and no conservation practice of surplus feed for dry period.

Interviewed farmers in each agro-ecology responded that there is no practice of growing as well as conservation of indigenous feed resources for critical periods in the form of hay.

The CP content of feeds collected from Metema ranges from 6% for '*Jingra'* to 25% for '*Askir'* with a mean value of 15. Among the collected feed types, 20% of the feeds have the potential to be used as a protein supplement as they contain more than 20% CP. Among the collected feeds, '*Gimarda'* and '*Arka/Gaba'* have a CP of 25% and 23%, respectively. It was found that 55% of the feeds assessed in Metema were above the critical value of 10% CP. The average NDF content of feeds are 63 with maximum and minimum NDF content of 83% and 43.32%, respectively (Table 2)

Table1. Chemical composition of indigenous feed resources at low altitude '*Kola'* (Metema) *Woreda* of North Gondar Zone.

LocalName	Location of species	Means of propagation	Mean DM%	Mean Ash %	Mean OM%	Ave. NDF%	Ave. ADF%	Ave. Lign	CP%
Kimo	Metema	seed	91.36	7.74	92.26	59.83	44.18	15.15	11.37
Shanshura	Metema	seed	91.46	16.24	83.76	78.88	54.65	7.26	7.60
Lalo	Metema	seed	91.61	15.33	84.67	43.32	31.09	8.35	16.22
Chara	Metema	seed	90.67	10.25	89.75	59.51	46.02	12.78	15.53
Tubas	Metema	seed	93.20	16.65	83.35	83.92	59.04	9.52	6.64
Goshboda	Metema		90.89	12.15	87.85	78.06	49.48	3.87	6.73
Arka/Gaba	Metema	seed	90.61	10.01	89.99	50.44	32.19	5.74	22.76
Gingra	Metema	Seed	89.44	20.97	79.03	70.43	58.11	7.54	6.09
Hochi	Metema	seed	90.60	9.09	90.91	50.87	35.99	12.94	14.40
Dirya	Metema	seed	90.42	14.04	85.96	73.88	40.10	16.55	14.93
Yekolawanza	Metema	seed	87.67	19.65	80.35	75.34	38.22	4.51	14.58
Gimarda	Metema	seed	90.33	10.08	89.92	62.65	43.83	11.16	25.28
Askir	Metema	seed	88.74	13.30	86.70	61.24	50.04	6.15	25.43
Wushadagusa	Metema	seed	88.74	15.17	84.83	73.88	45.96	4.70	9.82
Enkoy	Metema	seed	88.71	7.30	92.70	58.23	47.98	14.48	15.13
Yekolawanza	Metema	seed	87.34	14.86	85.14	71.40	63.98	15.32	13.79
Nechgirar	Metema	seed	90.64	12.90	87.10	56.90	43.15	6.39	16.07
Amirar	Metema		87.80	11.02	88.98	43.98	33.50	8.11	21.13
Gorgoro	Metema		88.98	6.41	93.59	59.49	52.81	15.45	16.93
Gambilo	Metema	seed	87.31	8.82	91.18	60.62	51.51	15.08	14.93

Table 2. Chemical composition of indigenous feed resources at Mid Altitude '*Woyinadega*' (Dembia and Gondar zuria) Woredas of North Gondar Zone.

Local name	Location	Prop.	Mean DM%	Mean Ash %	Mean OM%	Av. NDF %	Av. ADF%	Av. Lign	CP%
Gaja	Dembia		91.89	10.10	89.90	77.19	46.58	8.17	5.96
Checho	Dembia	seed	90.73	7.58	92.42	32.53	25.03	6.25	16.24
Tebelel	G/Zuria		91.10	8.35	91.65	50.76	39.10	12.85	16.74
Nechgirar	Dembia	seed	90.11	6.96	93.04	68.39	47.89	16.06	21.69
Gingra	Dembia	seed	92.04	11.49	88.51	79.50	51.28	8.89	9.74
Atat	G/Zuria	seed	91.48	10.53	89.47	46.83	37.97	13.26	11.12
Gagrda	Dembia	seed	91.40	16.75	83.25	73.17	48.54	7.13	11.37
Yekoksar	Dembia	seed	91.12	15.08	84.92	74.65	46.27	7.31	9.07
Kumia	Dembia		92.51	15.97	84.03	71.62	44.68	8.73	13.05
Gidzemede	G/Zuria	seed	89.07	21.71	78.29	37.57	21.24	7.93	17.11
Zigta	G/zuria	seed	91.98	8.59	91.41	29.68	21.01	6.59	13.41
Gorteb	Dembia	seed	90.72	12.67	87.33	50.88	35.57	14.56	20.91
Selselo	Dembia		92.42	22.41	77.59	76.52	47.06	7.53	9.66
Wonberet	G/Zuria	seed	88.99	14.57	85.43	47.01	31.07	6.84	11.20
Gambilo	Dembia	seed	90.64	8.26	91.74	49.17	35.75	7.14	15.38
Dedho	G/Zuria		90.62	6.24	93.76	60.53	41.94	13.49	11.26
Lenquata	G/Zuria	seed	91.16	10.20	89.80	47.25	33.70	7.44	20.01
Tiranja	Dembia		90.27	13.94	86.06	73.85	40.39	2.46	12.87
Gimero	G/Zuria	seed	90.75	10.63	89.37	34.29	28.09	5.41	30.15
Sirsira	Dembia		88.04	11.19	88.81	84.17	48.26	6.83	13.33
Wanza	G/Zuria	seed	89.84	17.28	82.72	68.58	56.25	15.94	16.47

Prop. = Means of propagation.

Both in '*weynadega*' (Dembia and Gondar zuria) and '*dega*' (Debark and Dabat) areas, the study showed that feeds which have greater than 20% CP are 19 and 15.6%, respectively. In Dembia and Gondar zuria, '*Gimero*' and '*Kontir*' were the highest list of species with CP content of 30% and 27%, respectively. In general, the study in Debark and Dabat showed that 54.8% of indigenous feeds were with CP content more than 10% and also in Dembia and Gondar zuria were 61%. Hence, animals which have access to these feed resources can fulfill at least their protein requirement for maintenance.

Table 3. Chemical composition of indigenous feed resources at High Altitude ‘*Dega’* (Dabat and Debark) *Woredas* of North Gondar Zone.

Local name	Location	Prop.	Mean DM%	Mean Ash %	Mean OM%	Ave. NDF%	Ave. ADF%	Ave. Lign	CP%
Amija	Debark	seed	90.77	6.42	93.58	46.41	37.71	15.17	17.73
Abejesh	Debark	seed	90.81	13.36	86.64	81.05	46.74	6.63	9.02
Amoja	Debark	seed	90.72	5.79	94.21	36.48	26.01	9.24	15.06
Mesela	Debark	roots	88.53	7.52	92.48	64.64	41.56	8.28	8.54
Abejesh	Debark	seed	91.29	9.68	90.32	83.01	46.46	8.45	7.31
Sirsira	Dabat	seed	91.42	8.15	91.85	73.58	40.08	7.24	5.59
Yesewlut	Debark	seed	88.62	18.87	81.13	35.31	24.24	7.99	23.01
Boren	Debark	seed	89.26	8.69	91.31	49.10	37.25	9.47	10.77
Almit	Dbark	seed	89.69	15.93	84.07	34.45	31.89	12.73	25.76
Jeroasfit	Debark		90.40	12.79	87.21	44.05	42.87	8.13	16.00
Yeahiyatosign	Debark	seed	89.38	9.00	91.00	63.22	55.01	4.99	9.40
Guasa	Debark	roots	91.60	9.23	90.77	77.35	49.11	3.45	10.47
Higsar	Dabat	seed	90.60	14.34	85.66	69.30	44.85	2.90	12.39
Telnji	Debark		89.88	14.41	85.59	66.71	44.86	9.21	13.59
Gaja	Debark	seed	90.80	8.32	91.68	81.95	47.00	3.80	7.71
Woyira	Debark	seed	91.07	6.52	93.48	79.11	40.51	7.67	18.68
Yewushalut	Debark	seed	89.31	13.90	86.10	53.11	46.01	9.71	21.05
Abatlut	Dabat	seed	91.53	18.60	81.40	35.42	30.23	10.54	15.31
Muja	Debark	seed	87.17	14.20	85.80	73.92	40.00	8.80	11.38
Wuchena	Debark	seed	89.67	5.14	94.86	57.54	38.88	9.38	12.26
Gicha	Dabat	seed	88.34	10.58	89.42	75.49	41.71	10.05	10.46
Wajima	Debark	seed	90.73	12.06	87.94	45.95	34.22	4.88	18.53
Keygrar	Debark	seed	90.67	14.14	85.86	44.29	36.26	6.53	16.82
Yesewtosign	Debark	seed	89.40	9.38	90.62	57.05	48.31	12.67	8.11
Gaja	Dabat	seed	90.40	10.12	89.88	78.03	41.41	4.24	7.02
Qega	Debark	seed	88.11	7.24	92.76	32.77	22.81	5.60	20.14
Meresar	Dabat		89.73	17.61	82.39	77.86	51.73	6.02	11.22
Serdo	Dabat	Stem, branch	89.24	11.21	88.79	77.43	42.37	5.04	10.68
Nechgirar	Dabat	seed	91.37	13.11	86.89	57.16	43.76	5.68	16.56
Boren	Debark	seed	86.49	7.28	92.72	49.54	43.61	7.76	8.89
Girar	Debark	seed	87.82	8.87	91.13	82.92	72.61	14.38	24.39

Prop. = Means of propagation.

Conclusion and recommendation

'Gumero', '*Almit'* and '*Askir'* are browse feed species which have a potential CP content of 30%, 26% and 25% and were found in mid, high and low altitude areas, respectively. Farmers in each agro-ecologies responded that there is no practice of growing of indigenous feeds as well as insignificant conservation for critical periods. Feeds that have crude protein content of 10% and higher are selected for further agronomic and animal evaluation studies. The average NDF (Neutral Detergent Fiber) value of feed resources in '*kola'*, '*weynadega'* and '*dega'* areas were found to be 64%, 58% and 58%, respectively which is more than 45%. High NDF value indicates poor quality, which is attributed to high structural components resulting to low digestion, low rate of passage and limited voluntary intake (McDowell, 1988).

References

AOAC (Association of Analytical Chemists). 1990. Official Methods of Analysis. 15th ed. AOAC. Inc.Arlington,Virginia.

Mc Dowell, R.E. 1988. Importance of crop residues for feeding livestock in smallholder farming systems, pp. 3-28. In: J.D. Reed, B.S. Capper and P.J.H. Neate (eds). Proceedings of the Workshop held at ILCA, Addis Ababa, Ethiopia. 7-10 December, 1987. ILCA Addis Ababa.

Seyoum Bediye and Zinash Sileshi. 1989. The composition of Ethiopian feedstuffs. Pp. 179-185. In Proceedings of the 2nd National Livestock Improvement conference. 24-26 February, 1988.Institute of Agricultural Research, Addis Ababa, Ethiopia.

Tsige-Yohannes Habte. 1998. Nutrition of ruminant animals in the thermal environment: Conditions and prospects in Ethiopia. In:Proc. 6th Annual Conference of the Ethiopian Society of Animal Production(ESAP). Ethiopian society of Animal Production, Addis Ababa. Ethiopia, 165-172pp. 16.

Van Soest, P.J. 1982. Nutritional ecology of the ruminant. O and B books Corvallis, Oregon.

Survey of indigenous fodder trees and shrubs in Wag-Lasta

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Abstract

The study was conducted to identify the major fodder tree and shrub resources and to assess their utilization and feeding calendar of the species in Bugna, Ziquala and Dahinaworedas.The identified indigenous fodder trees and shrubs, common names, species scientific name, propagation method, feeding calendar and livestock species feeding on them were identified. The fodders were found mostly in open grazing lands, around fences and in protected areas. The feeding system in all woredas were free grazing and browsing and in small scale cut and carry is practiced especially for lambs, kids and sick animals. Parts of the browse species utilized by animals were leaves, pods, twigs and flowers. Most of the selected species do not have the ability to remain green throughout the year due to severe moisture stress and biological nature of the plants in the area. And most of the plants have maximum foliage production in the wet seasons of the year (July to October). Few browse species shed leaves early, while others retained leaves late into the dry season. In difficult environmental conditions, where the available grazing is not sufficient to meet the maintenance requirements of animals for part of the year, the contribution from trees and shrubs is significant. Research on nutritive value of the major browse species, detailed tagged study, their seedling establishment mechanisms and problems, soil seed bank analysis and further ethno-botanical studies should be done.

Key words: Dry season, feeding calendar, indigenous fodder tree, shrub.

Introduction

In many parts of the country where land holdings are small and risks are high, crop and animal husbandry are strongly interlocked to the extent that one cannot exist without the other. As a result, segregating livestock and crop production, which are the mainstay of the society, will not seem to be an appropriate strategy, at least in the short term. At least a safety net livestock holding is compulsory in this long existed sedentary agricultural area to keep the agriculture alive because the farming community is used to the existing farming system whereby livestock strongly complement crop production. But livestock productivity has mainly been stagnant due to a range of biophysical constraints. One of the major constraints in livestock production is feed shortage.

The major animal feed resources in the district have been crop residues, grazing areas, bushes and shrubs and barks and leaves of fodder trees. Given the ever increasing population pressure, declining soil fertility and low annual rainfall, the carrying capacities of small private plots and a few patches of communal grazing fields is markedly low. Consequently, farmers use feeds obtained from locally available indigenous forage and crop residues. Many of the most palatable species are believed to have been over grazed.

Despite the ever increasing feed deficit, no valuable coping mechanisms against this problem have been devised so far except that the community by themselves started to reserve the scarce feeds of the rainy season for the dry seasons when feed is deficient and some animals changed their feeding habit (started consuming less palatable plant species). Attempts made so far to fill the feed deficit gap through various external measures such as promoting exotic forage species are all insignificant (Daniel & Hana, 2000). Promotion of the indigenous forage crops may require little turning towards environmental and social adaptation and may be adopted by the local farmers easily since they have already existed within the farming systems for a long period. This is, in general, not an attempt made to entirely replace the introduced forage crops, which are being promoted in some areas. Instead, it is to look for landrace forage resources and device methods of promoting them so as to complement the feed from other sources including exotic forage species and hence to diversify the potential fodder sources.

Therefore, the society and researchers have to look for local measures that can be operational and mutually co-existing with the land shortage problem of the district to retain the local palatable and acceptable forage species for longer period. The objective of this study was to identify the major fodder tree and shrub resources in Waghimra and Lasta *woredas* and to assess their utilization and feeding calendar of the species in the area.

Materials and methods

Sampling and identification

The study was conducted in selected woredas of Waghimra and Lasta. For the study, purposive sampling method was used considering livestock number and vegetation cover, three *woredas* were selected and three PAs were selected per *Woreda*. From each selected 9 PAs, 15-20 key informants (especially elders) who are well experienced in animal husbandry were selected to take the informal survey using the PRA tools.

The reconnaissance tour, semi-structured interview and group discussion were done to determine the study areas and preference ranking of the species was done to prioritize the species according to their advantages in the study areas. Identification of the different browse species followed the Flora of Ethiopia (Hedberg and Edwards, 1989). Finally, data analysis was performed using Microsoft Office Excel and organized, interpreted and presented in tables.

Results and discussion

Identified indigenous fodder trees and shrubs and their utilization

The identified indigenous fodder trees and shrubs, common names, species scientific name, propagation method, feeding calendar and livestock species feeding on them are presented in Tables 1, 2 and 3 for Bugna, Ziquala and Dahina *Woredas,* respectively. Farmers do not plant any of the indigenous fodder trees and shrubs for their feeding value. The fodders are found mostly in open grazing lands, around fences and in protected areas. The feeding system in all *woredas* were free grazing and browsing and in small scale cut and carry is practiced especially for lambs, kids and sick animals. Similar uses of browse species were reported by Teferi *et al*. (2008) in Abergelle, Ethiopia.

In an effort to alleviate the animal feed supply problem, looking for potential feed resources, particularly those which survive during the dry season, deserves due attention. In this regard, the use of browse species has great potential. As mentioned in many studies

(Bamualin *et al*., 1980; Ibrahim 1981; Devendra, 1990) the importance of these plants in the arid and semi-arid areas is well recognized throughout the world. The major use of foliage of browse species is as a source of CP. This quality of browse species is most useful during the dry season when most of the range grasses and other herbaceous species dry off (Devendra, 1990). Livestock species utilizing the fodder resources in order of farmers' preferences are goats, cattle and sheep. This might be because goats are the most important livestock in the area in supporting farmers livelihood compared to other livestock species. Parts of the browse species utilized by animals were leaves, pods, twigs and flowers. Almost all selected fodder trees and shrubs have also additional uses in the area for ethno-medicine, ethno-veterinary, fuel wood, charcoal, building materials and others.

Seasonal availability

Most of the selected species did not remain green throughout the year due to severe moisture stress and biological nature of the plants in the area. And most of the plants have maximum foliage production in the wet seasons of the year from July up to October. Certain browse species shed leaves early, while others retained leaves late into the dry season. Livestock herders in the area ranked those browse species which could retain leaves late into the dry season so that more feed could be supplied at critical times of the year when there is less availability of fresh vegetative biomass for feeding to livestock. Acacia species have good adaptation to produce foliage immediately after a short rain

Fodder trees and shrubs have always played a role in feeding livestock. Trees and shrubs are increasingly recognized as important components of animal feeding, especially as suppliers of protein. In difficult environmental conditions, where the available grazing is not sufficient to meet the maintenance requirements of animals for part of the year, the contribution from trees and shrubs is significant. Tree fodders contain high levels of crude protein and minerals and many show high levels of digestibility. They are readily accepted by livestock and presumably because of their deep-root systems, they continue to produce well into the dry season (Daniel and Hana, 2000). However, antinutritive factors can be a problem in some species.

Table 1. Major browse species identified in Bugina Woreda.

Scientific name	Local name	Propagation method	Parts used as animal feed	Season of used	Type of animals used
Allophylusabyssinicus	Embs	Seed	leaves, twig/ branch	January to May	cattle, shoats
Rumexnervosus	Embacho	Seed	leaves, twig/ branch	year round	cattle, shoats
Oleaeuropeasspcuscupideta.	Weyra	Seed	leaves, twig/ branch	year round	cattle, shoats
Dodonaeaanguistifolia	Kitikita	Seed	leaves, twig/ branch	year round	cattle, shoats
Grewia bicolor	Sefa	Seed	leaves, twig/ branch	year round	cattle, shoats
Stereospermumkunthianum	Zana	seed	leaves, fruit		cattle, shoats
Arundodonax	Shebeko	seed and root split	leaves, twig/ branch		cattle, shoats
Acacia bervispica	Gorngoro	seed	leaves, twig/ branch	October to January	cattle, shoats
Acacia sp	Girar	seed	leaves, pod and seed	October to January	cattle, shoats
Myricasalicifolia	Haya	seed and stem	leaves, twig/ branch		cattle, shoats
Acacia lahi	Qarita	seed	leaves, pod	year round	cattle, shoats
Grewavillosa	Lenquata	seed	leaves, fruit	year round	cattle, shoats
Capparismicrantha	Gimero	seed	leaves, fruit	year round	cattle, shoats
Cordiaafricana	waniza	seed	leaves, twig/ branch		cattle, shoats
Grewiamollis	betremusie	seed	leaves, twig/ branch		cattle, shoats
Dombeyatorrida	wulkifa	seed	leaves ,twig/ branch	year round	cattle, shoats
Rhusnatalensis	qaqimatalo	seed	leaves		cattle, shoats
Baddlejapolystachya	anfer	seed and stem	leaves, twig/ branch		cattle, shoats
Phytolaccadodecandra	endod	seed	leaves, twig/ branch		cattle, shoats
Ficussycomorus	warka	seed	leaves, twig/ branch		cattle, shoats
Stephaniaabyssinica	nechihareg	seed	leaves, twig/ branch		cattle, shoats

Table 2. Major browse species identified in Ziquala Woreda.

Scientific name	Local name	Propagation method	Parts used as animal feed	Season of used	Type of animals used
Grewiavilosa	Mata	seed	leaves, twig/branch and fruit	Oct. to Dec.	cattle, shoats
Commiphoraabyssinica	anqwa	seed	leaves, twig/ branch	year round	cattle, shoats
Ziziphusspina-christi	giba	seed	leaves, twig/ branch	year round	cattle, shoats
Acacia asak	tsalwa	seed	leaves, twig/branch, pod	Oct. to Nov.	cattle, shoats
Balanitesaegyptiaca	goza	Seed	leaves, twig/ branch	Sept. to Dec.	cattle, shoats
Acacia tortolis	abiqa	Seed	leaves, twig/branch, pod	Sept. to Nov.	cattle, shoats
Dodonaeaanguistifolia	kitikta	Seed	leaves, twig/ branch		cattle, shoats
Combretummolle	abelwa	Seed	leaves, twig/ branch		cattle, shoats
Cappaistomentosa	Gimero	Seed	leaves, twig/ branch		cattle, shoats
Cordiaafricana	Wanza	Seed	leaves, twig/ branch		cattle, shoats
Stereospermumkunthianum	Zana	Seed	leaves, twig/ branch		cattle, shoats
Arundodonax	Shenbeqo	Seed	leaves, twig/ branch		cattle, shoats
Dombeyatorrida	Wulkifa	Seed	leaves, twig/ branch		cattle, shoats
Grewiaferugina	Lenquata	Seed	leaves, twig/ branch		cattle, shoats
Rhusnatalensis	QaqmaTalo	Seed	leaves, twig/ branch		cattle, shoats
Grewia bicolor	Sefa	Seed	leaves, twig/ branch		cattle, shoats
Buddlejapolystachya	Anfer	Seed	leaves, twig/ branch		cattle, shoats
Phytolaccadodecandra	Endod	Seed	leaves, twig/ branch		cattle, shoats
Carrisaspinarum	agam	Seed	leaves, twig/ branch		cattle, shoats
Acacia lahi	qarita	Seed	leaves, twig/ branch		cattle, shoats
Terminaliabrowni	ekma	Seed	leaves, twig/ branch		cattle, shoats
Acacia brevispica	girar	Seed	leaves, twig/ branch		cattle, shoats
Commiphoraafricana	anqua	Seed	leaves, twig/ branch		cattle, shoats
Grewiavilosa	Mata	Seed	leaves, twig/ branch		cattle, shoats
Cappaistomentosa	gimero	Seed	leaves, twig/ branch		cattle, shoats

Table 3. browses species identified in Dahina Woreda.

Scientific name	Local name	Propagation method	Parts used as animal feed	Season of used	Type of animals used
Acacia lahi	karita	Seed	leaves, pod	year round	cattle, shoats
Ziziphusspina-christi	geba	seed	leaves, fruit, twig/branch		cattle, shoats
Rhusnatalensis	talo	seed	leaves, twig/branch, seed		cattle, shoats
Terminaliabrowni	ekma	seed	leaves, twig/branch		cattle, shoats
Acacia sp.	gerar	seed	leaves, twig/branch, pod		cattle, shoats
Oleaeuropeasspcuscupideta	weira	seed	leaves, twig/branch		cattle, shoats
Clematis hirsute	azohareg	seed	all parts		cattle, shoats
Rosaabyssinica	kega	seed	leaves, fruit, twig/branch		cattle, shoats
stephaniaabyssinica	nechihareg	seed	all parts		cattle, shoats
Arundodonax	shembeko	cutting, root	leaves		cattle, shoats
Baddlejapolystachya	anfar	seed	leaves, twig/branch		cattle, shoats
Acacia lahi	karita	seed	leaves, pod, twig/branch		cattle, shoats
Dodonaeaanguistifolia	ketkita	sees	leaves, twig/branch		cattle, shoats
Carissa spinarum	agam	seed	leaf, twig/branch, fruit		cattle, shoats
Commiphoraafricana	ankwa	seed	leaves, twig/branch	July-Sept	cattle, shoats
Combretummolle	abalo	seed	leaves, twig/branch	Sep.-Oct.	cattle, shoats
Ziziphusspina-christi	geba	seed	leaves, twig/branch	July-Dec.	cattle, shoats
Grewia sp.	lenqwata	seed	leaves, twig/branch	June-Jan.	cattle, shoats
Terminaliabowni	ekma	seed	leaves, twig/branch		cattle, shoats
Jasminumgrandiflorum	tembelel	seed	all parts		cattle, shoats
Capparistomentossa	gemero	seed	all parts		cattle, shoats
Grewiavilosa	mata	seed	leaves, fruit		cattle, shoats
Grewia bicolor	sefa	seed	leaves, fruit		cattle, shoats

The importance of trees and shrubs in the feeding of animals in the tropics and sub-tropics has long been recognized by livestock owners. In arid areas where the growth of herbaceous plants is limited by lack of moisture, leaves and edible twigs of trees and shrubs can constitute well over 50% of the biomass production of rangeland. At high altitudes, tree foliage may provide over 50% of the feed available to ruminants in the dry season, branches being harvested and carried to the animals (Daniel and Hana, 2000). Even in regions of higher rainfall where grass supplies the major proportion of the dry matter eaten by ruminants, tree leaves and fruits can form an important constituent of the diet, particularly for small ruminants.

Conclusion and recommendations

Certain browses were consumed preferentially by certain species, but not by others. Grazers were much more selective in feeding on browse species than browsers. But during the long dry seasons where feed is severely scarce, any plant species that stayed green will be consumed, since there is no preference. Certain browse species shed leaves early, while others retained leaves late into the dry season. Parts of the browse species utilized by animals were leaves, pods, twigs and flowers. In all browses, leaves were the plant parts most utilized by animals. All browse species were reported to have other uses. Based on the results of the study, further works are recommended on assessing nutritive value of the major browse species, their seedling establishment mechanisms and problems, soil seed bank analysis and ethno-botanical values.

References

Bamualin A Jones R J and Murray R M. 1980. Nutritive value of tropical browse legumes in the dry season. Proceedings of Australian Society of Animal Production 13: 229-232.

Daniel Fantaye and Hana Haile. 2000. Indigenous Fodder Crops Availability, Weldia.

Devendra C. 1990. The use of shrubs and tree fodders by ruminants. In: Devendra C (Editor). Shrubs and Tree Fodders for Farm Animals. Proceedings of a Workshop, 24-29 July 1989, Denpasar, Indonesia. International Development Research Center, Ottawa, Canada.

Hedberg I and Edwards S. 1989. Flora of Ethiopia. Volume 3. The National Herbarium, Addis Ababa, Ethiopia.

Ibrahim K M. 1981. Shrubs for fodder production. In: Advances in food producing systems for arid and semi-arid lands. Academic Press Inc.

Teferi Aregawi, Solomon Melaku and Lisanework Nigatu 2008 Management and utilization of browse species as livestock feed in semi-arid district of North Ethiopia.

Adaptation and growth performance of Nile tilapia (O. niloticus) in integrated fish farming on North Western Amhara Region

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Abstract

Improper management has led to over fishing of most inland waters. Therefore, more attention has to be given to fish farming (aquaculture) in Ethiopia. Currently aquaculture contributes over 30% of the fish consumed throughout the world. An investigation was carried out to evaluate the adaptation and growth performance of tilapia fish in aquaculture ponds established within agricultural lands. The study was conducted in three different administrative zones of the Amhara Regional State; East Gojjam, West Gojjam and Awi Zones. A total of 15 fish farmers from different agro-ecologies had been selected. Each farmer has a fish pond size of 100 m^2 with 1.5 m average depth. A total of 4,000 tilapia fish (Oreochromis niloticus) fingerlings, 3-5g in size, have been collected from the wild and stocked. Fish sample was collected every two months and the growth and maturity of fish was recorded. The pond water was supervised and managed at its optimum quality required for fish growth in grow out ponds. More than 97% of the experimental fish adapted pond culture and the maximum mortality record was during the first 5 days after stocking. Fish have shown different growth performances depending on the agro-ecology they were stocked. Those in the warmer areas grew faster and attained 231g within 9 months of time, whereas those in the colder took a year and more to attain the required size. Stocking tilapia in farmers pond constructed within agricultural land is a promising technology to be scaled-up/out, but the size of fish fingerlings going to be stocked should be compromised with the agro-ecology where the ponds are going to be established.

Key words: Aquaculture, fingerling, fish pond, scale-up, tilapia.

Introduction

Backyard ponds can be designed and built to serve multiple purposes including fish farming with advanced planning. Pond fish culture is the most popular method of growing tilapia. The advantage of pond fish farming is that the fish are able to utilize natural foods (Rakocy *et al*, 2005) and farmers can receive higher net returns from fish farming integrated with agricultural practices. Even small ponds can contribute to farm income or reduce family spending as fish are sold, bartered or eaten.

The various types of aquaculture form a critical component within agricultural and farming systems development that can contribute to reduce malnutrition through the provision of food of high nutritional value, decreased risk of production, sustainable resource management and increased farm sustainability (Little and Edwards, 2003). Aquaculture, especially integrated one, is sustainable because it makes use of locally available materials. Integration with other forms of agriculture diversifies farm productivity; provide opportunities for intensified production with more efficient allocation of land, water, equipment and other limited capital than practices which run independently. Fish culture integrated with garden irrigation, livestock watering and various domestic uses are all possible.

Fish being cheap source of high quality protein is used as an alternative way to fulfill the protein requirement of the farm family. Production cost of fish, if the ponds are constructed once, is lower when compared with poultry, beef and sheep. Pond fish convert food in to flesh efficiently as they are essentially weightless in water, and thus expend little energy for locomotion or maintain a normal upright position. They are cold blooded animals and do not expend energy to maintain a relatively high body temperature as other warm blooded ones. Thus, the amount of energy required to produce one kg of fish is much less than the amount required producing an equal weight of terrestrial animal.

Tilapia are extremely tough fish that can thrive in poor quality water, on low-cost feeds (Bronson, 2005), fast-maturing fish, easy to keep, popular with consumers and nutritious with white meat (CTA, 2007) and proven to grow on kitchen scraps and other low-cost inputs (WFC, 2007; Economist, 2007). They exhibit maximum growth rates at temperatures between 25 and 30°C (Bocek, 2003), making them more likely to become established and invasive in tropical climates. Nile tilapia (*Oreochromis niloticus*) is the most predominant species of tilapia in aquaculture (Gupta and Acosta, 2004); and well adapted to artificial culture environments, gain weight quickly at optimum conditions and reproduce on the farm without special management or infrastructure. Nile tilapias (*O. niloticus*) reach sexual maturity at about 5 to 6 months (Gupta *et al*., 2004).

If the natural productivity of a pond is increased through fertilization or manuring significant production of tilapia can be obtained without supplemental feeds. To maximize fish production, manure from livestock should be added daily to the pond in amounts that do not reduce dissolved oxygen (DO) to harmful levels as it decays. A pond should be fertilized at a rate of 10kg for cattle, equine and sheep/goat manure and 6-8 kg for pig and chicken in a 100m² ponds every week. The maximum rate depends on the quality of the manure, the oxygen supply in the pond and water temperature. The rate of manuring should be increased gradually as the fish grow (Rakocy *et al*., 2005). Liming (at a rate of 1000 to 2000 kg/ha) promoted phytoplankton growth and increase fish production.

The farmers do have water running and by-passing via their backyard or stored at and their farm land. In some areas small streams residing around the backyard are barraged to irrigate tree nurseries and vegetable seedbeds. Mostly, a family does have cattle or small ruminants or chicken or both who potentially can produce manure every day that will be used to fertilize water stored in a pond. Fertilized water can provide live food for fish since multiplication and growth of important plankton species is enhanced. Today, aquaculture becomes responsible for an ever-increasing share of global aquatic food production, which has increased from 3.9% in 1970 to 31.9% in 2003 (Carballo *et al*., 2008). Despite of these opportunities, the farming family is suffered from malnutrition and scarcity of protein food. The gap between supply and demand for fish is widening, natural fish stocks in the region as elsewhere in the country been declined yet human populations and hence demand, continue to increase. Backyard fish farming research has been demonstrated in three zones (East Gojjam, Awi and West Gojjam) of the Northwestern Amhara for the last three years since 2008. The demonstration has been undertaken to check whether it is possible to integrate fish farming in farmers' back yard.

Material and methods

Backyard demonstration ponds were prepared at *eight Woredas* of the North Western Amhara Region; fife in East Gojjam, two in west Gojjam and one in Awi Zone. The ponds were located at different altitude ranges (1791 to 2314 meters above sea level). All backyard fish ponds were earthen but the one at Dangila and the other at Bahir Dar Zuria were lined and plastered with hard plastic sheet (geo-membrane) cover as the area which percolates pond water.

Ponds were located on land with a gentle slope. They are rectangular or square-shaped, having dikes and devoid from the entrance of run-off water from the surrounding watershed. Side slopes varied from 2:1 or 3:1 (each meter of height needed 2 or 3 meter of horizontal distance) for easy access to the pond and minimized risks of erosion. Most of the ponds drained water partly when the fish were harvested. Ponds receiving water from surface sources did have an inlet pipe (PVC) or ditch or canal that let water in and an outflow to remove water out. Every pond did have plot of land around, most of them down to the pond, so as to perform different agricultural activities. One pond built with chicken shade over it and chickens were reared on over the pond so that the litter dropped in to the pond water, which is used as a fertilizer of the pond water.

Water: The source of water for the backyard ponds varied according to the resource found in the area. Majority of the ponds in East Gojjam were ground sources where by water has been recharged and filled naturally by pumping it up. A farmer from Bahir Dar district pumped water from Lake Tana to refill and refresh the pond. Most of the farmers used irrigation water which had been running over the backyard farm land before the adoption of fish farm technologies.

Cultivable land: All participant framers integrated fish production with different vegetable production, tree seedling and chicken rearing. Each farmer had plot of land aside from his fish pond. The size varied from 300 to 500 m^2. The vegetables which were cultivated most include Cabbage (*Brassica oleracea*), Carrot (*Daucus carota*), Tomato (*Lycopersicon esculentum*), Beetroot (*Beta vulgaris*) and Pepper (*Capsicum annum*). Tree seedling species which were grown by farmers was Eucalyptus tree (*Eucalyptus globulus*). The breed of chickens reared by farmers along with his fish pond was Rhode Island Red.

Equipment and inputs used: Global Positioning System (GPS) were used to navigate the location of each pond. Tape meter used to delineate the pond area and to construct the pond. Big plastic jar, filled with water and equipped with oxygen supplier (aerator), were used to transfer fish fingerlings from the hatchery/natural water body to the farmers' ponds (grow out ponds). Seine net and/or gillnets of 6 and 8 cm mesh size, cast net, sensitive balance, measuring board and different scoops have been used to collect and measure pond fish during sampling. Water quality parameter measuring field equipments like Oxygen meter, pH meter and secchi disc were used. Lime was applied at a rate of 100 grams/pond to make the pond bottom comfortable for fish and adjust the soil pH prior to filling the pond with water and stocking fish. Tilapia fish fingerlings (mixed sex) were used to stock each pond. Animal manure (mostly cow dung) was used to fertilize the pond water.

Methodology

A total of 15 farmers (14 male and 1 female households) having a pond or two with an area of 100 m^2 and more were selected. Ponds were prepared at a depth of 1.25 m on the inlet and 1.75 m on the outlet side (Average 1.5 m). Once the ponds were dug, lime was spread on the sides and its bottom at a rate of 10 kg per 100 m^2. After the application of lime and filled with water, manure was added at a rate of 15 kg in a week to fertilize the pond (FAO, 1994). Once the pond is fertilized and food availability in the pond is realized, fish fingerlings were collected from hatcheries or natural water body and stocked at a density of 2 fishes per m^2.

The fish used for this demonstration was mixed sex Tilapia fingerlings having a size of 3-5 grams. For ponds which were established within the basin area of Lake Tana, artificially reared Nile Tilapia (*Oreochromis niloticus*) fingerlings were stocked to avoid contamination of the Lake with other Tilapia strains. Fish fingerlings died during the first three days after stocking has been recorded. Fish adaptation and growth were checked every two months using seine net and gillnets with different mesh sizes (6, 8, and/or 10 cm). Once the fish attained the recommended table size (150 grams and more), they were collected from the pond and taken to home for food or market for sale. During fish collection 50% of the pond water is lowered first. The fertilized pond water siphoned out from pond regularly and irrigated the cultivable plot of land. All the fish were collected once they reached the intended table size. To track the fish produced, consumed and/or sold as well as the costs expended, records were made using data recording sheet given to individual farmers.

Results and discussion

Fish adaptation and growth

The average pH of all the pond water was between 4 and 9 and that of temperature was in between 14 and 26.8 ^{O}C depending of the altitude where the ponds are situated. In rare cases the temperature has been dropped to the minimum limit for tilapia. The average Dissolved Oxygen level was in between 1.74 and 10.93 mg/lit. The lower temperature was recorded during rainy season on ponds where the runoff water enters. The adaptation of fish stocked in the ponds reached 97.05%. The remaining 3% lost due to temperature shock happened while refreshing the pond water from the river during cold season in areas where the altitude is higher.

Productions from the integration

Fish: The selected farmers adapted the technology of fish farming in integration with the existing and new farming practices. Fish growth has been increased by 2 fold after 2 months of stocking in warmer sites. Fish has been grown at a maximum weight of 231 grams, 85% of the fish fall between 190 and 231 grams and 75% of the fish had a length of more than 23 cm. A farmer enabled to produce 17 kg of fish/cycle. Growth performance varied depending on the time that the fish spent and the altitude. The fish needed 9 to 14 months to reach table size at an altitude range of between 1791–2320 m.

All the 15 demonstration household farmers prepared 16 fish ponds covering an area of 1660 m^2. The total fish produced from these ponds reached to 2.89 quintals. According to Rakocy *et al* (2005) approximately 22 kg of fish per year can be produced in an acre of pond with local management, but the result in this integration exceeded by manifolds.

Farmers living at the lower elevated areas enabled to produce more fish than the others living in higher altitudes using the same size of backyard fish pond. The time taken to produce table size fish (150 gm and more) varied with elevation, the higher the elevation the longer it took. The time required to produce 13.9 kg of fish was 14 months at an altitude of 2320 m. But a farmer used to live at an altitude of 1791 m required only 9 months of time and produced 17.82 kg of fish (Table 1) at an average temperature of 23.7 ^{0}C. The pond water temperature varied from place to place and the source of water.

Table 1. Weight of 90 sampled fish in a pond at different demonstration sites (altitude).

Elevation (m, a.s.l)	Time taken (months)	Average production (Kg/pond)	Average pond water temperature (^{O}C)	Pond size (m^2)
1791	9	17.82	23.7	100
1845	9	17.46	23.2	100
1878	10	17.91	23.1	100
1898	10	17.01	21.3	120
2210	12	14.8	19.8	100
2219	10	15.03	21.3	120
2224	13	14.22	18.6	100
2235	11	14.67	21	100
2247	11	14.31	21	100
2275	13	14.13	19	100
2278	13	14.13	18.8	110
2314	14	13.95	18.7	100
2320	13	13.41	18.6	100

Fish production proven to have inverse relation with both time required and elevation or altitude of the production area. The lower the altitude is the higher the production of fish within shorter period of time. The higher the altitude, the longer is the time needed to produce a given amount of fish (Fig. 1).

Two farmers were rearing fish fingerlings by supplementing their pond with locally available fish feed mainly of home leftovers like injera (local bread), vegetables and fruits. The framers benefited both socially and economically from these fingerlings. A farmer has given 240 fish fingerlings for his relatives who wanted to adapt the technology. A farmer around Bahir Dar town sold 1,200 fingerlings with 400 birr and the other farmer at Enemay district sold 1,020 fingerlings with 510 ETB.

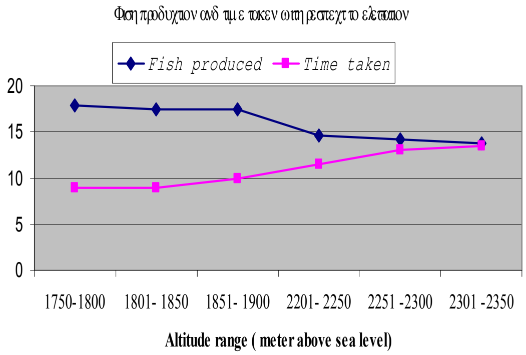

Figure 1. Fish produced (kg/pond) and time required (month) with altitude.

Vegetables

The farmers integrated vegetable production with fish were14 in number. Demonstration farmers produced, including those never did before, 168 to 2500 kg of vegetables using the fertilized pond water where fish were growing. Those farmers prepared bigger plot (500 m^2) of land and having previous experience in cultivation of vegetables has got more production than the others started during the demonstration (Table 2). Totally 153 quintals of different vegetables produced in a year (i.e. one fish production cycle). Most of the vegetables (more than 93%) produced in the farmers' plot of land sold to the local market and about 6% (nearly 10 quintal) of the produce used at home. Aside from their vegetables, two farmers produced 40 fruit and 15,000 tree seedlings for market.

Table 2. Vegetable produced and sold by category of farmers.

Category	Number of participants	Vegetable produced (kg)	Vegetable sold (kg)	Vegetable consumed (kg)
Experienced farmers	8	12,904	12,078	826
Non experienced (Starters)	7	2,428	2,258	170
Total	15	15,332	14,336	996

Chicken

A farmer at Bahir Dar zuria woreda constructed chicken house and reared Rhode Island Red breeds in one season (Figure 2). Chicken manure was directly added to the pond water and the farmer planted some green feeds for the chicken using pond water. The water has been fertilized frequently and the multiplication and growth of planktons were fast. Apart from the scarcity of chickens, it has been possible to rear more than one time in one fish production cycle as the fish in his pond stayed for about 9 months to reach table size. He brought a month old 36 chicken from multiplication center and keep for 3 months of time. He grew all the chicken successfully and sold all of them at a time.

Figure 2. Integrated farming experience of a farmer at the vicinity of Bahir Dar city.

Market value of the products

In areas where fish has never been produced or hardly known, it was possible to produce and use it. Currently children and women are taking fish out of their pond when meat is needed at home. Furthermore the farmers realized the possibility of producing fish to the local market and made money. More than 50% of the demonstration farmers (Table 2) have been producing vegetables since the last 4 to 5 years, but not in integration with fish. During this demonstration, farmers enabled to produce a new product and got additional yield and income with low cost using the pond water. A farmer has got net income of more than 8,000 birr from integrated farming system (Table 3). Those started to produce fish fingerlings by supplementing feed has got better income than those waiting for the grow-out fishes only. The gross income of this integration reached more than 57,000 ETB and fish farming contribution varied from 5% to 40%. The overall gross income contribution of vegetable production, chicken rearing and fish production in the integration system was 84%, 3% and 12%, respectively.

Table 3. Income (birr) generated from integrated farming.

Farmer code	Cost of production			Gross income			Net Income
	Fish	Agriculture	Total	Fish	Agriculture	Total	
01	187	230	417	254	3,360	3614	3197
02	187	230	417	280	3,200	3480	3063
03	122	340	462	338	4,500	4838	4376
04	127	230	357	184	600	784	427
05	110	360	470	1046	7,500	8546	8076
06	100	340	440	426	4,500	4926	4486
07	100	340	440	328	6,000	6328	5888
08	319	230	549	1080	1,600	2680	2131
09	228	230	458	418	5,000	5418	4960
10	162	230	392	302	2,000	2302	1910
11	160	230	390	236	3,000	3236	2846
12	198	340	538	300	1,620	1920	1382
13	161	230	391	284	450	734	343
14	150	230	380	470	3,200	3670	3290
15	178	980	1158	755	3,844	4599	3441

Conclusions and recommendations

Tilapia fish can adapt and grow up to an altitude of 2300 m (pond water average T° of ≥ 18 ^{O}C) with appropriate management practice and allow to stay extra growing time. Using fingerlings having a size of ≥30 grams and mono-sex fish shown best performance. The demonstration indicated that integrating pond fish farming at the farmers' backyard can at least improve the nutritional status of the farm family and fetch an income. In this demonstration, it is proved that the technology can potentially sustain the livelihood of a family. This system helped the farmers to adapt new technology and acquire knowledge so that they could able to be benefited more. For the success of this technology the species to be selected for integration should fit to the site. In higher altitude areas aquaculture ponds need to be protected from the cold wind and cold river water during cold seasons of the year. Due consideration should be given to promote the technology through awareness creation and participatory demonstration. As the produce of the integrated technology are mostly perishable; appropriate handling, processing and marketing system should be arranged. Further research has to be undertaken on the implementation of the technology, especially on mono-sex fish fingerling production system for different species to be integrated and pond depth and management practices to be applied in highland areas.

References

ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA). 2007. Making a living with fish farming. CTA practical guide series, No.9. ISSN 1873-8192.

Bocek, R. 2003. Water harvesting and aquaculture for rural development. International centre for aquaculture and aquatic environments. Swing hall, Auburn University, Alabama. USA.

Bronson H. 2005. Aquaculture Plan Florida Aquaculture Plan 2005-2006. Florida department of Agriculture and consumer services, Division of aquaculture. Florida, USA).

Carballo E., van Eer A., van Schie T. and Hilbrands A. 2008. Small-scale freshwater fish farming. Agrodok 15. ISBN Agromisa: 978-90-8573-077-4

Food and Agriculture Organization (FAO). 1994. Hand book on Small-Scale freshwater fish farming. FAO Training series. Food and Agriculture Organization of the United Nations. Rome,1994.

Gupta M. and Acosta B. 2004. A review of global tilapia farming practices. Aquaculture Asia Magazine IX (1).

Little D. and Edwards P. 2003. Integrated livestock-fish farming systems. Inland water resources and aquaculture service. Animal production service Food and Agriculture Organization of the United Nations, Rome.

Rakocy and McGinty. 2005. Pond culture of Tilapia. Published by Southern Regional Agricultural Center and the Texas Aquaculture Extension Service. USA.

The Economist. 2007. Fish versus AIDS. August 30, 2007. https://www.economist.com/world/africa/ Accessed July 28, 2010.

World Fish Centre (WFC). 2007. Innovative Fish Farming Project for HIV-affected Families in Malawi Doubles Incomes and Boosts Household Nutrition. http:// www.worldfishcentre.org/ resource centre/WorldFish Press Release. Final. pdf. Accessed July 28, 2010.

Status of Lake Tana commercial fishery

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Abstract

The status of Lake Tana Fishery was evaluated from analysis of commercial catch data of number I fishers cooperative. The data collection has been carried out from September 2003 to September 2009. Results indicated that Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and species flock of endemic, large *Labeobarbus* spp. were the three main species groups targeted by commercial gillnet fishery of Lake Tana and form 65%, 20% and 15% of the annual catch compositions of fish species during the study period respectively. There was significant variability among sampling years encompassing temporal aspects. Especially, commercial catch of *O. niloticus* were significantly booming up to 2007 and declining after wards. The most likely explanations for the declining catch of *O.niloticus* and others are the illegal use of undersized monofilament gillnet imported from Sudan town (Gelabat) and the harmful increase of the commercial gillnet fishery targeting the spawning aggregations of *L.barbus* spp. and *C.gariepinus* in the river mouths and littoral areas. The observed decline in the commercial catch of *O.niloticus* and others stress the need for the urgent development of a management plan focusing on controlling import of undersized monofilament gillnet, fishing effort and gear restrictions in the river mouths and major tributaries during the breeding seasons and implementing the regional fishery legislation.

Key words: Commercial, monofilament, sustainable, spawning.

Introduction

Ethiopia is endowed with significant area of inland water, including about 7,400 km^2 of lakes and reservoirs, and about 7,000 km of rivers. Estimates of maximum sustainable yields might allow a production growth between 30,000 to 40,000 tones per year, from the main lakes only. The rivers fishery potential is roughly estimated at about 5000 t/year. however, the estimated annual production in 1992/93 increased by about 30 % leading to an estimated fish harvest of 6,500 tones (FAO, 2003). As a matter of fact, the incidence, depth and severity of food poverty are much more serious in Ethiopia. The national food security strategy has therefore, been formulated with an overall objective to raise the level of food self reliance nationally and ensure household food security strategy of the regions, much more comprehensive packages of interventions are needed to ensure food security in the regions. It can be stressed that the fisheries and aquaculture sub-sector of the livestock sector can play a significant role for the regions food security as far as resources of fishery is numerous.

Lake Tana, the source of the Blue Nile, is Ethiopia's largest lake; it probably was formed during late Pliocene or early Pleistocene times. It now covers an area of about 3150 km^2 and has an average depth of 8 m, with a maximum of 14 m. It is situated at an altitude of 1830 m and can be characterized as oligo-mesotrophic Lake (Rzoska 1975; 1976; Demeke Admasu, 1986) with a very truncated fish fauna (Green wood, 1976) that is it is poor in species and families. There is only one representative of the family Cichlidae: *Oreochromis niloticus,* a very wide spread species in Africa. The three species of clarias (Family Claridae), that (Boulinger, 1911) describes for the lake (Including the endemic Clarias tsanensis Boulinger 1902), have recently been synonyms to C*larias gariepinus*, the most common member of this genus (Teugels, 1982).

The Largest family in the lake is the Cyprinid, which is represented by three genera: Varicorhionius, with one single species *V. beso* Garra, for which Boulenger (1911) describes two species in Lake Tana: *G. quadrimaculata* and *G.dembensis* and the last well described genus of Cyprinidae fishes from Lake Tana Barbus, which has been revised several times as a result seventeen morphotypes of lake Tana Labeobarbus were identified. According to Martin degraaf (2003), to prevent extinction of the unique Barbus species flock, effort control restrictions near the river mouths during August-September (peak breeding period) have to be implemented immediately to protect the vulnerable spawning aggregations.

Since its introduction in 1986, little has been documented about the development and characteristics of the commercial gillnet fisheries and development of the three targeted species groups, *L.Barbus*, *C.gariepinus*, and *O.niloticus*. This lack of knowledge about the natural resources and the impact of the commercial gillnet fishery is one of the main reasons why to date no management plan or fisheries regulations exist in Lake Tana. However, in recent years fishers have noted a drastic reduction of their catches in Lake Tana. This stresses the need for sound data on Lake Tana's fish and fisheries in order to provide a scientific base for advice on development of a management plan and fisheries regulations. Therefore, the purpose of the study is to know the general trend of catch compositions and weight of Lake Tana commercial fishery and evaluate status of fishing activities in Lake Tana.

Materials and methods

Study site was at the landing site of Bahir-Dar number one fishers cooperative station. Data was collected by identifying fish species just after arrival of motorized boat to the station and taking their weight on daily bases using a sensitive balance. Data collection has been carried out from September 2003 to September 2009. Reconnaissance survey was conducted to overview the fishing site and fishing materials at different landing and fishing sites. Survey was conducted by collecting information from the beneficiaries and fishers from motorized and reed boat by interview while they are fishing. Fishing gears type and size were assessed at their landing and fishing sites. Data was analyzed using statistical software (SPSS version 16) and descriptive statistics.

Results and discussion

Total catch composition and weight

The three main species groups targeted by commercial gillnet fishery of L. Tana during the study were found to be a species flock of endemic, large *Labeobarbus* spp., African catfish (*Clarias gariepinus*) and Nile tilapia (*Oreochromis niloticus*) (Fig. 1). Total catch from Lake Tana by Bahir- Dar fishers number one cooperative recorded during the study was *O.niloticus* 1689.1 tone, *C.gariepinus* 527.3 tone and *L.barbus* 383.8 tone. Annual catch shows that, compositions of fish species for seven respective years are mainly *O.niloticus* which constitutes 64.96 %, *C.gariepinus* 20.28 % and *L. barbus* 14.76 % of the total catch (Fig. 2). Even though species diversity for *L.barbus* species is more divers, which enables

Abay basin rich in fish diversity due to *L.barbus* endemisity exclusively in L. Tana. The previous two species are more abundant in total catch respectively, but *L.barbus* species is rare, the most possible explanation is due to inappropriate fishing burdens for several years on their spawning grounds with non applicable fishery legislations in the region that make *L.barbus* composition rare in commercial catch composition of fishers of Bahir-Dar number one fishers cooperative. Full time fishers and off time fishers of Lake Tana vicinity target *L.barbus* species at spawning grounds especially at all Lake Tana tributary river mouths and upstream rivers while fishes migrate for breeding purpose.

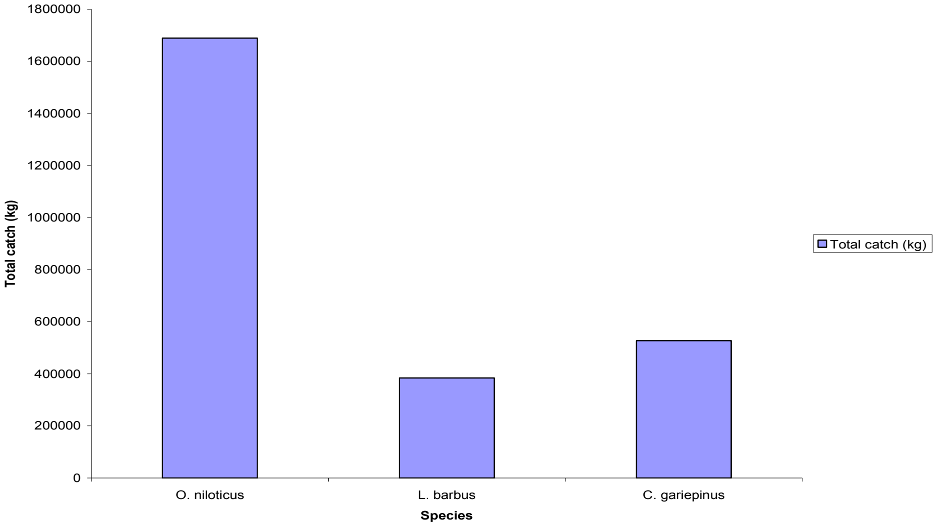

Fig. 1. Total catch of commercial gillnet fishery of L. Tana by Bahir-Dar number one fishers cooperative from 2003 to 2009.

Fishing activities

Lake Tana fisheries consist of mainly artisanal predominantly subsistence fishery conducted from papyrus reed boats (Tankwa), which resemble those of ancient Egypt. The fishermen, who are using mainly fish traps and small gill nets, are almost exclusively members of the reed boat fishers. Since 1986 a motorized commercial gillnet fishery developed by Amhara fishermen in cooperation with fishermen in Urk (Netherlands).

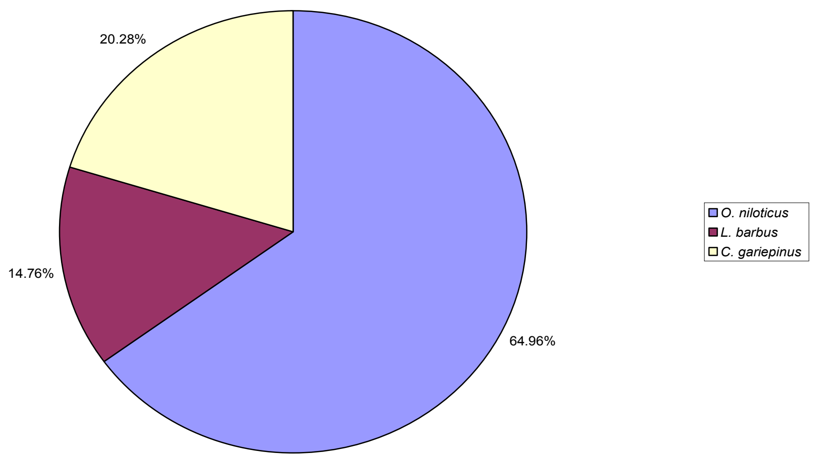

Fig. 2. Total catch percentage of commercial gillnet fishery by Bahir-Dar number one fishers cooperative from 2003 to 2009.

As a result currently fishing with motorized boat becomes common; fore example Bahir-Dar number one fishers cooperative has more than 70 motorized boats. Commercial catches of large barbs in Lake Tana over the last decade have sharply decreased, due to over fishing in river mouths during fish migration to their spawning rivers (de Graaf *et al*., 2004). However, at the 4th Pan African Fisheries and Fish Association (PAFFA) conference held in September 2008 at Addis Ababa, habitat degradation at the breeding ground of fish (rivers, tributaries and wetlands) contributed more than over fishing for the sharp decline. The present study shows that almost all fishers both reed boat and motorized boat fishing pressure mainly concentrate on breeding season and spawning ground of each species. *O.niloticus* fishing is carried out at littoral regions, *C.gariepinus* at flooded areas, littoral and river mouths. *L.barbus* mostly targeted at river mouths and a little distance towards upstream (Fig. 3). The most surprising fishing activities that makes shock and lead to overall collapse of Lake Tana fishery resource is using undersized monofilament gillnet imported from Sudan town (Gelabat) market starting from 2008 (personal communication with fishers). During peak spawning season at pre-rainy season, peak rainy season and post rainy season at all spawning grounds setting 5 cm up to 7 cm stretched mesh all fishers become common practice (Fig. 4).

Fig. 3. Catch of commercial gillnet fishery from Enfranz River mouth tributary of LakeTana during *L. barbus* spawning season.

Fig. 4. Monofilament gillnet introduced to Lake Tana commercial gillnet fishery from Sudanese market (Gelabat).

Fishing by monofilament gillnet is performed mostly starting from early in the morning up to 10 a.m by disturbing spawning ground with strong stick to kick surface water for several times and several places until they caught enough catch. The demand of filleted fish by immediate fish traders who export Lake Tana fish mainly to Addis Ababa and Sudan as well as different towns of the country trigger fishers to have catch from small sized fish population by using illegal small sized monofilament gillnets which have never been practiced any years before. The other fishing practice recently started by many of fishers is using small mesh sized cast net (usually <4 cm) used at the shore sides of Lake Tana especially during *O.niloticus* spawning seasons (Fig. 5).

Fig. 5. Fishing with 4-5 cm stretched mesh size cast net at shore sides of Lake Tana.

During both the day time and night, monofilament gillnet is refuge somewhere in the vicinity of L. Tana covered by vegetations at littoral areas, what makes different from the previous activity is setting the appropriate gillnet for the whole night and they set off early in the morning and left their gillnet for the next day harvesting (Fig. 6).

Fig. 6. Monofilament gillnet during off time (day time) put at refuge at littoral region.

The commercial gillnet fisheries was monitored during 2003 to 2009. According to experimental trawling program of (de Graaf *et al*., 2006) commercial catch large specimens of African catfish (>50 cm) and Nile tilapia (>20 cm) decreased significantly over the last 10 years time, but recruitment of young fish to the adult populations was not negatively affected.

During the same period the commercial catch of riverine spawning *Labeobarbus* spp. declined with 75%. In the experimental fishery a similar decrease was observed and the populations of juvenile *L. barbus* in the littoral (Length range: 5-18 cm) decreased even by more than 85% (de Graaf *et al*., 2006). The major reason for the collapse of these fish species is due to destructive fishing during their spawning season and destruction of the river ecology that serves as a spawning ground. These species form aggregations in the river mouths in August-September, during which period they are targeted by the commercial gillnet fishery.

Annual catch distribution pattern

The present study shows that, *O. niloticus* show an increasing order starting from 2003 up to 2007, but after 2007 it become decline sharply year after year for consecutive two years. Of course *C.gariepinus* and *L.barbus* do not show significant change, year after year except *L.barbus* species show significant decline during 2007 (P<0.05). From annual catch composition *O.niloticus* plays a leading catch by weight, this is because of targeting the spawning seasons and spawning aggregation grounds. The other two species had been targeted illegally for several years as a result at both spawning seasons and grounds there is no remarkable catches whatever fishing effort is applied. Overfishing of *L.barbus* near and in river mouths and upstream in the rivers on and near the spawning grounds by fishers for several years reduced their abundance to a very low level (Figure 7).

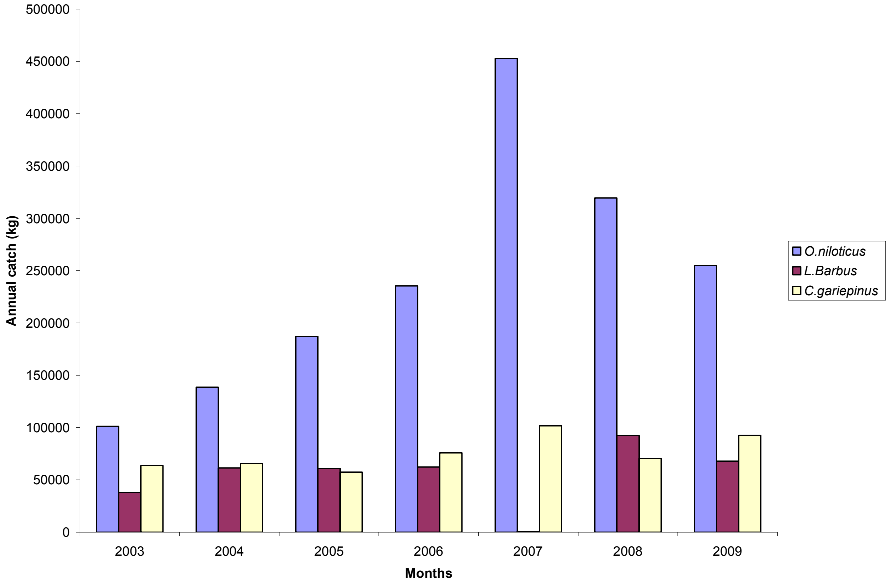

Fig. 7. Annual catch pattern by weight from 2003 to 2009 by fishers of Bahir Dar number One fishers cooperative.

At every year of commercial gillnet catch of *O.niloticus* takes a leading dominant species by weight starting from 2003 to 2007 at an increasing order. The total amount commercial catch of *O.niloticus* during 2007 is 450 tone, but after a year of 2007 it starts to become decline. Of course total annual commercial catch declines during 2008 and 2009 at decreasing order respectively (Fig. 8). Catch weight increment of *O.niloticus* from 2003 up to 2007 is due to fishing pressure at spawning grounds with illegal monofilament introduction, this is supported by the amount of catch recorded at a particular seasons, which are peak spawning seasons of *O. niloticus* (Feburary, March and April).

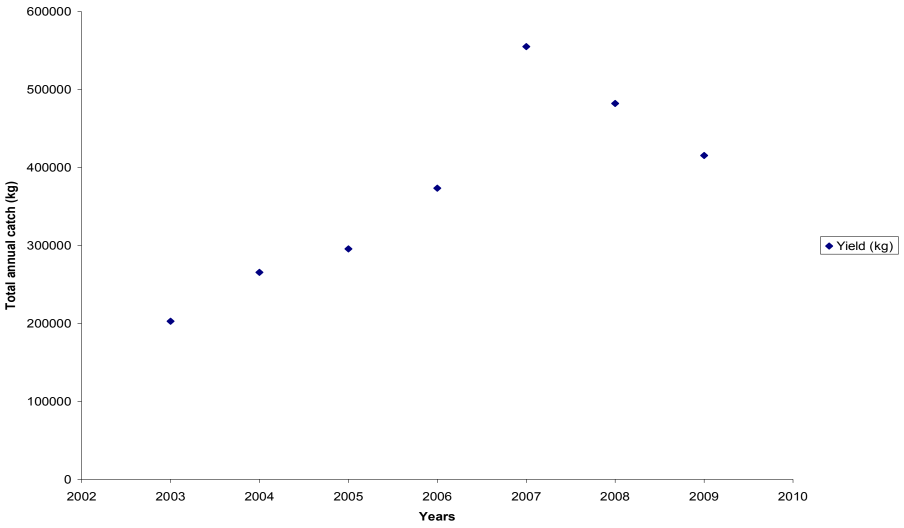

Fig. 8. Total annual commercial gillnet fishery catch by Bahir-Dar number one fishers cooperative from 2003 to 2009.

The highest catch of *O.niloticus* was recorded during 2007 which is 452.7 tone/year and least was recorded during 2003, 101.1 tone/year and the mean catch by weight is 241.3 tone/year. The highest catch of *C.gariepinus* was recorded during 2007 which is 101.6 tone/year and least was recorded during 2005, which is 57.5 tone/year and the mean catch by weight is 75.3 tone/year. The highest catch of *L.barbus* was recorded during 2008 which is 92.4 tone/year and least was recorded during 2007, which is 0.7 tone/year and the mean catch by weight is 54.8 tone/year (Fig. 8).

Total catch distribution shows that, March exhibit the highest catch and it follows with February and April respectively. May, Jun, July and August exhibit the second category for better catch distribution. The least was recorded from September up to December (Fig. 9). Specifically *L.barbus* annual catch starts to increase during July, peak in August and it starts to decline in September. This is the peak spawning season for *L.barbus* species. The highest catch was recorded for *C.gariepinus* in Jun and it follows in July, which is the spawning season for *C.gariepinus*. The other seasons exhibit least production. The highest total catch for *O.niloticus* was recorded during March followed by February and April respectively (Figure 10).

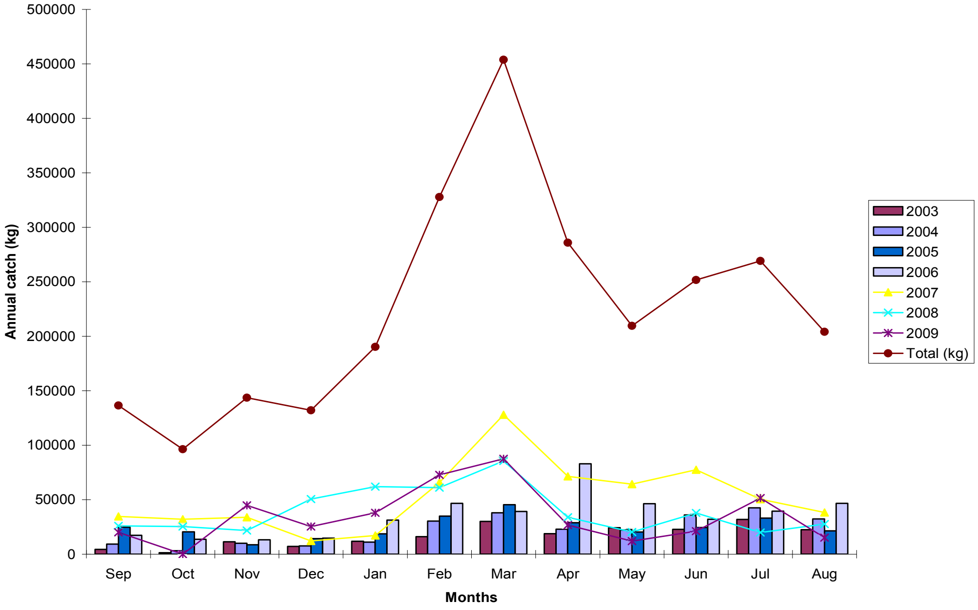

Fig. 9. Total catch distribution on monthly bases from 2003 to 2009 from catches of Bahir Dar number one fishers cooperative.

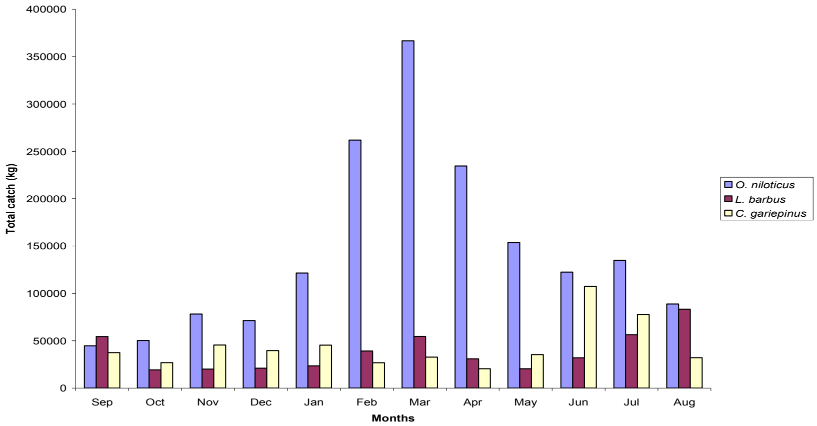

Fig. 10. Total catch distribution of three species in monthly bases.

Fisher's trip of fishing days per year was increased from 2003 to 2005. This shows that fishers was used an appropriate fishing material throughout the year. But during year 2006 fishing trips get declined and it remains constant until 2008. Trips per year during 2009 again start to declined. This indicates that fishing is carried out during the selected seasons, which is breeding seasons and at the same time breeding grounds of the most economically important fish species of Lake Tana (Fig. 11).

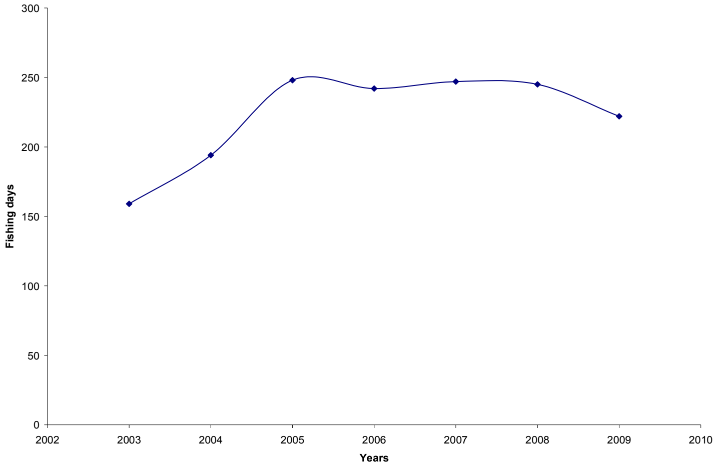

Fig. 11. Effort by using trips/year.

CpUE using kg of their catch per trip shows that, during 2005 it has got declined and from 2005 onwards up to 2007 it was at increasing order and again after 2007 it became declined (Fig. 12). The number of fishers from 2003 up to 2005 it was almost the same. But starting from 2005 up to 2009 it is on an increasing order (Fig. 13), this implies that the number and length of fishing gears are at the same time gets an increment.

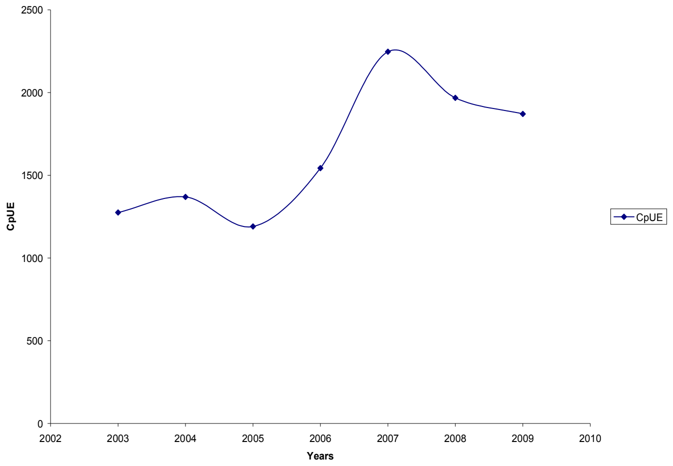

Fig. 12. CpUE using kg/trip.

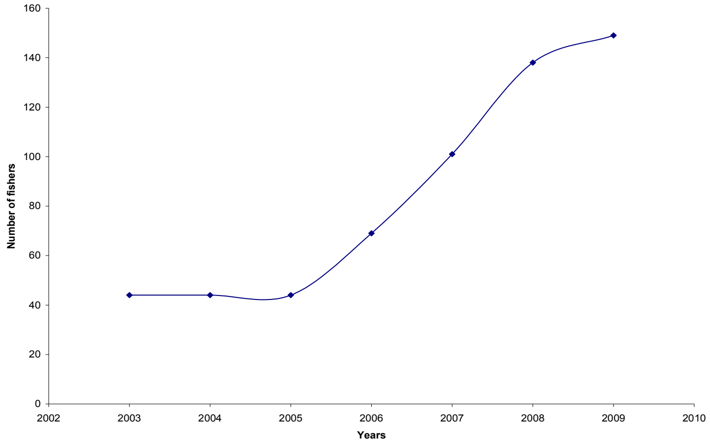

Fig. 13. Number of fishers per year.

Conclusion and recommendation

At every year of commercial gillnet catch of *O.niloticus* takes a leading dominant species by weight starting from 2003 to 2007 at an increasing order. The total amount commercial catch of *O.niloticus* during 2007 was 450 tone, but after a year of 2007 it starts to become decline. Of course total annual commercial catch declines during 2008 and 2009 at decreasing order respectively. Catch weight increment of *O.niloticus* from 2003 up to 2007 was due to fishing pressure at spawning grounds with illegal monofilament introduction, this is supported by the amount of catch recorded at a particular seasons, which are peak spawning seasons of *O.niloticus* (Feburary, March and April).

- Closed seasons and spawning grounds for different fish species have to be implemented
- Prohibit illegal fishing such as using small stretched mesh size gillnet, monofilament gillnet, beach seines during spawning aggregations, small mesh sized cast net at shore sides, which is major sites for breeding and nursery.
- Generally, implementing the existing fishery legislation is a vital issue to alleviate the problems that Lake Tana fishery resource encountered.

References

Boulenger, G.A. 1905. The distribution of African freshwater fishes. *Nature* 72(1869):413-421.

Boulenger, G.A. 1911. *Fresh water Fishes of Africa*. Vol. II, pp.1-512. London.

Degraaf, M. 2003. Lake Tana‘s Piscivorous Barbs (Cyprinid, Ethiopia) PhD thesis. Wageningen University. The Netherlands.

DeGraff, M., Marcel, A.M., Machiels, M., Tesfaye Wudneh and Sibbing, F.A. 2004. Declining stocks of Lake Tana’s endemic *Barbus* species flock (Pisces: Cyprinidae): natural variation or human impact? *Biol. Cons.* 116:277-287.

DeGraaf , M., van Zwieten, P.A.M., Machiels M.A.M., Lemma, E., Wudneh T., Dejen, E. and Sibbing, F.A. 2006. Vulnerability to a small-scale commercial fishery of Lake Tana’s (Ethiopia) endemic Labobarbus compared with African catfish and Nile tilapia: An example of recruitment-overfishing? Fisheries Research 82:304-318.

FAO, FID/CP/ETH/. 2003. Fishery Country Profile. Rev.3. pp. 1-6.

Green Wood, P.H. 1976. *Fish Fauna of the Nile*. **In**: The Nile, Biology of an ancient River (J.Rzoska, Ed.), pp. 127-141. The Hague, The Netherlands: W. Junk Publishers.

Teugels, G.G. 1986. A systematic revision of the African species of the genus Clarias (Pisces;Claridae). Annales de la Mussee Royal de l' Afrique Central, Science Zoologique 247: 1-199.

On- Farm growth performance evaluation of Abergelle goats under traditional management in Sekota Woreda

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Abstract

The study was conducted at abergelle in the semi arid parts of Sekota Woreda to evaluate growth performance of abergelle goats under traditional management. The result of this study is based on on-farm monitoring data collected from 724 kid's birth for two years. The mean body weight of kids at birth was 1.91 ± 0.04 kg. The body weight at weaning, six month and yearling age were 6.84 ± 0.19, 9.13 ± 0.31 and 16.42 ± 1.20 kg. Kids born single, male and kids from later parity and kids born during wet season were heavier ($P<0.001$) than twins, females, kids born from first parity and kids born during hot dry season at weaning. The mean weight gain during pre-weaning and post weaning period were 53.44 and 29.26 g/day. Kids born from later parity, single and kids born at wet season had higher ($P<0.001$) pre-weaning growth rates than kids born from first parity, as twins and kids born during hot dry season, respectively. For the future study improvement of the breed through selection and feeding management is important.

Key words: Growth, reproductive performance, Sekota, Semi arid.

Introduction

The goat population of Ethiopia is estimated to be 18.5 million (CSA, 2007). It is maintained with a very little resource input under the traditional subsistence management system. Goats are important for diversifying production, creating employment, increasing income, building capital, contributing to human nutrition and reducing risk during crop failure, property security and investment. A national systematic breed characterization (phenotype and genotype) of Ethiopian goat types has been conducted by FARM-Africa in collaboration with ILRI and Haramaya University and distinct indigenous goat types were identified and classified into four major families: namely, Nubian, Small Rift Valley, Somali and Small East African (FARM-Africa, 1996). This family classification is based on combination of their morphological appearance.

Abergelle goat types are categorized under the Rift Valley family. They are extensively reared and found widely distributed in the mid altitude of Southern Tigray, North Wollo, and Waghimra Zone and along Tekeze River Valley. The Central Highland goats are categorized under the Small East African family and are found widely distributed in the Central Highlands, west of the Rift Valley escarpment inTigray, Wollo, Gonder and North Shoa.

Goats in the Sekota woreda are managed mainly under mixed crop livestock production system in relatively large flocks. Goat rearing in this woreda is predominantly for milk and meat production (Nigatu, 1994). They serve as an alternative to cash, may be easily converted into cash, provide milk and meat in the poor feed resources areas and harsh environments. Despite their significance, goat research on production and reproductive performance of local goat breed is limited. Identifying constraints limiting the traditional goat production system are important. Evaluation of the genetic merit of adapted local breeds is important for the formulation of sound breeding plans and improvement of genetic potential. Therefore, this experiment was conducted with the objectives to evaluate the growth and reproductive performance of Abergelle goats under traditional management systems

Materials and methods

Study area

The study was conducted in Sekota Woreda, Waghimra Administrative Zone. It is located about 720 km North from Addis Ababa. The Altitude varies from 1340-2200 masl (ZAD, 1995). Annual rainfall ranges between 350-700 mm, falling mainly from July to September. The pattern and distribution of the rainfall is erratic and uneven. Average temperature ranges from 16-27oC (ZAD, 1995).

On-farm flock monitoring

For this study, two peasant associations were purposively chosen for monitoring purpose in semi arid part of the woerda based on the goat population of breeds. Fourteen households from the semi arid area for monitored Abergelle goats that possessed goats were randomly selected. The age and parity of does of the flock were determined by dentition and interviewed the owners at the beginning of the monitoring. All animals were ear tagged at the beginning and individual were established data were collected by trained enumerators recruited from the locality and supervision carried out on 15 day basis by the researcher for two years from June 2004 to June 2006. Growth data (birth weight, and fortnight weight for pre-weaning kids, monthly BW for adults) were used. Seasons were categorized into three by considering the availability of feed and temperature. Category 1 (July to September) is characterized by rainy season and green natural pasture is available. Category 2 (October to January) has relatively cool temperature with aftermath grazing available. The quantity and quality of natural pasture is depleted in this time. Category 3 (February to June) has a very hot temperature and both the natural pasture and aftermath grazing is scanty. All data were coded and recorded in excel sheet for growth and reproductive traits. The preweaning and post-weaning growth performances were adjusted by the following formulae (Inyangala et al., 1992).

$$\text{Adjusted weaning weight (kg)} = \frac{90(w2 - wl)}{D} + wl$$

$$\text{Adjusted six months weight (kg)} = \frac{180(w3 - wl)}{D} + wl$$

$$\text{Adjusted yearling body weight (kg)} = \frac{365(w4 - wl)}{D} + wl$$

Where, W2, W3 and W4 = weight at a given age

W1 = birth weight

D= number of days between weighing date and date of birth

$$\text{Average daily BW gain up to weaning (g)} = \frac{(AWWT - BWT)}{90}$$

$$\text{Average daily BW gain from weaning to yearling (g)} = \frac{(AYWT - AWWT)}{275}$$

Where, BWT= Birth weight

AWWT= Adjusted weaning weight at 90 days

AYWT= Adjusted yearling weight at 365 days

Statistical analysis

Birth weight, three month weight, six month weight and yearling weight were analyzed using were analyzed by GLM analysis of variance (SAS, 1999) the following fixed effects model.

Results and discussion

Growth performance

The overall least-squares mean of birth weight of Abergelle kids were 1.91±0.04 kg (Table 1). The result of the current study was in agreement with the value of 1.9±0.14 kg, reported for indigenous goats of Swaziland under traditional management (Lebbie and Manzini, 1989). The observed mean birth weight for Abergelle kids in the present study were lower than 2.29 kg reported by Muluken (2006) for the same breed. It was also lower than reported value (2.34 kg) for Boran Somali, but higher than the value of 1.5 kg for Mid Rift Valley kids (Tesfaye *et al*., 2000). The lower birth weight of Abergelle kids observed in this study may be related to the critical shortage of forage both in quantity and quality which is also caused by recurrent drought of the area.

Birth weight of Abergelle kids born in the first parity was lower (1.77±0.01) as compared to 2nd and higher order of parity (1.92±0.01 to 1.99±0.06). This might be related to the doe weight at kidding. It was stated that an advance in age of doe up to fourth parity was accompanied by increased kid weight at birth and up to weaning (Negi *et al*., 1987; Singh *et al*., 1987). Due to the fact that parity of dam and BW of does at kidding time were strongly positively correlated with milk yield and with the general principle of productive output being proportional to the metabolic weight of the dam (Taylor and Murray, 1987). Wilson (1987) also found that the age of dam has significant effect on birth weight and pre-weaning growth rate of offspring in that young ewes tend to produce smaller lambs at birth. The fact that mothering ability, especially milk production, increases with parity. First parity ewes are still growing and thus must provide for their own growth in addition to the foetal demand (Stobart *et al*., 1986). Contrary to this Zeleke (2007) stated that kids born from dams of fifth parity had lighter weights at birth compared to kids born from dams of first to fourth parities in Somali goats at Haramaya university.

Table 1. Least-squares means (± SE) of kid birth weight of Abergelle goats.

Class	N	Abergelle KBW (kg)
Overall	724	1.91 ± 0.04
Parity		***
1	153	1.77 ± 0.01^{b}
2	173	1.92 ± 0.01^{a}
3	167	1.91 ± 0.04^{a}
4	142	1.93 ± 0.04^{a}
Type of Birth		***
Single	676	2.02 ± 0.04^{a}
Twin	48	1.80 ± 0.05^{b}
Sex		***
Female	384	1.88 ± 0.04^{b}
Male	340	1.96 ± 0.04^{a}
Season		***
Cool dry	569	1.96 ± 0.02^{a}
Hot dry	146	1.80 ± 0.03^{b}
Wet	9	1.960.10^{a}

*and*** indicate significant difference at p<0.05 adn p<0.001.Means followed by the same letters are not significantly different. KBW= Kid birth weight; LSM = Least square mean, N = number of observation, SE = standard error.

Single born kids were heavier (P<0.001) at birth than those born as twins (Table 1). This difference may be due to the effect of maternal influence. The reduction in birth weight of lambs for large litter size is related to the fact that as the number of fetuses increases in utero, the number of caruncles attached to each fetus decreases, as a result the feed supply to the fetuses thus reduces (Robinson *et al*., 1977). Any more possible reason for lower birth weight of twins than singles was due to their smaller size and weight in the uterus. After birth, single kids had an advantage over twins as twins had to compete for the milk from their dam. Kids born in the wet and cool dry season were heavier (P<0.001) than those born in the hot dry season. This is probably due to either the small number of observation (9 vs 569) of wet season or due to doe's nutritional status during the late stage of pregnancy. Doe's kidding during the wet season have got better browses and green pasture at late stage of pregnancy than doe's kidding during the dry season. Eltawil *et al.*, (1970) stated that seasonal influence on birth weight functions through its effect on the dam's uterine environment mostly in late gestation. Similarly, Dunn and Moss, (1992) explained that rapid rate of fetal growth occurs at late stage of pregnancy, nutritional stress during this time resulted to BW losses and increased the risk of reproductive wastage due to abortion, retardation of fetal growth and reduced birth weight.

Weaning and post weaning body weights

The least square means of weaning, six month and yearling weight of kids of Abergelle goats are presented in Table 2. The overall mean weaning weight of Abergelle kids were 6.84±0.19 kg. The mean weaning weight of Abergelle kids' was comparable with the value of 6.32 and 6.72 kg for reported for Mid Rift Valley kids and Highland goats (Tesfaye *et al.*, 2000). Abergelle kids weaning weight (6.8 kg) was however lower than that of Arsi Bale (8.4 kg) (Tatek *et al.*, 2005), Boran Somali kids (7.2 kg) (Tesfaye *et al.*, 2000) and Highland kids (9.02±0.18 kg) in the present study.

Analysis of variance of weaning weight showed significant difference on parity. It was lower ($P<0.001$) for first parity than later parity. This indicates that as the does parity increased they are able to provide more milk than first parity does (Eltawil *et al.*, 1970). Single birth and male kids were heaver ($P<0.001$) than twin and female kids. Kids born during wet season have heavier weight and retained this rank up to the age of six months.

The value of six month and yearling weight (9.1 and 14.2 kg) of Abergelle goats was comparable with that for Borana Somali goats as reported by Tesfaye *et al.* (2000), who observed that the weight of Borana Somali goats were 9.3 and 13 kg at six month and yearling, respectively, and more than 7.9 and 12.9 kg six month and yearling weight reported for Mid Rift Valley goats. In contrast to these, the six month and yearling weights obtained in this study was less than 11 and 16 kg of Afar goats (Kasshun, 1989).

Pre-weaning growth performance

The mean daily BW gain from birth to weaning for Abergelle kids were 53.44 g/day (Table 3). These are lower than pre-weaning growth rate under traditional managements (104 g/day) of Ethiopian goats reported by Mukassa-Mugerwa *et al*. (1989). The differences in the pre-weaning weight gains are closely associated with the differences in level of milk intake during milk feeding period and the nutritional status of the doe (Negi *et al*., 1987; Singh *et al*., 1987).

Analysis of variance of pre-weaning growth rate showed significant difference (P<0.001) on parity. These traits were lower for first parity than later parity. This indicates that as the does parity increase, they were able to provide more milk than first parity does. There was no difference (P>0.05) on pre-weaning BW of kids born from 2nd parity and afterwards parity for Abergelle goats at shown in Table 2. The pre-weaning growth rate of kids depends on the dam's milk yield and nutrition status of the dams (Wilson, 1987). Does at first parity may have less mothering ability than those in later parity.

Post weaning growth performance

The mean daily BW gain from weaning to 12 month of Abergelle and Central Highland goats were 29.26 and 43.41 g/day (Table 3). In this study, post weaning growth of kids was not influenced by parity and type of birth. Sex and season of birth had significant effect on post weaning growth of Abergelle kids. Das *et al*. (1993) explained that the rate of growth of kids after weaning was partly determined by the genetic potential of the kids and the level of environmental influences.

The mean daily post weaning BW gain of kids born in the wet season was lower (P<0.001) than the kids born in other seasons. The likely reason for this might be kids born during dry season had low growth rate at the pre-weaning growth stage due to the restriction of milk yield of their does, may compensate, growth in the post weaning growth period. Similarly, Hary (2001) explained that kids born to low milking does were able to compensate (g/day) for restriction in milk availability by starting to graze on pasture forage at early stage.

Table 2. Least square means (± SE) of weaning weight, six month weight, and yearling weight of Abergelle goats in Sekota woreda.

Factor	N	WWT (kg)	N	SWT (kg)	N	YWT (kg)
Overall	639	6.84 ± 0.19	427	9.13 ± 0.31	195	14.15 ± 1.20
Parity		***		*		NS
1	130	5.99 ± 0.19^{b}	74	9.33 ± 0.32^{b}	40	13.65 ± 1.15^{a}
2	157	6.76 ± 0.19^{a}	100	9.99 ± 0.30^{ab}	53	14.33 ± 1.18^{a}
3	148	6.79 ± 0.18^{a}	111	10.12 ± 0.29^{a}	49	14.69 ± 1.18^{a}
4	121	6.69 ± 0.18^{a}	86	9.61 ± 0.30^{ab}	29	14.72 ± 1.22^{a}
TB		***		NS		NS
Single	599	7.08 ± 0.14^{a}	399	9.89 ± 0.22^{a}	177	14.71 ± 1.11^{a}
Twin	40	6.21 ± 0.23^{b}	28	9.49 ± 0.37^{a}	18	13.60 ± 1.23^{a}
Sex		***		**		***
Female	335	6.49 ± 0.17^{b}	230	9.45 ± 0.27^{b}	122	13.50 ± 1.14^{b}
Male	304	6.80 ± 0.17^{a}	197	9.92 ± 0.28^{a}	73	14.80 ± 1.17^{a}
Season		***		***		***
CD	531	6.56 ± 0.10^{b}	365	8.60 ± 0.18^{b}	162	15.10 ± 1.17^{a}
HD	99	5.30 ± 0.14^{c}	53	9.21 ± 0.28^{b}	33	13.21 ± 1.16^{b}
wet	9	8.07 ± 0.40^{a}	9	11.26 ± 0.59^{a}	-	-

*and*** indicate significant difference at $p<0.05$ and $p<0.001$and NS indicates non significant difference. Means followed by the same letters are not significantly different. CD = Cool dry, HD = Hot dry, LSW = Least square mean, N = Number of observation, SE = Standard error, SWT = Six month weight, TB = Type of birth, WWT = Weaning weight.

Tabe 3. Least squares means (± SE) of pre- and post-weaning average daily BW gain of Abergelle goats.

Class	N	PRBWG(g/d)	N	PWBWG(g/d)
Overall	639	53.4 ± 2.30	176	29.3±4.32
Parity		***		NS
1	127	47.7 ± 2.38^{b}	34	31.0 ± 4.20^{a}
2	158	54.8 ± 2.25^{a}		29.6 ± 4.30^{a}
3	148	54.9 ± 2.15^{a}	41	31.5 ± 4.31^{a}
4	122	53.5 ± 2.18^{a}	28	30.3 ± 4.44^{a}
TB		***		NS
Single	601	58.8 ± 1.67^{a}	161	29.1 ± 4.02^{a}
Twin	38	48.1 ± 2.82^{b}	15	29.4 ± 4.57^{a}
Sex		NS		**
Female	337	52.5 ± 2.02^{a}	111	27.6 ± 4.11^{b}
Male	302	54.4 ± 2.07^{a}	65	30.9 ± 4.25^{a}
Season		***		NS
Cool dry	537	48.9 ± 1.26^{b}	147	29.2 ± 4.24^{a}
Hot dry	93	37.2 ± 1.72^{c}	29	29.4 ± 4.23^{a}

*and*** indicate significant difference at $p<0.05$ and $p<0.001$and NS indicates non significant difference. Means followed by the same letters are not significantly different. LSW = Least square mean, N = Number of observation, POBWG = Post weaning BW gain, PRBWG = Pre-weaning BW gain, SE = Standard error, TB = Type of birth.

Conclusion

Evaluation of growth, reproductive performance and carcass characteristics of Abergelle goats under traditional management system was conducted at Sekota woreda. The study result revealed that the overall mean of weight of kids at birth was 1.91±0.04 kg. Season of birth, type of birth and parity exert effects on birth weight. Kids born single had heavier weight at birth than twins (2.02 vs 1.80) and male kids were heavier than females (1.96 vs 1.88). The overall mean of weaning, six months and yearling weight were 6.8±0.19, 9.1±0.31 and 14.2±1.2 kg for Abergelle goats. The pre-weaning growth rate of Abergelle kids was found to be 53.4±2.3 g/day. The post weaning growth performance was affected by sex and season of birth of the kids. The overall mean of post weaning growth rate was found to be 29.3±4.3 and 43.4±2.9 g/day for Abergelle goats. From the results of evaluation of growth performance of Abergelle goats, the weight of kids at birth is very low. Growth performance is influenced by kid birth of parity, birth type and season of birth. The result of the current study revealed that birth weight of abergelle kids are very low compared to other tropical breeds. Therefore, for future study improvement of the breed through selection and feeding management is important.

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References

CSA (Central Statistical Agency). 2007. Federal Democratic Republic of Ethiopia, Agricultural sample survey, Reports on livestock and livestock holding characteristics. Statistical Bulletin No.388, Addis Ababa Ethiopia. (2): 12-16.

Das S.M., J.E.O. Rege and Mesfin Shibre. 1993. Phenotypic and genetic parameters of growth traits of Blended goats at Malya, Tanzania. Small ruminant research and development in Africa. Lebbie S.H.B, Rey B and Irungu E.K. (eds). Proceedings of the second Biennial conference of the Africa Small ruminant research network, AICC, Arusha, Tanzania, 7-12 December,1992 ILCA(International Livestock Centre for Africa)/CTA (Technical centre for agricultural and rural co-opration), ILCA, Addis Ababa, Ethiopia.268pp.

Dunn, T.G., and G.E Moss. 1992. Effects of nutrient deficiencies and excesses on reproductive efficiency of livestock. Journal of Animal Science, Vol.70:1580-1593.

Eltawil L.E., L.N. Hazel., G.M. Sidwell and C.E Terrill. 1970. Evaluation of Environmmental factors affecting birth, weaning and yearling traits in Navajo sheep. Journal of Animal Science 31(5): 823-827.

FARM-Africa. 1996. Goat types of Ethiopia and Eritrea. Physical description and management systems. Published jointly by FARM-Africa, London, UK, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 76pp.

Hary Ingo and Horst-Jürgen Schwartz. 2002. Effects of seasonal breeding on productive performance of pastoral goat herds in northern Kenya: a longitudinal analysis of growth in kids and body weight development of does. doi:10.1006/jare.2001.0918

Kassahun Awgichew, Yibrah Yacob and Fletcher, I. 1989. Productivity of purebred Adal and quarterbred Saanen x Adal goats in Ethiopia. IN: Wilson, R.T. and Azeb Melaku (eds) African Small Ruminant Research and Development. International Livestock Centre for Africa: Addis Ababa, Ethiopia, pp. 510-523.

Lebbie, S.H.B. and A.T. Manzini. 1989. The productivity of indigenous goats under traditional management in Swaziland. In: Wilson R.T. and Azeb M. (eds). African small uminant research and development. Proceedings of a Conference held at Bamenda, Cameroon. pp. 39-50.

Muluken Zeryhun. 2006. Goat husbandry practices and productive performances in Sekota woreda of Amhara Region. MSc Thesis, Haramaya University, Haramaya. Pp71

Negi, P.R., Bhat, P. Pran and R.C. Garg. 1987. Factors affecting pre-weaning body weights in Gaddi sheep and its crosses. Indian Journal of Animal science, 57(5): 489492.

Nigatu Alemayehu. 1994. Characterization of Indigenous Goat Types & husbandry Practices in Northern Ethiopia. MSc. Thesis, Alemaya University of Agriculture. Alemaya, Ethiopia.

Robinson J.J., I. McDonald, C. Fraser and R.M.J. Crafts. 1977. Studies on reproduction in prolific ewes. 1. Growth of the products of conception. Journal of Agricultural Science (Cambridge) 88: 539-552.

SAS. 1999. Statistical Analysis. SAS user's Guide, statistic. SAS Institute Inc. Cary, North Carolina, USA.

Singh Gurmej, B.S. Mehta, I.C. Sethi and C.L. Arora. 1987. Genetic and non-genetic factors affecting growth traits of Nali and its Cross breed lambs under semi–arid conditions. Indian Journal Animal Science 57(7):728-734.

Taylor, St C.S., Murray, J. 1987. Inter-breed relationship of birth weight and maternal and paternal weight in cattle. Animal production 44:55-64.

Tesfaye A., Alemu R and Lemma F. 2000. Preliminary production and reproduction performance evaluation of Mid Rift Valley and Borana Somali goats. In: R.C. Merkel, G.

Wilson, R.T. 1987. Productivity of traditionally managed small ruminants in an agropastoral system in Northern Burkina Faso. Tropical Agriculture 64(3):163-169.

ZAD (Zonal Agricultural Department Office). 1995. Waghimra Zone Baseline Data.P65.

Zeleke Mekuriaw. 2007. Environmental influences on pre-weaning growth performances and mortality rates of extensively managed Somali goats in Eastern Ethiopia. Livestock Research for Rural Development 19 (12).

Reproductive performance of Abergelle goats under traditional management in Sekota Woreda, Ethiopia

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Abstract

Reproductive performance of Abergelle goat was studied at Sekota Woreda of Amhara National Regional State. The results of this study are based on on-farm monitoring data collected from 700 kids born in two years in the semi arid parts of the woreda. The mean litter size and annual kidding rate were 1.04 and 1.22±0.17. The mean age at first kidding and kidding interval were 447.93 and 339.3 days. Therefore, to increase the validity of conclusion based on on-farm study, it is important to undertake well planned on-station study to predict the genetic potential of the breed.

Key words: Abergelle, On-farm, Reproductive performance, Semi arid, Sekota

Introduction

The goat population of Ethiopia is estimated to be 18.5 million (CSA, 2007). It is maintained with a very little resource input under the traditional subsistence management system. Goats are important for diversifying production, increasing income, contributing to human nutrition and reducing risk during crop failure, property security and investment. Goats are generally found in all agro-ecological zones from arid to humid and over the whole range of production systems from intensive smallholder production to very extensive nomadic pastoralism (Payne and Wilson, 1999).

Goat production is characterized by minimum profit resulting from poor management of the grasslands and seasonal fluctuations in feed resources. Periodic droughts and extensive dry seasons cause severe feed shortages resulting in undernourishment and low productivity among the animals. Grazing alone may not be sufficient for optimum body weight gain. Abergelle goat types are categorized under the Rift Valley family. They are extensively reared and found widely distributed in the mid altitude of Southern Tigray, North Wollo, and Waghimra Zone and along Tekeze River Valley. Goats in the Sekota woreda are managed mainly under mixed crop livestock production system in relatively large flocks. Goat rearing in this woreda is predominantly for milk and meat production (Nigatu, 1994).

Despite their significance, goat research in the past has been scanty. Assessing the potential of available genetic resources, and identifying and prioritizing the major constraints limiting the traditional goat production system are urgent in order to carry out research and development strategies. Without adequate evaluation of the genetic merit of adapted local breeds, the formulation of sound breeding plans and improvement of genetic potential is not possible. Therefore, this experiment was conducted with the objectives to evaluate the reproductive performance of Abergelle goats under traditional management systems

Materials and methods

The study area

The study was conducted in Sekota Woreda, which is located in the Amhara Region, Waghimra Administrative Zone. It is located about 720 km North from Addis Ababa. The Altitude varies from 1340-2200 meters above sea level (ZAD, 1995). Annual rainfall ranges between 350 - 700 mm, falling mainly from July to September. The pattern and distribution of the rainfall is erratic and uneven. Average temperature ranges from 16-27^{o}C (ZAD, 1995). The vegetation can be characterized as being semi-arid shrubs dominated by various *Acacia* species with a sparse ground cover of annual grasses. The farming system of the area is a mixed crop-livestock production system dominated by livestock production.

Physical characteristics of Abergelle goats

Abergelle goats are among the major indigenous goat types in Ethiopia. They have developed specific adaptations to survive and produce under extremely adverse environmental conditions (poor feed quality and quantity, water shortage) that make them suitable for use in the traditional low-external input production system (Nigatu, 1994).

Abergelle goats as described by Nigatu (1994) have compacted bodies, short height at withers (females 59-66 cm; males 65-73 cm). Weight of females ranges from 21-30 kg and that of mature males ranges from 27-39 kg. They have slightly to markedly concave facial profile. Males have spiral shaped obliquely backward horns, while the horns of females point upward. Their coat type is smooth, fine and short with 45% plain color, 36% patchy (have mixed color) and 17% with spotted patterns. The reddish-brown color predominates (29%) and others are black, white and gray. Wattles are less than 5% in both sexes (FARM Africa, 1996).

Management system

Goat production in agro-pastoral and sedentary farming systems depend on native pasture grazing on communal lands and fallow plots, occasionally provided with straws, crop residues and stubble (aftermath) depending on seasons and household by-products (Nigatu, 1994). During the cropping season, they are largely dependant on hillsides, field margins and roadside grazing. Even if the climate of the woreda is characterized by long dry season for the purpose of this study, seasons were categorized into three by considering the availability of feed and temperature. Category 1 (July to September) is characterized by rainy season and green natural pasture is available. Category 2 (October to January) has relatively cool temperature with aftermath grazing available. The quantity and quality of natural pasture is depleted in this time. Category 3 (February to June) has a very hot temperature and both the natural pasture and aftermath grazing is scanty.

On-farm flock monitoring

For this study, two peasant associations were purposively chosen for monitoring purpose in semi arid part of the woerda based on the goat population. 14 households from the semi arid area that possessed goats were randomly selected. The age and parity of does of the flock were determined by dentition and interviewed the owners at the beginning of the monitoring.

For monitoring activities all animals were ear tagged at the beginning of the study and individual were established and data were collected by trained enumerators recruited from the locality and supervision was carried out on 15 day basis by the researcher on reproduction, growth for two years from June 2004 to June 2006.

Reproductive data (age at first kidding, kidding interval, parity, birth type, litter size and kid sex) were taken. Kidding interval was calculated as the difference (in day) between two successive kidding for all does with more than one kidding record. Age at first kidding was calculated as the difference (in days) between birth and first kidding date of does. Litter size was computed as number of kids born/doe/kidding. Annual kidding rate (AKR) was calculated as: AKR = litter size × 365 per subsequent kidding interval.

Statistical analysis

Age at first kidding, kidding interval, average litter size and annual kidding rate were analyzed by GLM analysis of variance (SAS, 1999). Age at first kidding was analyzed using the following fixed effect model: $Y_{jklm}=\mu + T_j + M_k + \varepsilon_{jklm}$

Where, Y_{jklm} = observation (Age at first kidding) on j^{th} type of birth in the k^{th} season of birth

μ = overall mean common to all animals in the study

T_j = fixed effect of j^{th} type of birth of doe (1=single, 2= twin)

M_k = fixed effect of the k^{th} season of birth of doe (1-3)

ε_{jklm} is the random error term which is assumed to be normally distributed with a variance equal to δ^2 and a mean = 0.

Kidding interval was analyzed using the following fixed effect model:

$Y_{jkln} = \mu + P_j + M_k + N_l + \varepsilon_{jkln}$

Where, Y_{ijklm} = observation (kidding interval) on j^{th} type of birth in the k^{th} season of birth and l^{th} post partem weight of does.

μ = overall mean common to all animals in the study.

P_j = fixed effect of j^{th} birth type (1 = single, 2 = twin)

M_k = fixed effect of the k^{th} season of birth of kid (1 = wet (July to September.), 2 = cool dry (October to January) and 3 = hot dry (February to June)

N_l = fixed effect of the l^{th} post partem weight of doe (l = ranked postpartum body weight).

ε_{jkln} is the random error term which is assumed to be normally distributed with a variance equal to δ^2 and a mean = 0.

Results and discussion

Litter size

The total of 700 doses of Abergelle kidded, out of this 24 does kidding were as twin and , the rest 676 does kidding were as single (Table 1). This means 96.6% were single births, 3.4% were twin births. This is comparable to 98.7 and 1.3% single and twin births, respectively reported by FARM Africa (1996) for same breed. Dereje (2004) also reported 10% twining for goats in Ziquala woreda. The author attributed low twining rate to poor nutrition since farmers reported that the ability of does to give twin births was higher before one-two decades.

The overall mean litter size was 1.04±0.03 (Table 1). These were lower than that of Arsi Bale (1.21) and Central Highland goats (1.42) reported by Tatek *et al*. (2005) and Tesfaye *et al*. (2006), respectively, and comparable with that reported for indigenous goats of Swaziland (1.18) (Lebbie *et al*., 1989) and Borana Somali (1.00) (Tesfaye *et al*., 2000). The lower litter size of the breed in the present study probably might be related to the scarcity of forage in the study area at the time of breeding. Litter size showed significant difference ($P<0.001$) for parity five. In general, twin birth was higher in later parities than the first or second parity. Wilson and Light (1986) explained that the lower litter size of younger does might be associated with an underdeveloped state of the reproductive features required for successive litter bearing compared with older does that have reached physiological maturity. A relatively higher ($P<0.01$) litter size during hot dry season as compared to other season might be related with better feed availability during the wet season, i.e., at time of conception.

Table 1. Least squares means (± SE) of litter size of Abergelle goats in Sekota woreda.

Variable	N	Litter size
Overall	701	1.04 ± 0.03
Parity of dam		***
1	155	1.01 ± 0.03^b
2	173	1.00 ± 0.03^b
3	155	1.06 ± 0.03^b
4	135	1.03 ± 0.02^b
5	51	1.14 ± 0.03^a
>5	32	1.06 ± 0.04^b
Season of birth		NS
Hot dry	132	1.08 ± 0.02
Cool dry	560	1.05 ± 0.01
Wet	9	1.02 ± 0.06

*and*** indicate significant difference at $p<0.05$ and $p<0.001$and NS indicates non significant difference. Means followed by the same letters are not significantly different. CV= Coefficient of variance; LSW = Least square mean, N = Number of observation, SE = Standard error.

Annual kidding rate

The overall mean of annual kidding rate of Abergelle goats were 1.22±0.17 litters (Table 2). The analysis of variance showed that annual kidding rate was affected ($P<0.001$) by birth type and season of birth. Does that gave twin births and kidded in the hot dry and wet season had larger litters. Does that gave birth during the wet season had higher ($P<0.001$) litters than cool dry season kidding. This might be explained similar to that of the litter size in that does that kidded in the hot dry season may have had better quality feed at the time of breeding.

Table 2. Least squares means (±SE) of annual kidding rate of Abergelle goats in Sekota woreda.

Variable	N	Annual kidding rate
Overall	214	1.22 ± 0.17
Parity of dam		*
1	50	1.91 ± 0.10^a
2	67	2.01 ± 0.10^a
3	35	2.09 ± 0.10^a
4	47	2.00 ± 0.09^a
5	6	2.16 ± 0.15^b
TB		***
Single	203	1.40 ± 0.07^a
Twin	11	2.78 ± 0.14^b
Season of birth		***
Hot dry	41	2.09 ± 0.08^b
Cool dry	166	1.89 ± 0.07^a
Wet	7	2.38 ± 0.17^b

*and*** indicate significant difference at $p<0.05$ and $p<0.001$and NS indicates non significant difference. Means followed by the same letters are not significantly different. CV = Coefficient of variance, LSM = Least square mean, N = Number of observation, SE = Standard error.

Age at first kidding

Age at first kidding is a good indicator of sexual maturity in does. The mean age at first kidding of Abergelle goats was found to be 447.9 days (Table 3). This is in agreement with that reported by Wilson (1984) for goats of most Sub-Sahara Africa that stated the mean ages at first kidding to be between 303 and 556 days. Similarly, Wilson (1988) and Lebbie and Manzini (1989) reported mean age at first kidding of goats in Sub-Saharan Africa to be between 301-431 days under traditional management. Workneh (1992) reported that 36% of the does had their first kidding by eruption of their first incisor teeth among the goat types of southern Ethiopia; it is lower age as compared to the current result. The parity at which the dam was born and her birth type did not influence (P>0.05) the age at first kidding of does. However, this might be related to accessibility of feeds between seasons and doe's born in the wet season sexually mature at the successive dry season in which forage is scarce and may delay estrus.

Table 3. Least squares means (±SE) of age at first kidding of Abergelle goats in Sekota woreda.

Variables	N	Age at first kidding (days)
Overall	25	447.93 ± 29.42
parity of dam		NS
1	4	483.27 ± 25.10
2	7	445.06 ± 26.41
3	8	413.62 ± 25.19
4	5	419.14 ± 31.25
5	1	478.54 ± 50.19
TBD		NS
Single	22	457.07 ± 18.62
Twin	3	438.78 ± 34.04
SBD		NS
Hot dry	2	433.62 ± 37.53
Cool dry	23	462.24 ± 16.46
Wet	-	-

*and*** indicate significant difference at $p<0.05$ and $p<0.001$and NS indicates non significant difference. Means followed by the same letters are not significantly different. N = Number of observation, SBD = Season of birth of does, SE = Standard error, TBD = Type of birth of does.

Kidding interval

Kidding interval is one of the major components of reproductive performance that influences production systems. The mean kidding interval of Abergelle goats were 339.3±21.21days (Table 4). These results were higher than reported kidding interval for most Small East African goats' that ranges from 236-265 days (Wilson and Durkin, 1988). Type of birth and parity of does did not affect ($P>0.05$) kidding interval of Abergelle goats. Season of previous kidding had effect ($P<0.001$) on kidding interval of two breeds. Does that kidded the first kids in the cool dry season had a relatively longer kidding interval than does that gave birth of first kids either in wet or hot dry season for Abergelle does. This might be due to the fact that does having first kidding in the cool dry season, had to face shortage of fodder availability for a longer period of time as compared to does kidding in the other seasons. This might delay the induction of estrus.

Dams that had their previous kid during the rainy season had shorter kidding interval as reported by Wilson and Murayi (1988). Does' previous postpartum weight had effect (P<0.01) on kidding interval of Abergelle goats, in that does that had lower weight (15-20 kg) at the previous parturition had longer kidding interval, whereas Central Highland goats were not affected by their previous postpartum weight. Sulieman *et al*. (1990) found that lambing interval decreases by 4.4 days for every 1 kg increase in postpartum live weight. Doe that have larger post partum body weight take less time to induce estrus.

Table 4. Least squares means (±SE) of kidding interval (days) of Abergelle goats in Sekota woreda.

Variable	N	Kidding interval (days)
Overall	221	339.3 ± 21.21
previous birth parity of dam		NS
1	53	292.9 ± 21.64
2	70	275.6 ± 19.39
3	50	265.5 ± 18.37
4	34	297.1 ± 18.07
5	8	280.6 ± 28.77
>5	6	258.8 ± 33.35
TB		NS
Single	211	286.4 ± 12.26
Twin	10	270.4 ± 26.11
CDPPW		**
15-20	27	320.4 ± 22.28^{b}
20.1-25	91	277.2 ± 16.41^{a}
25.1-30	70	269.6 ± 18.20^{a}
30.1-35	33	246.6 ± 21.65^{a}
>35	-	-
Season of previous birth		***
Cool dry	169	361.1 ± 12.63^{c}
Hot dry	45	316.0 ± 14.01^{b}
Wet	7	243.1 ± 28.97^{a}
CV		21.6%

*and*** indicate significant difference at p<0.05 and p<0.001and NS indicates non significant difference. Means followed by the same letters are not significantly different. N = Number of observation, SE = Standard error.

Conclusion

In this study age at first kidding were not affected by does own birth type and parity for both breeds. Season of previous kidding had significant (P<0.001) effect on kidding interval. Does that kidded the first kids in the wet season had short kidding interval (243.1±28.97) than does that gave birth of first kids in cool dry season (361.1±12.63). From the results of evaluation of reproductive performance of Abergelle goats reproductive performance is influenced by kid birth of parity, birth type and season of birth. The result of the current study revealed that litter sizes are very low compared to other tropical breeds. Therefore, to increase the validity of conclusion based on on-farm study, it is important to undertake well planned on-station study to predict the genetic potential of the breed.

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References

CSA (Central Statistical Agency). 2007. Federal Democratic Republic of Ethiopia, Agricultural sample survey, Reports on livestock and livestock holding characteristics. Statistical Bulletin No.388, Addis Ababa Ethiopia. (2): 12-16

Dereje Andualem. 2004. Preliminary Survey of Livestock Production Systems in Ziquala Woreda, Waghimira Zone of Amhara Regional State. M.Sc thesis, Alemaya university of Agriculture, Alemaya, Ethiopia. 72pp.

FARM-Africa. 1996. Goat types of Ethiopia and Eritrea. Physical description and management systems. Published jointly by FARM-Africa, London, UK, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 76pp.

Lebbie, S.H.B. and A.T. Manzini. 1989. The productivity of indigenous goats under traditional management in Swaziland. In: Wilson R.T. and Azeb M. (eds). African small ruminant research and development. Proceedings of a Conference held at Bamenda, Cameroon. pp. 39-50.

Nigatu Alemayehu. 1994. Characterization of Indigenous Goat Types & husbandry Practices in Northern Ethiopia. MSc. Thesis, Alemaya University of Agriculture. Alemaya, Ethiopia.

Payne, W.J.A. and R.T. Wilson. 1999. An Introduction to Animal Husbandry in the Tropics. Black Well Science. UK. 815p

SAS. 1999. Statistical Analysis. SAS user's Guide, statistic. SAS Institute Inc. Cary, North Carolina, USA.

Sulieman A.H., A.R. Sayers and RT.Wilson. 1990. Evaluation of Shugor, Dubasi and Watish subtypes of Sudan Desert sheep at the EI-Huda National Sheep Research Station, Gezira Province, Sudan. ILCA Research Report 18. ILCA (International Livestock Center for Africa), Addis Ababa, Ethiopia. 38pp

Tatek W., Hailu D., Mieso G., and Dadi G. 2005. Productivity of Arsi Bale goat types under farmers' management condition: A case of Arsi Negelle. Adami Tulu Agriculture Research Center. Ziway, Ethiopia. P 67-71.

Tesfaye A., Alemu R and Lemma F. 2000. Preliminary production and reproduction performance evaluation of Mid Rift Valley and Borana Somali goats. In: R.C. Merkel, G.

Tesfaye G., Sisay L, Dereje T., Abebe M., and Solomon G. 2006. Growth and Reproductive Performance of Central Highland Goats in North Shoa and South Wollo. Sisay Lemma and Eshete Dejene (eds). Proceeding of the first annual conference on completed livestock research activity. August 14-17 2006, Amhara Region Agriculture Research Institute. Bhar Dar, Ethiopia.

Wilson and R.T. and J. Durkin. 1988. Livestock production in Central Mali: reproductive components in traditionally managed sheep and goats. Livestock production science19:523-529.

Wilson R T and T. Murayi. 1988. Productivity of the Small East African goat and its crosses with Anglo Nubian and the Alpine in Rwanda. Tropical Animal Health and Production 20:219-228.

Wilson R T. 1989. Reproductive performance of African indigenous small ruminants under various management systems: a review. Animal Reproduction Science 20:265-286.

Wilson, R.T. 1984. Indigenous Goats: Productivity in traditional livestock systems of semi-arid Africa. Int. Goat and Sheep Res. 2(3):243-251.

ZAD (Zonal Agricultural Department Office). 1995. Waghimra Zone Baseline Data. P65.

Sero-Epidemiological study of small ruminant Brucellosis in and around Bahir Dar, Northwest Ethiopia

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Abstract

A cross sectional study was carried out from October 2008 to April 2009 to determine the sero-prevalence of brucellosis and assess the impact of potential risk factors in small ruminants in and around Bahir Dar, Northwest Ethiopia. The sampling method used was purposive sampling technique for the district and simple random for the study animal. A total of 500 serum samples (270 from sheep and 230 from goats) were collected from extensive management system with no history of vaccination. All serum samples were initially screened by Rose-Bengal-Plate Test (RBPT) and positive reactors to RBPT (n=6) were further tested by complement fixation test (CFT) for confirmation. Accordingly, the overall prevalence of brucellosis in small ruminants was 0.4%. Rose Bengal Plate Test detected (1.2%) of the samples as seropositive for brucellosis where 4(1.74%) were goats and 2(0.74%) were sheep. Up on further testing using CFT only 2 (0.4%) were positive which were adult goats. The seroprevalence of brucellosis was found higher in females (0.4%) than males (0%). Although seropositive animals are low in number it was found that animals > 1 year are more affected than animals < 1 year. The result of the present study revealed that the sero-prevalence of small ruminant brucellosis in the study area was very low. However, the existence of the disease in the study area has possible risk of spread in the future. Accordingly, elimination of positive sero-reactors will provide better considerable success in the control of brucellosis in these species of animals.

Key words: Brucellosis, CFT, goats, RBPT, Sheep.

Introduction

The small ruminant population of Ethiopia is estimated to be nearly 23 million goats and 23 million sheep (IBC, 2004). In the central highlands of Ethiopia where mixed crop- livestock production system is practiced, small ruminants account for 40% of cash income and 19% of the house hold meat consumption (Zelalem and Flecher, 1993). Sheep and goats are highly adaptable to broad range of environmental conditions. Moreover, low cost of production, requirement of little land and higher prolificacy made them attractive asset for development. Investment in sheep and goats avoid losses due to high inflation rates that are found in unstable economies of many underdeveloped countries like Ethiopia. This is because sheep and goats provide rapid cash turn over (Gatenby, 1991; Steel, 1996).

There is also a growing export market for sheep and goats meat in the Middle Eastern Gulf states and some African countries. At optimum offtake rates, Ethiopia can export 700,000 sheep and 2 million goats annually, and at the same time supply 1,078,000 sheep and 1,128,000 goats for the domestic market (Alemu and Markel, 2008).

In spite of the presence of huge small ruminant population, Ethiopia fails to optimally utilize this resource as a sector. This is because of small ruminant production is constrained by the compound effect of diseases, poor feeding, poor management and low genetic endowment. Among many factors that limit economic return from small ruminants, production diseases stand in the front line. One of such disease that hampers the productivity of small ruminants is Brucellosis (Ademosoum, 1994; LMA, 1995). The genus Brucella is now considered to contain six species: namely, *B. abortus*, *B. melitensis, B. suis, B. ovis, B. canis* and *B. neotomae*. *Brucella melitensis* (biovars 1, 2 or 3) is the main causative agent of caprine and ovine brucellosis and it is highly pathogenic for humans causing one of the most serious zoonoses in the world (OIE, 2000).

Despite the presence of larger population of small ruminants in different regions of Ethiopia, very limited researches have been done on small ruminant brucellosis even if it is said to be endemic in the country. Thus this experiment was conducted to determine the Sero- prevalence of small ruminant Brucellosis and assess some of the possible epidemiological risk factors that might contribute for the infection of brucellosis in small-ruminants in the study area.

Materials and methods

The study area

The study was conducted in and around Bahir Dar starting from October 2008 to April 2009. Bahir Dar is located at Northwestern part of Ethiopia, 565 km away from Addis Ababa. It is the capital city of Amhara National Regional State situated in the Southwest direction of Lake Tana.

The minimum and maximum altitude of this town rages from 1810 to 1850 meter above sea level. The minimum and maximum temperature of the town ranges from 10 to 38 ^{O}C. The area receives mean annual rainfall of 750 mm. The area is marked by two distinct climatic seasons namely; the dry season extending from December to May; and the wet season which extends from June to September. The livelihood of major section of the population in the area depends on crop-livestock mixed farming.

Study animals

The study animals were indigenous breeds of sheep and goats kept under extensive management system. The sampling included all sheep and goats above 6 months of age with no history of previous vaccination against brucellosis.

Sampling method and survey design

The sampling method used was purposive for the district and simple random sampling technique for study animal. The study design was cross-sectional. As there was no study conducted in small ruminant brucellosis in the study area 50% expected prevalence was considered in sample size determination. The other determinants considered in sample size determination are 95% confidence interval and 5% desired absolute precision.

Hence, $N = \frac{(Zx)^2 \, Pexp\,(1-Pexp)}{D^2}$

Where, N= the required sample size

Pexp = the expected prevalence rate (50%)

Zx = the value of the required confidence interval (1.96)

D = desired absolute precision (5%)

Hence, $N = \frac{(1.96)^2 \, 0.5\,(1-0.5)}{(0.05)^2}$ = 384 heads of sheep and goat were the actual sample size.

However, to increase the precision of the survey, the sample size was increased to 500 (270 sheep and 230 goats).

Data collection

Relevant data of the study animals was recorded along side with blood specimens collection. The individual animal details such as the name of the animal, sex, age, flock size and source of animals were registered. Further more, history of abortion and placenta retention were recorded.

Blood sample collection

About 10 ml of blood was collected from the Jugular vein of each sheep and goats using plain vacutaioner tubes and needles. The blood was allowed to clot for 1-2 hours at room temperature, stored horizontally overnight at 4^{o}c, and then the serum was separated from the clot by centrifugation at 2000-3000 rpm for 10-15 minutes. Then the separated serum was labeled and kept under refrigeration (-20^{o}c) until tested.

Laboratory procedure /serological tests

Rose Bengal plate test (RBPT)

The Rose Bengal plate test (PBPT) was used as a screening test for the serum samples collected for the presence of *Brucella* agglutinins. The test was conducted as per the procedure recommended by Alton *et al.* (1975) and Nilsen and Dunkan (1990). This test was carried out at Bahir Dar regional veterinary laboratory.

Complement fixation test (CFT)

All sera which tested positive by the RBPT were retested using CFT for further confirmation. Standard B. abortus antigen for CFT was used to detect the presence of anti-brucella antibodies in the sera. A hemolytic reaction of 25% at a dilution of 1:5 was considered the minimum positive threshold (Dohoo *et al*, 1986). The Complement Fixation Test (CFT) was done at the National Animal Health Diagnostic and Investigation Center (NAHDIC).

Interpretation: Serum with strong reaction, more than 75% fixation of complement (3+) at a dilution of 1: 5 and at least 50% fixation of complement (2%) at a dilution of 1:10 and at dilution of 1:20 were classified as positive (Alton *et al*., 1975; OIE, 2004).

Data analysis

Data was stored in the Microsoft excel spread sheet program and analyzed using STATA version 8.0 software. The seroprevalence was calculated by dividing the number of CFT positive animals by the total number of animal tested.

Results

The results of the study are summarized in Tables 1 and 2 below. Of a total of 500 serum sample tested (270 sheep and 230 goats), six (1.2%) tested positive for brucellosis infection by the RBPT and only two (0.4%) of the six were found positive for CFT (Table 2).

Table 1. Seroprevalence of small ruminant brucellosis according to species of animals in and around Bahir Dar.

Animal species	Number of sera tested	RBPT positive	CFT positive
Caprine	230	4 (1.74%)	2(0.86%)
Ovine	270	2 (0.74%)	0
Total	500	6(1.2%)	2(0.4%)

Discussion

This study demonstrated that the overall sero prevalence of small- ruminant brucellosis in and around Bahir Dar to be 1.2% by the RBPT and 0.4% by CFT. Almost half of the sera which tested positive for anti *Brucella* antibodies by RBPT, tested negative by CFT. This could be due to cross-reactions between *Brucella* and other bacteria which share similar epitopes.

Table 2. Serprevalence of small ruminant brucellosis according to sex and age in and around Bahir Dar.

Risk factor	Number of animals tested	RBPT positive	CFT positive
Caprine			
Male	48	1(2.08%)	0
Female	182	3(1.64%)	2(1.09%)
Ovine			
Male	60	0	0
Female	210	2(0.95%)	0
Total	500	6(1.2%)	2(0.4%)
Age			
Young (< 1 year)	104	1(0.96%)	0
Adult (> 1 year)	396	5(1.26%)	2(1.50%)
Total	500	6(1.2%)	2(0.4%)

This prevalence is lower than prevalences recorded in previous studies carried out in different parts of the country; 4.8% in Afar Ashenafi *et al* (2007); 9.7% in Afar and Somali Teshale *et al*. (2007); 1.5% in sheep and 1.3% in goats in central highlands of Ethiopia Tekeleye and Kassali(1990); 16% in Afar region Yibeltal (2005); 3.37%, 0.11%, 3.94% and 0.49% from Afar Region, Somali Region, Borena Zone and South Omo Zone respectively Melesse *et al. (*2006*)*. The difference in the prevalence of brucellosis between the current and previous studies might be attributed to the differences in geographical location, sample size and management systems. In Afar and Somali Region, large numbers of different species of animals are raised on communal pastures under limited watering areas, where as the livestock management in the Northwestern Ethiopia is characterized by mixed farming, in which fewer animals are raised separately.

According to the present study, from a total of 500 sera tested, only two goats were sero positive for CFT while no sero-positive sheep were detected. This finding is in agreement with the reports of Omer *et al.* (2000); Radostits *et al.* (2007), and Yibeltal (2005) which indicated that goats are at higher risk of acquiring *Brucella* infection than sheep. This may be due to greater susceptibility of goats to *Brucella* inflection. It could also be partly due to the fact that goats excrete the organism for a long period of time, unlike sheep.

All seroreactors were adult female goats while no sero-positive young goat was found. It has been reported that brucellosis is essentially a diseases of sexually matured animals Quinn *et al.* (1999); Radostits *et al. (*2000). This may result from the fact that sex hormones and erythritol, which stimulate the growth and multiplication of *Brucella*, tend to increase in concentration with age and sexual maturity (Radostitis *et al.,* 2007).

The present study showed, CFT positive sera were found only in female goats; the absence of male seroreactor animals in this study could probably be due to the small number of males (N = 108) tested as compared to the larger number of females (n = 392). It has also been reported that males are usually resistant than female animals to *Brucella* infection (Radostitis *et al.,* 1994). Hirsh and Zee (1999) have reported that male animals are less susceptible to infection, due to the absence of erythritol. Moreover, it has been reported that the serological response of male animals to *Brucella* infection is limited and testes of infected male animals were usually observed to be non reactors or showed low antibody titers (Crawford *et al*., 1990).

Conclusions

The result of the present study showed that the sero prevalence of small ruminant brucellosis in the study area was very low. However, the existence of the disease in the study area has possible risk of spread in the future. Accordingly, elimination of positive reactors will provide better considerable success in the control of brucellosis in these species of animals. Based on the above conclusion the following recommendations are forwarded:

- Detailed studies should be done to have a clear picture on the prevalence of brucellosis in small ruminants in the region.

- The role of different epidemiological factors such as species, age, sex, and other possible risk factors in the prevalence of the disease should clearly be established in order to understand their effect in the control of the disease in the future.

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References

Ademosoum, A.A. 1994. Constraints and prospects for small ruminant research and development in Africa. ILCA, Addis Ababa, Ethiopia. Pp.1-5.

Alemu, Y., and Markel, R.C. 2008. Sheep and Goat Production Handbook for Ethiopia, Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP), Addis Ababa, Ethiopia, pp. 2-6.

Alton, G.G., Jones, M.J., Lois, M. and Peitz, D.E. 1975. Serological methods .In: Laboratory Techniques in brucellosis.2nded. WHO, Geneva.Pp.64-124.

Ashenafi, F., Teshale, S., Ejeta, G., Fikru, R., and LaikemariamY. 2007. Distribution of brucellosis among Small ruminants in the pastoral region of Afar. Rev Sie. Tech. Off. Int. Epiz, 26(3), 731-739.

Cooper, C.W. 1991. The Epidemiology of human brucellosis in well defined urban population in Saudi Arabia. Journal of Tropical Hygiene 94:416-422.

Crawford, R., Huber, J.D. and Adams, B.S. 1990. Epidemiology and surveillance. In: Nilsson, K. and Dunkan, J. R. (eds), Animal Brucellosis, CRS Press Inc., Florida, pp. 131-148.

Dahoo, I.R., Wright, P.F., Ruckerbauer, G.M., Samagh, B.S., Robertson, F. and Forbes, I.B. 1986. A comparative of five serological tests for bovine brucellosis. Can, J. Vet. Res., 50, 485-493.

Gatenby, R.M. 1991. Sheep, The Tropical Agriculturalist. Macmillan Education Limited, London and Basingstoke, pp.1-2.

Hirsh, D.C and Zee Y.C. 1999. Veterinary Microbiology. Blackwell Science, Cambridge, Massachusetts, pp.196-203.

IBC (Institute of Biodiversity Conservation). 2004. The state of Ethiopia's farm animal genetic resource: country report. A contribution to the first report on the state of the world's animal genetic resources, IBC, May, 2004. Addis Ababa, Ethiopia.

Lapriak. 1982. Latent Bovine Brucellosis. Vet. Record. 3, 578-579.

Livestock Marketing Authority (LMA). 2001. Brief baseline information on Ethiopian livestock resource base and its trade. Livestock Marketing Authority. Addis Ababa, Ethiopia, pp. 1-9.

Melesse B, Sintayehu G, and Alehegne, W. 2006. Epidemiological surveillance of brucellosis in small ruminants of the pastoral areas of Ethiopia. In: Proceedings of Research Projects Completion Workshop, 1-2 February 2007, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia, pp. 220-221, 233.

Nielsen, K. and Dunkan, J.R. 1990. Animal Brucellosis CRS Press INC. Pp 173-179

OIE. 2000. Manual of standards for diagnostic tests and vaccines. 4thed. Paris. Pp.475-481.

Omer, M. K., Asaw, T., Skjerve, E., Teklegiorgis, T., and Woldehiwot, Z. 2002. Prevalence of Antibodies to *Brucella* Spp and risk factors related to high-risk occupational groups in Eritrea. *Epidemiology and infection.* 129, 85-91.

Quinn, P.J., Carter, M.E., Markl, B. and Carter, G.R. 1999. Clinical Veterinary Microbiology. Virginia, by Mos .Pp. 261-267.

Radostitis, M.O., Gay, C.C., Hinchcliff, K.W. and Constable, P.D. 2007. Veterinary Medicine, A Textbook of the Disease of Cattle, Horses, Sheep, Pigs and Goats. 10th ed. London, Baillier and Tindal, pp. 984-987.

Radostitis, O.M., Gay, C.C., Blood, D.C. and Hinchcliff, K.W. 2000. Veterinary Medicine Textbook of Diseases of Cattle, Sheep, Goats, Pigs and Horses, 9th ed., ELBS, Baillier Tindall, London, UK, pp. 870-871.

Radostitis, O.M., Blood, D.C. and Gay, C.C. 1994. Brucellosis caused by *Brucella* spp. In: Veterinary Medicine Textbook of the Diseases of Cattle, Horses Sheep, Pigs and Goats, 8th ed., ELBS, London, Baillier Tindall, UK, pp. 787-812.

Steele, M. 1996. Goats, The tropical Agriculturalist. Macmillan Education Limited, London and Basingstoke, pp.1-2.

Tekleye, B. and Kasali, O.B. 1990. Brucellosis in sheep and goats in central Ethiopia. Bull. Anim. Hith. Prod. Afr. 38, 23-25.

Teshale, S., Muchie, Y., Dagne, A. and Kidanemariam, A. 2007. Sero-prevalence of small ruminant brucellosis in selected districts of Afar and Somalia pastoral areas of Eastern Ethiopia; The impact of husbandry practices. Rev. Vet. Med., pp. 157, 557-563.

Yibeltal, M. 2005. A Sero-prevalence Study of Small Ruminant Brucellosis in Selected Sites of the Afar and Somali Regions, Ethiopia. DVM Thesis, Factuality of Veterinary Medicine, Addis Ababa University, Debre Zeit, Ethiopia.

Zelalem, A. and Fletcher, I.C. 1993. Small ruminant productivity in Ethiopia mixed farming system. In Proceedings, 4th National Livestock Improvement Conference 13-15 November, IAR, Addis Ababa, Ethiopia.

Off take and mortality rate of Washera sheep at Yilemanadensa and Quarit districts of Amhara region, Ethiopia

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Abstract

Small ruminant production has profound value on the livelihoods of Ethiopian smallholder farmers. The study was conducted to examine off take and mortality rate of Washera sheep. Data was collected at Yilemanadensa and Quarit districts from October 2004 to April 2010. Data collected includes animal characteristics (sex, age, color, body weight and body condition), purpose of buyer's, and transaction date. The main sheep disposal reason was sale (65.8%), death (24.1%), slaughter (9.7%) and other (0.4%). There was statistically significant difference among those disposal reasons in terms of proportion of sheep disposed (χ^2 = 2044, P <0.001). Gross average commercial off take rate and mortality rate of sheep were 39% and 14.53%, respectively. Off take and mortality rate was high at Quarit district compared to Yilemadensa district. The highest disposal via sale and death occurred at the age of below one year. This study highlights breed conservation and improvement, fattening, reducing lamb mortality, and culling and fleshing of old ewe.

Key words: Disposal, mortality, off take.

Introduction

Washera sheep population found in the highlands of Western Amhara region, has potential for commercial mutton production for the local as well as export market and relatively high reproductive and productive performances (Mengistie *et. al.,* 2009 and 2011; Solomon *et. al.,* 2008; Chipman, 2003). The most common sheep production system of the study area is the traditional smallholder production system in which sheep are kept as an adjunct to other agricultural activities along with other livestock species. In the traditional smallholder management system the majority of people in the highlands keep small flocks and practice mixed crop-livestock agriculture. In the mixed crop-livestock production system, sheep provide cash income, meat, manure, skin and coarse wool for the smallholder farmers (Markos, 2006).

Based on preliminary survey conducted by DBARC (2002, unpublished), that reported the extant of constraints to exploit potential of the breed, community-based conservation and improvement for washera sheep was initiated including the economic worth of the different non-productive traits in selection for breeding in line Girma *et al*. (2006). Interventions in addressing indigenous breed improvement and small holder market participation need to consider off take and mortality rate with attributes of animals. Therefore, the objective of the study was to examine off take and mortality rate of sheep in the study districts.

Materials and methods

Data collection

Data were collected at Yilemanadensa and Quarit districts for more than five years from October 2004 to April 2010 by enumerators. Sheep disposal data were collected as sold, slaughtered, death and others such as scarification and gifts with its date of disposals on permanently prepared recording sheet. For those animals disposed by selling, animals attributes (sex, age, color, live body weight and body condition) and purpose of buyer's were collected. For those animals disposed by death, only animal attributes that is sex and age were collected. Age was confirmed by birth date if it was recorded or number of teeth withdraws and classified in to six categories. Color was recorded as red, white, red and white, black, and others. Sex was taken as male and female. Body condition was assessed by enumerator and gave score as poor, medium and fat. Purpose of buyer's was found as consumption, resale/profit, reproduction, growing, and others (scarification or fattening).

Data analysis

Descriptive analysis was used to analyze the relationship between the different categorical variables with Statistical Package for Social Sciences version 16.0, (SPSS 2009). Gross commercial off take rate formula employed was in line with Negassa and Jabber (2008).

The formula specified as:

$$Gross\ commercial\ offtake\ rate\ in\ period\ (t) = \frac{sales}{0.5\ (Opening\ stock + Ending\ stock)} * 100$$

Mortality rate estimation method developed by ILCA (1990) was adopted. The formula specified as: $Mortality\ rate\ in\ period\ (t) = \frac{died}{0.5\,(Opening\ stock + Ending\ stock)} * 100$

Result and discussion

Disposal reasons

In the study district, sheep were disposed for different reasons such as sale, slaughter, death, and others. Of the total 2053 disposed sheep, 65.8%, 24.1%, 9.7% and 0.4% were sold, died, slaughtered and others, respectively, and there was statistically significant difference (p <0.001) among the categories of animal's disposal reason. The result shown sale and death that have opposite effect on producer's income were the main reasons of sheep disposals hence the study focused on commercial off take and mortality of sheep (Table 1).

Table 1. Disposal reasons of sheep from the flock.

	Disposal reason										
Study Districts	Total sum	Sold		Slaughtered		Died		Other		χ 2	Sig
		sum	%	sum	%	sum	%	sum	%		
Yilemanadensa	766	527	71.3	101	13.7	110	14.9	1	0.1	884.98	***
Quarit	1315	821	62.5	99	7.5	387	29.4	8	0.6	1221.47	***
Overall	2053	1348	65.8	200	9.7	496	24.1	9	0.4	2044.81	***

***p <0.001, N= Number of observation, % = Percentage.

Offtake rate

Gross commercial off take rate of sheep at Yilemandensa and Quarit district was 39% which is higher than the national figure (Negassa and Jabber, 2008) but lower than sub-Saharan Africa countries (Markos, 2006). Gross average commercial off take rate of sheep was higher at Quarit (45.82%) than Yilemanadensa (32.96%) for the reason limited source of income and/or lesser household income that oblige farmers to supply sheep to the market rather than consuming it.

Sex and age group for sale

Cross tabulation analysis revealed that 58.4% of sheep were sold at the age of less than six months followed by age between six months and one year, 19.4%, regard less of sex categories (Table 2). The number of sheep that are sold decreased as the age of sheep increased. The age of male sheep supplied to the market was less than three years old. The result indicated that mostly farmers supplied young animals (less than one year) for local market which is an important attribute for export market, however, their live weight (<18 kg) without supplementing concentrate does not full fill the minimum requirement of live weight for export market, 30 kg (DBARC,2002, unpublished).

Purpose of buyer's

The proportion of sheep sold for those buyers who have different purpose across study districts was statistically significant difference at p <0.001. From the total transaction, about 45% of sheep were sold for resale purpose which is the predominant purpose of buyer's. As table 3 indicated access to market influenced purposes of buyer's, for instance, 85.9% of sheep at Yilemanadensa were sold for resale purposes while at Quarit only 22.8% (Table 3).

Purpose of buyer's and animal characteristics

As table 4 indicated across all purpose of buyer's, higher proportions of sheep were sold at the age of less than six months. Sex distribution for reproduction purpose was dominated by female in the two districts. While sex distribution for resale and consumption purpose, male was higher at Quarit while at Yilemanadensa female was higher. Regardless of purpose of buyer's, more than 45% of sheep were red and white skin color followed by red skin color (>30%). For each type of purpose of buyer's, 80% and above sheep that sold at Yilemanadensa have medium body condition while at Quarit district 73% and above sheep have fat body condition.

Table 2. Distribution of sex and age group of sale.

Districts and sex group	Total sum	A≤0.5		0.5<A≤1		1<A≤2		2<A≤3		3<A≤4		A>4		χ2	Sig.
		sun	%	Sum	%	sum	%	sum	%	sum	%	sum	%		
Yilemanadensa															
Male	248	180	72.6	59	23.8	8	3.2	1	0.4	-	-	-	-	331.77	***
Female	273	164	60.1	36	13.2	27	9.9	21	7.7	15	5.5	10	3.6	379.46	***
Subtotal	522	345	66.1	95	18.2	35	6.7	22	4.2	15	2.9	10	1.9	973.22	***
Quarit															
Male	360	249	69.2	82	22.8	23	6.4	6	1.7	-	-	-	-	409.89	***
Female	447	183	40.9	80	17.9	66	14.8	42	9.4	39	8.7	37	8.3	209.36	***
Subtotal	811	434	53.5	163	20.1	89	11.0	49	6.0	39	4.8	37	4.6	876.82	***
Male	608	429	70.6	141	23.2	31	5.1	7	1.2	-	-	-	-	740.24	***
Female	720	347	48.2	116	16.1	93	12.9	63	8.8	54	7.5	47	6.5	543.40	***
Overall	1333	779	58.4	258	19.4	124	9.3	71	5.3	54	4.1	47	3.5	1813.05	***

A = Age in year, % = percentage, *** *p*<0.001.

Table 3. Purpose of buyers across the study districts.

Study district	Total sum	Reproduction		Resale		Consumption		Growing		Other		χ 2	Sig.
		sum	%	sum	%	sum	%	sum	%	sum	%		
Yilmanadensa	442	38	5.0	379	85.7	10	2.3	-	-	15	3.4	873.93	***
Quarit	772	297	38.5	176	22.8	198	25.6	98	12.7	3	0.4	316.10	***
Overall	1214	335	27.9	555	45.7	208	17.1	98	8.1	18	1.5	735.93	***

*****p* < .001.

Mortality rate

In the study districts, overall mortality rate of sheep was 14.53%. Mortality rate at Yilemadensa and Quarit district was 21.47% and 6.72%, respectively (Table 5). Sheep mortality at Quarit was threefold higher than Yilemanadensa district given the same health intervention during the study period. Markos (2006) noted that mortality rate of sheep ranges from 8-50%. This implies mortality rate of sheep at Yilemanadensa was so low.

Sex and age group of death

Mortality rate across age categories was inconsistent. Mortality rate (45.4%) was high at the age of less than six months regardless of sex groups. Likewise, mortality for female and male sheep was varied. This is might be because of male sheep sale or slaughter at early age while female rear for long period for breeding purpose. The mortality rate of male sheep (55.6%) and (86.8%) was occurred below six months old age at Yilemandensa and Quarit, respectively. Mortality rate of female sheep (33.7%) was high at the age of less than six months at Quarit district. While at Yilemadensa, higher female sheep mortality (27.7%) was occurred above four years old age. The result revealed that lamb and old ewe was vulnerable group of animals.

Table 4. Cross tabulation of purpose of buyer's with animal characteristics.

Animal characteristics	Reproduction		Resale		Consumption		Growing		Others	
	Yilemanadensa	Quarit	Yilemanadensa	Quarit	Yilemanadensa	Quarit	Yilemanadensa	Quarit	Yilemanadensa	Quarit
	%	%	%	%	%	%	%	%	%	%
Age (N)	39	294	396	175	11	195	-	98	15	3
A ≤ 0.5	41.0	43.5	65.7	69.1	72.7	42.1	-	83.7	73.3	33.3
0.5 < A ≤ 1	20.5	15.6	19.7	20.0	18.2	28.7	-	13.3	13.3	33.3
1< A ≤ 2	20.5	19.4	6.1	4.6	9.1	7.7	-	3.1	6.7	33.3
2 <A ≤ 3	10.3	7.1	4.0	3.4	-	7.2	-	-	-	-
3 < A ≤ 4	-	10.5	3.0	2.3	-	7.7	-	-	6.7	-
A > 4	7.7	3.4	1.5	0.6	-	6.7	-	-	-	-
Sex (N)	39	295	396	176	11	197	-	98	15	3
Male	35.9	8.8	48.0	69.3	45.5	53.8	-	91.8	60.0	66.7
Female	64.1	91.2	52.0	30.7	54.5	46.2	-	8.2	40.0	33.3
Color (N)	39	294	392	174	11	194	-	97	15	-
Red	43.6	26.5	36.5	24.7	27.3	23.2	-	22.7	46.7	-
White	5.1	13.9	8.9	17.2	9.1	12.9	-	16.5	13.3	-
Red and white	46.2	56.8	45.2	50.6	54.5	59.3	-	57.7	33.3	-
Black	-	1.0	1.8	3.4	-	2.6	--	1.0	-	-
Others	5.1	1.7	7.7	4.0	9.1	2.1	-	2.1	6.7	-
Body condition (N)	38	288	342	170	11	195	-	98	15	3
Medium	97.4	13.2	90.0	27.1	100	22.1	-	24.5	80.0	-
Fat	2.6	86.8	10.0	72.9	-	77.9	-	75.5	20.0	100

A = Age in year, N= Number of observation, % = Percentage.

Table 5. Sheep mortality in age and sex wise across districts.

Districts and Sex group	Total sum	Age categories												χ 2	Sig.
		A≤ 0.5		0.5<A≤ 1		1<A≤ 2		2<A≤ 3		3<A≤ 4		A> 4			
		sum	%	sum	%	sum	%	sum	%	sum	%	sum	%		
Yilmanadensa															
Male	27	15	55.6	5	18.5	4	14.8	3	11.14	-	-	-	-	13.74	***
Female	83	17	20.5	10	12	10	12	3	3.6	20	24.1	23	27.7	20.16	***
Subtotal	110	32	29.1	15	13.6	14	12.7	3	2.7	23	20.9	23	20.9	27.02	***
Quarit															
Male	114	99	86.8	13	11.4	1	0.9	1	0.9	-	-	-	-	235.90	***
Female	255	86	33.7	36	14.1	39	15.3	28	11	29	11.8	37	14.5	55.73	***
Subtotal	372	187	50.3	49	13.2	40	10.8	30	8.1	29	7.8	37	9.9	306.71	***
Male	141	114	80.9	18	12.8	5	3.5	1	0.7	3	2.1	-	-	332.58	***
Female	338	103	30.5	46	13.6	49	14.5	31	9.2	49	14.5	60	17.8	54.095	***
Overall	482	219	45.4	64	13.3	54	11.2	33	6.8	52	10.8	60	12.4	294.34	***

A = Age in year, % = Percentage, *** $p<0.001$

Monthly mortality

The prevalence of death across months and between districts was not uniform as indicated in Figure 1. Higher mortality rate of sheep was occurred in January and August at Quarit and Yilemandensa, respectively. And each study district has specific justification. That is high disease prevalence (e.g. Pasteurollosis) and feed shortage at Quarit and Yilemandensa, respectively (personal communication). As the figure indicated,mortality rate was varied during dry and wet season between the study districts. Mortality rate was high at Quarit during dry season (i.e., from December to June) while at Yilemadensa it was high during wet season (i.e., from July to November).

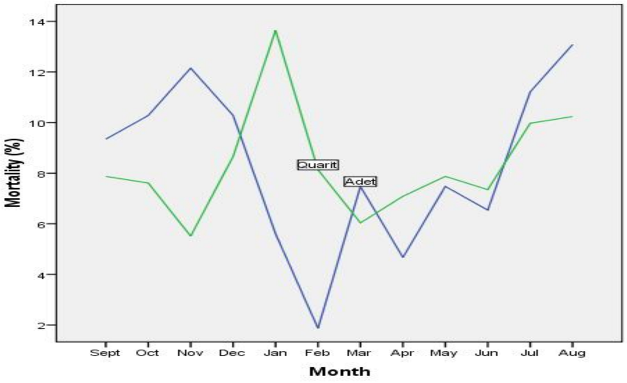

Figure 1. Monthly mortality across the study districts.

Conclusion and recommendation

Commercial offtake rate was high that promotes commercialization process of small holder farmers in the study districts. Both commercial offtake and mortality rate specifically lamb mortality were high at Quarit district compared to Yilemanadensa district. About 45 and 75% of mortality and offtake rate, respectively, was carried out at the age of less than six months. At this age, sheep are preferred for the export markets even if at farmer's management they are below the minimum weight requirement. In contrast, this might have counter effect on selection. Farmers could gain benefit from introducing and promoting of modern sheep fattening technologies together with conservation and improvement of breed. Moreover, reduction of lamb mortality and promotion of culling and fleshing of old ewe practices can enhance the return from sheep production.

References

Asfaw Negassa and Jabbar M. 2008. Livestock ownership, commercial off take rates and their determinants in Ethiopia. Research report 9 ILRI (International Livestock Research Institute), Nairobi, Kenya.

Chipman, J. 2003. Observations on the potential of Dangila sheep for improved food security around Quarit and Adet, West Gojjam, northwestern Ethiopia. A Field Study Hosted by International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

DBARC (Debre Birhan Agricultural Research Centre). 2003. Survey and monitoring of on-farm flocks of Dangila/Washera sheep Types in West Gojjam zone of the Amhara region.

ILCA (International Livestock Centre for Africa) working paper 1. Livestock systems research manual Volume 1, December 1990, Addis Ababa, Ethiopia.

Girma Tesfahun Kassie, Clemens B. A.Wolly, Awudu Abdulai, Adam G. Drucker, and Workneh Ayalew. 2006. Farmer's preferences of phenotypic traits in cattle production and marketing: A case study in central Ethiopia. P.61-70. Institutional arrangements and challenges in market-oriented livestock agriculture in Ethiopia. Proceedings of the 14th annual conference of the Ethiopian Society of Animal production (ESAP) held in Addis Ababa, Ethiopia, September 5-7, 2006.

Markos Tibbo. 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopia Highlands. Faculty of veterinary medicine and animal science department of animal breeding and genetics Uppsala. Doctoral thesis. Swedish university of agricultural sciences. Sweden.

Mengistie Taye, Girma Abebe, Solomon Gizaw, Sisay Lemma, Abebe Mekoya and Markos Tibbo. 2009. Growth performances of Washera sheep under smallholder management systems in Yilmanadensa and Quarit districts, Ethiopia. Trop Anim Health Prod. DOI 10.1007/s11250-009-9473-x.

Mengisite Taye, Girma Abebe, Sisay Lemma, Solomon Gizaw, Abebe Mekoya and Marikos Tibbo. 2011. Reproductive performances and survival of Washera Sheep under traditional Management Systems at Yilmanadensa and Quarit Districts of the Amhara National Regional Stte, Ethiopia. Journal of Animal and veterinary Advances 10 (9):1158-1165.

SPSS for windows, 2009. Statistical Package for Social Science (SPSS). Release 16.0. The Apasche software foundation.

Solomon Gizawa, Aynalem Haile and Tadelle Dessie. 2010. Breeding objectives and breeding plans for subsistence and market-oriented Washera sheep production in Ethiopia. Eth. J. Anim. Prod. 10(1):1-18.

Agricultural knowledge management in dairy production improvement: the case of Bure Woreda, West Gojjam zone, Amhara Region

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Abstract

The government of Ethiopia gives great attention to agriculture and rural development for the country's economy development. Dairy development is one of the components of agricultural development. To improve dairy production in certain locality, dairy producers should be able to access and use appropriate knowledge for the particular problem at the right time. This research was conducted to assess agricultural knowledge management system and its challenges and opportunities in Bure district. To address these objectives, both primary and secondary data were used. These were collected from primary (i.e. dairy producers and experts of different GOs and NGOs using semi-structured questionnaire and checklist) and secondary sources (i.e. literature reviews). To select representative respondents, multi stage sampling techniques were used. SPSS software (version 15) was used to analyze the data which is collected by questionnaire. As survey result, keeping the health condition of animals, feed green pasture to their milking cows, animal selection and using crossbreed cow are the major mechanisms, which are used by dairy producers, to improve the milk production in the district. They obtain these knowledge/mechanisms from WARDO, their own experience, neighbors and family through different means. These are observing the farmer's farm, listening to radio, experience sharing sessions and on-farm demonstrations. Majority of the dairy producers use the new knowledge by doing partial modification. They also transferred their knowledge to their neighbors, friends, relative and children. Therefore, concerned bodies should promote and strengthen the existing good practices in knowledge managements processes.

Key Words: Agriculture, dairy, knowledge.

Introduction

The Government of Ethiopia gives high priority to agriculture and rural development as an engine of pro-poor growth and efforts to enhance agricultural productivity, increase the commercialization of smallholder surpluses and reduce rural poverty are cornerstones of the government's economic growth strategy, i.e. Agriculture Development-Led Industrialization (Spielman *et al*, 2008). Agriculture is pivotal to Ethiopian economy development.

According to Teklu (2008), it contributes on average 46 percent of the real GDP and 85 percent of export earnings, and the sector employs about 85% of the population and about this 85% of the population lives in rural areas and practices subsistence agriculture and livestock production. Therefore, the development of Ethiopian agriculture will have direct impact on the overall development of the country.

Increasing milk production from cattle and buffaloes is a national priority in most developing countries, because milk is one of the most important foods in human nutrition (Devendra, 2007). To do so, the government of developing countries introduced improved exotic breeds into their country. Besides, for a long period, various research activities have been carried out on livestock sectors, particularly in dairy production development, in regional, national and international research institutions to generate knowledge/improved technologies. These generated knowledge/technologies mostly remained in the research centers rather than reaching into the end users.

Among other developmental resources, appropriate knowledge is an important resource. To bring development in dairy production, we need to have the right knowledge and able to utilizing this knowledge at the right time and place. So, developing knowledge management (identification, development, use and sharing of vital knowledge) system is very important in order to accelerate adoption of improved dairy technologies and enhance dairy production and productivity. Therefore, understanding knowledge management of a certain locality will help to develop appropriate researchable and development agendas. Thus this study was conducted to assess agricultural knowledge management system in dairy production and dairy improvement around Bure districts of Amhara Region.

Materials and methods

Description of the study area

Bure is one of the 15th woredas of West Gojjam Administrative Zone of Amhara National Regional State. It is one of the consistently surplus producer woredas of the Region. It is found 400 km northwest of Addis Ababa and 148 km southwest of the Regional State capital, Bahir Dar. It is nearby and connected by all-weather road to East

Wollega Zone of the Oromia Regional State and Metekel Zone of the Benishangul Gumez Regional State (Yigzaw and Kahsay, 2007). Population of the woreda is 169,609 of which 143,854 (85%) live in rural area. The number of agricultural households, 21,793, is about eight times higher than the households in the urban areas (Yigzaw and Kahsay, 2007). The total area of the woreda is 72,739 ha of which 46.6% is cultivated and average household cultivated land holding is about 1.6 ha. At present, the woreda is divided into 22 rural peasant associations (PAs) and two town associations. The annual rainfall ranges between 1386 and 1757 mm. Agro-ecologically, it is classified into moist and wet lowland (10%), wet Woina-Dega (82%) and wet Dega (8%). The altitude of the woreda ranges from 713 to 2604 meters above sea level. Long-term annual mean temperature of Bure ranges from 14 ^{o}C to 24 ^{O}C. The Woreda has three soil types namely Humic Nitosols (63%), Eutric Cambisols (20%) and Eutric Vertisols (17%) (Yigzaw and Kahsay, 2007).

Sampling procedures and methods of data collection

Sampling technique

Multistage sampling technique was used to select representative respondents. According to Adebabay (2009), in Bure woreda there are three milk production systems. These include rural smallholder, peri-urban and urban milk production system. This study was conducted based on these three milk production systems. The list of milk producers of rural, peri-urban and urban milk production system were obtained from the district agricultural and rural development office.

Therefore, first the study area was classified into three dairy production systems based on Adebabay's finding i.e. urban (inside Bure town), peri-urban (around Bure town) and rural (the rural parts of the Bure woreda) dairy productions. Second, from each urban and per-urban milk production system 30 milk producers were selected purposively because of the accessibility and willingness of the respondents. Rural milk production system was further classified into three agro-climate zones. These are lowland, midland and highland. From each agro-climate zones, one kebele was selected purposively based on its dairy production potential and accessibility. Finally, because of the accessibility and willingness of the farmers, 10 farmers were selected purposively from each respective kebeles. Therefore, primary data were collected from 90 dairy producers who are in urban, peri-urban and rural areas; and also from various service providers in the Bure woreda.

Data collection technique

The study was conducted using qualitative and quantitative research design. By doing so, both qualitative and quantitative data were collected. To collect both types of data both primary and secondary sources of data were used. Qualitative data sources were included participant observation (fieldwork), key informant discussion, focal group discussion, reviewing documents and texts. To gather information in the qualitative part, this research typically relied on the analysis of documents and materials. Therefore, extensive related research and literature reasoning were reviewed. In quantitative part of the study semi-structure questionnaire were implemented. To ensure the validity of the questionnaire pre-testing was conducted. Finally, well appropriate semi-structured questionnaire was developed and used for the fieldwork interview.

Data sources

In this study both primary and secondary data were used. Primary data was collected using a multitude of data collection techniques from the dairy producers, extension workers, researchers and others which are working on dairy production development in the woreda. Secondary data was collected from the woreda Agricultural and Rural Development office's annual and quarter reports, different research findings, MIPS's documents, documents of milk cooperative etc.

Data analysis

Once the raw data was collected, quantitative and qualitative methods of data analysis were employed. Descriptive statistical tools such as frequency tables, percentages, graph, mean and standard deviation were used to describe the data. To test the difference among the subsystems on a certain variable, both t-test and chi-square statistical tools were used. Then based on the information obtained from data analysis, generalizations about the population were made. For data analysis SPSS (version 15) software was used. For the data gained through key informant interview and unstructured interviews qualitative analysis was applied.

Result and discussion

Knowledge management on dairy production

In the study area, farmers who are engaged in dairy production try to find solution for their dairy production problems by themselves and were able to acquire adequate experience/knowledge on dairy production management. They acquired this experience/knowledge from different sources, through different means, utilize in different forms, shared to other dairy producers. The details of these KM process in the study area are illustrated in the following subchapters of this paper.

Farmers' mechanism to improve milk production

Majority of the respondents (89.9%) believe that keeping the health condition of their animal is the most important mechanism to improve milk production and 79.8% of the respondents feed green pasture to their milking cows, 66.3% of the respondents exercise animal selection, and 46.1% of the respondents use crossbred cow to improve milk production (Table 1) in their dairy farm.

In the study area, few respondents also used concentrate animal feed (43.8%), give special treatment to milking cow from its calving stage (21.3%) and increase number of milking cow (15.7%) as mechanisms to improve milk production in their dairy farm. In the contrary, only two respondents (one from peri-urban and rural subsystems) do not use any mechanisms to improve their milk production in their dairy farm.

As Table 1 shows, some of the mechanisms have statistically significant different across subsystems in improving milk production in the district. Some mechanisms such as using improved crossbred cow, feeding green pasture and keeping animal health mechanism show statistically significant difference ($p<0.01$) and feeding concentrate animal feeds to milking cow also showed statistically significant difference ($p<0.05$) across the sub systems. In the contrary, mechanisms of animal selection, increasing number of milking cows and giving special treatment to milking cow from its calf stage didn't show statistically significant difference across the subsystems.

Table 1. Frequency distribution of the respondents on mechanisms of milk production improvement.

Mechanisms to improved milk production		Sub system Urban	Peri-urban	Rural	Total	Test value (x^2)	Sig.
Improved crossbred cow	N	23	9	9	41	17.56	***
	%	25.8%	10.1%	10.1%	46.1%		
Concentrate animal feed	N	18	8	13	39	6.79	**
	%	20.2%	9.0%	14.6%	43.8%		
Green pasture	N	29	27	15	71	22.95	***
	%	32.6%	30.3%	16.9%	79.8%		
Keep animal health	N	30	28	22	80	11.7	***
	%	33.7%	31.5%	24.7%	89.9%		
Animal selection	N	23	19	17	59	2.76	NS
	%	25.8%	21.3%	19.1%	66.3%		
Increase number of milking animal	N	6	4	4	14	0.68	NS
	%	6.7%	4.5%	4.5%	15.7%		
Give special treatment for cow from its calf stage	N	14	2	3	19	17.75	NS
	%	15.7%	2.2%	3.4%	21.3%		
Nothing to do	N	0	0	1	1	1.1	NS
	%	.0%	.0%	1.1%	1.1%		
Total	N	30	30	29	89		
	%	33.7%	33.7%	32.6%	100.0%		

***, **, and * statistically significant at 1%, 5%, and 10% probability level, respectively. NS = statistically not significance.

Farmers' sources of knowledge for dairy production improvement

The major sources of knowledge on dairy production in the study area are *Bure* woreda Agricultural and Rural Development office (BWARDO) (54.7%), their own experience (46.5%), neighbors (33.7%), family (32.6%), radio (27.9%) and friends (26.7%) (Table 2). Radio (20.9%), TV (18.6%), farmers' experience (17.4%) are the major sources of knowledge for dairy producers in urban subsystems, while BWARDO, farmers' experience and neighbors are the major sources of knowledge for both peri-urban and rural dairy producers. No respondents in the rural dairy production systems use research centers, TV, reading material and formal education as source of knowledge on dairy production improvement (table 2). Some of the sources of knowledge such as TV, radio, and reading materials show statistical difference ($p<0.01$) across the subsystems and college of agriculture as source of knowledge was statistically different ($p<0.05$) across the subsystem. The other sources of knowledge were not statistically different across the subsystems.

Table 2. Source of knowledge on dairy production improvement.

Farmers' source of knowledge	Subsystems						Total		Test value (X^2)	Sig.
	Urban		Peri-urban		Rural					
	N	%	N	%	N	%	N	%		
Her/ his own experience	15	17.4	11	12.8	14	16.3	40	46.5	1.17	NS
Family	8	9.3	9	10.5	11	12.8	28	32.6	0.73	NS
Neighbor	10	11.6	10	11.6	9	10.5	29	33.7	0.10	NS
Friends	8	9.3	8	9.3	7	8.1	23	26.7	0.12	NS
Community Elders	2	2.3	0	0.0	4	4.7	6	7.0	4.29	NS
Research Centers	1	1.2	1	1.2	0	.0	2	2.3	1.02	NS
BWARDO	13	15.1	17	19.8	17	19.8	47	54.7	1.43	NS
TV	16	18.6	0	0.0	0	0.0	16	18.6	38.9	***
Radio	18	20.9	3	3.5	3	3.5	24	27.9	25.57	***
NGOs/IPMS	2	2.3	2	2.3	1	1.2	5	5.8	0.42	NS
Reading material	9	10.5	0	0.0	0	0.0	9	10.5	20	***
College of agriculture	3	3.5	0	0.0	0	0.0	3	3.5	6.21	**
Total	29	33.7	30	34.9	27	31.4	86	100.0		

***, **, and * statistically significant at 1 %, 5 %, and 10 % probability level, respectively, NS= statistically not significance.

Means of access to knowledge on dairy production

In the study area majorities of the respondents can access to knowledge on dairy production through observing the farmer's farm (61.7%) and followed by listening to radio (29.6%), experience sharing sessions (24.7%), on-farm demonstrations which were arranged by BWARDO or IPMS or both (21%), watching TV (19.8%) and training 14.5% (table 3). There were also other means through which dairy producers can access to knowledge on dairy production improvement. Some of them are visiting research center (6.2%), technology exhibition (3.7%), and attending formal agricultural education (2.5%).

In the urban dairy production system, majorities of the respondents accessed to knowledge on dairy improvement through listening to radio (22.2%), TV (19.8%) and observing the farmers' dairy farm (18.5%), whereas majorities of dairy producers in peri-urban dairy subsystem access to knowledge through observing farmers' farm (24.7 %) and experience sharing sessions (7.4%). In rural subsystem, the majority dairy producers access to knowledge through observing the farmers' farm (18.1 %), listening to radio (7.2%) and experience sharing sessions (6.0%) (Table 3).

Table 3. Means through which dairy producers can access to knowledge on dairy production improvement.

Means of knowledge getting		Subsystems			
		Urban	Peri-urban	Rural	Total
Observing the farmer's farm	N	15	20	15	50
	%	18.5%	24.7%	18.5%	61.7%
On-farm demonstration	N	9	3	5	17
	%	11.1%	3.7%	6.2%	21.0%
Visiting research center	N	0	2	3	5
	%	.0%	2.5%	3.7%	6.2%
Technology exhibition	N	1	0	2	3
	%	1.2%	.0%	2.5%	3.7%
Experience sharing sessions	N	9	6	5	20
	%	11.1%	7.4%	6.2%	24.7%
Watching TV	N	16	0	0	16
	%	19.8%	.0%	.0%	19.8%
Listening to radio	N	18	3	3	24
	%	22.2%	3.7%	3.7%	29.6%
Training	N	5	4	3	12
	%	6.2%	4.9%	3.7%	14.8%
Formal agricultural education	N	2	0	0	2
	%	2.5%	.0%	.0%	2.5%
Reading	N	9	0	0	9
	%	11.1%	.0%	.0%	11.1%
Tota	N	29	29	28	86
	%	33.7%	33.7%	32.6%	100%

Knowledge utilization on dairy production improvement

Majorities of dairy producers in *Bure* district are modifying new knowledge on dairy production improvement when they use it. As Table 4 shows, majority dairy producers (50.6%) use the new knowledge by partially modifying, 40.2% of dairy producer use the new knowledge as it is and only 11.5% of the respondents use the new knowledge by totally modifying based on their own farming system. In the study area, the overall nature of knowledge utilization in all dairy production systems is the same but its proportion is varying among dairy production subsystems.

Table 4. Frequency distribution of the respondents on knowledge utilization.

			Knowledge utilization			
			Knowledge utilization as it is	Partial modification	Totally modification	Total
Dairy production systems	Urban	N	10	16	4	29
		%	11.5%	18.4%	4.6%	33.3%
	Peri-urban	N	13	14	3	30
		%	14.9%	16.1%	3.4%	34.5%
	Rural	N	12	14	3	28
		%	13.8%	16.1%	3.4%	32.2%
Total		N	35	44	10	87
		%	40.2%	50.6%	11.5%	100.0%

Knowledge transfer

Majorities of dairy producers (88.9%) transfer their new dairy production improving knowledge to other dairy producers (Table 5). There is no statistically significant difference among the subsystems in knowledge transferring. 28.9%, 31.1% and 28.9% of the respondents of the urban, peri-urban and rural dairy producers, respectively, transfer their knowledge to other dairy producers.

Majorities of the respondents transfer their knowledge to their neighbors (94.9%) and followed by friends (74.7%), relative (69.6%) and children (40.5%). There is no statistically significant difference in the persons to whom knowledge is transferred among subsystems, except transferring to children (Table 5).

Table 5. Frequency of distribution of individuals to whom the respondents transfer their knowledge.

			Sub system				Test value (X^2)	Sig.
			Urban	Peri-urban	Rural	Total		
Knowledge transferring	Yes	N	26	28	26	80	0.9	NS
		%	28.9%	31.1%	28.9%	88.9%		
	No	N	4	2	4	10		
		%	4.4%	2.2%	4.4%	11.1%		
Dairy producers transfer knowledge to	Friends	N	18	21	20	59	0.69	NS
		%	22.8%	26.6%	25.3%	74.7%		
	Children	N	8	9	15	32	4.17	**
		%	10.1%	11.4%	19.0%	40.5%		
	Relative	N	14	20	21	55	4.02	NS
		%	17.7%	25.3%	26.6%	69.6%		
	Neighbor	N	24	27	24	75	1.44	NS
		%	30.4%	34.2%	30.4%	94.9%		
Total		N	25	28	26	79		
		%	31.6%	35.4%	32.9%	100.0%		

** = statistically significant at 5% probability level and. NS = statistically not significance

Farmers' means of knowledge transferring

Dairy producers can transfer their knowledge to other dairy producers through different means. There is no statistical significant difference in all farmers' means of knowledge transferring across the subsystems in the study area (Table, 6). Majorities of the respondents (80.2%) transfer their knowledge to other dairy producers through informal discussion and followed by experience sharing (29.6%) and allowing farmers to visit their own dairy farm (25.9%). Only few respondents (2.5%) transferred their knowledge through written materials, 100% of them were used in the urban subsystem.

Table 6. Farmers' means of knowledge transferring.

Respondents' means of knowledge transferring		Subsystems			Total	Test value (X^2)	Sig.
		Urban	Peri-urban	Rural			
Allow the farmers to visit my own dairy farm	N	6	8	7	21	0.37	NS
	%	7.4%	9.9%	8.6%	25.9%		
Informal discussion	N	22	23	20	65	0.78	NS
	%	27.2%	28.4%	24.7%	80.2%		
Experience sharing	N	9	7	8	24	0.34	NS
	%	11.1%	8.6%	9.9%	29.6%		
Through written material	N	2	0	0	2	4.09	NS
	%	2.5%	.0%	.0%	2.5%		
Total	N	26	28	27	81		
	%	32.1%	34.6%	33.3%	100.0%		

NS = statistically not significance.

Conclusion and recommendation

In the district, there are three dairy production systems. The study was conducted based on these subsystems differences. In the study area, keeping the animal health condition, feeding green pasture to milking cow, animal selection and using crossbreed cow are the major mechanisms which are used to improve milk production. Dairy producers can access to such kinds of knowledge from different sources such as Agricultural and Rural Development office, their own experience, neighbor, family, radio and friends. In urban dairy production system, majorities of the respondents use radio, TV, farmers' experience as source of knowledge on dairy production. Whereas, in both peri-urban and rural dairy production subsystems, the major sources of knowledge are BWARDO, their own experience, neighbors, family and friends.

In the study area majorities of the respondents accessing knowledge on dairy production through observing the farmer's farm, listening to radio, experience sharing sessions, on-farm demonstrations which were arranged by BWARDO or IPMS or both, watching TV, and training. In the urban subsystem, majority dairy producers are accessing knowledge through listening to radio, watching TV and observing the farmers' dairy farm. Whereas, in rural and peri-urban subsystems, observing the farmers' farm, listening to radio and experience sharing are the major means of access to knowledge on dairy production improvement.

Dairy producer use the new knowledge by partially modifying in accordance with their farming system. Some of dairy producers use the new knowledge as it is which comes from other sources. Only very few respondents use the new knowledge by totally modifying which can fit to their farming systems. Either before or after utilizing the knowledge they can transfer their knowledge to other dairy producers. Majority of dairy producers transfer their knowledge to their neighbors, friends, relative and children via informal discussion, experience sharing and allowing farmers to visit their own dairy farm.

Dairy producers in the study area face different problems in accessing as well as transferring knowledge. Inadequate technology, poor delivery system, complex nature of the technology and long distance of knowledge source are the major problems of the farmers for accessing knowledge on dairy production improvement. Alike the hindering factors in accessing knowledge, the major problems in transferring new knowledge to other dairy producers are also lack of adequate knowledge/ improved dairy technology, lack of awareness and even the dairy producers themselves are not interested to transfer their knowledge.

Since in the study area has three dairy production systems, any planning on dairy production development should be carried out based on the nature and characteristics of the dairy subsystems in order to avoid blanket recommendation and able to transfer appropriate dairy technologies to the right farming system.

To avail important knowledge for dairy producers in the study area, government and non government body should approach the local community through the existing knowledge management system and then further efforts should be taken to transfer the existing knowledge management system into technology based knowledge management system. In the study area efforts should be made to improve the availability of health service in terms of quality and quantity in all dairy subsystem by encouraging private sectors to involve in the sector.

To alleviate concentrate feed shortage, government should design good strategy to encourage and support the available milk cooperatives to involve in input supplying system for dairy production. For this *Bure Damot* milk cooperative can take the leading role in solving the problems. Local government and planer should design the strategy in which College of Agriculture and Research Centre around in the study area to involve in dairy production development process.

References

Adebabay Kebede. (2009).Characterization of Milk Production Systems, Marketing and On-Farm Evaluation of the Effect of Feed Supplementation on Milk Yield and Milk Composition of Cows at Bure District. Bahir Dar University. Master thesis.

Devendra C. (2007). Constraint Analysis To Improve Integrated Dairy Production Systems In Developing Countries: The Importance Of Participatory Rural Appraisal. Springer Science.

J. Spielman D., K. E. Davis, M. Negash, & Gezahegn Ayele. (2008). Rural Innovation Systems and Networks. IFPRI Discussion Paper 00759. International Food Policy. www.ifpri.org

Teklu Tesfaye. (2008). Ethiopia Review of Bank Group Assistance to the Agriculture and Rural Development Sector. Operations evaluation department. African development bank group.

Yigzaw Desalegne and Kahsay Berhe. (2007). Bure Pilot Learning District Diagnosis and Program Design. Unpublished

Phenotypic characterization of Northwestern highland goat in West Gojjam Zone of Amhara Region, Ethiopia

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Abstract

The study was conducted in four districts of west Gojjam zone of Amhara National Regional State with objectives of characterizing the phonotypic characteristics of North Western Highland Goat in the area. The study was conducted by observing and recording of goat qualitative characters, by measuring and recording body weight and linear body measurements. Four hundred thirty two mature male and female animals and 37 morphological variables were used. Different procedures of Statistical Package for Social Science was used to assess the effect of sex and location on the morphological traits and body weight of the animal and also to analyze both the morphological and body weight data. Sex of the goat had a significant effect ($p<0.05$) on all quantitative traits except ear length and on all qualitative traits except the presence/absence of ruff and beard. Females had smaller mean values of body weight, chest girth, height at wither, body length, ear length and pelvis width than males. Most males have ruff and beard while most females are without ruff and beard. Location had no significant effect ($p>0.05$) on all quantitative and qualitative traits. It was concluded that goat types of the area are phenotypic ally characterized by large goat breed type (Mean height at wither 71.8±0.29 and 69.9±0.14 cm for buck and for doe, respectively); long-eared (Mean ear length 15.5±0.05 and 14.9±0.02 cm for buck and for does, respectively), and with dominant white plain coat colour.

Key words: Characterization, phenotypic, Northwestern.

Introduction

Goats form an important component of the livestock system, in all agro-climatic zones of Ethiopia and have a variety of functions for the owner (Alemayehu Reda, 2003). Although goats' contribution to the economic well being of the small holder farmers is significant, these animals have never been a subject of much attention for research and development (Jansen, 1996). Despite the large size of the country goat population and their high apparent potential, the productivity per unit of animal and the contribution of this sector to the national economy is relatively low (Alemayehu Reda, 2003). One of the main factors which contribute for this is low genetic potential of the available local breed. Therefore, there is a need in the improvement of the genetic potential of the animal which in turn improves the productivity of the animal. This activity involves identification, classification and characterization of the breeds or strains of livestock under village condition (Kosgey and Okeyo, 2007).Thus, this study was aimed at phenotypic characterization of Northwestern highland goat in West Gojjam administrative zone, in their respective environments.

Materials and methods

The study areas

The study was conducted in four (Semen Achefer, Mecha, Gonji kulela, and Bahirdar Zuria) districts of West Gojjam Administrative Zone, Amhara National Regional State. According to the respective Woreda Office of Agriculture and Rural Development (WOARD, 2001) of the four districts, the four districts are located within longitude of 15º 16’N and latitude of 37º 29’E with altitude ranging from 700 to 2635 meter above sea level (m a.s.l). The temperature in the areas is as high as 35 ^{O}C and as low as 10 ^{O}C (WOARD, 2001). The study area has uni-modal rainfall pattern and the rainy season extends from end of May to the end of September. The predominant farming system is mixed crop-livestock production.

Data collection and management

Four representative districts (study areas) mentioned above and three peasant associations from each selected districts (Semen Achefer: Sankira, Kunzilla, and Denbola; Mecha: Andinet, Goragot, & Bachimma; Gonji kulela:Woyzazirt, Zegansa and Wolekea and from Bahirdar Zuria: Zemochinazelanbet, Majdebrenigist and Achader) were selected purposively. Data on phenotypic characteristics were collected from 432 mature animals using 37 breed descriptor variables (discreet and continuous variables).

The discreet variables include coat colour pattern, coat colour type, head profile, horn shape, horn orientation, hair type, ear form, ruff, wattle, and beard. Data on the discrete variables were collected using the pre-coded format through rapid observation of each sampled goat (Workneh and Rowlands, 2004). Continuous variables such as mature body weight (BW); body length (BL); chest girth (CG); wither height (WH); pelvic width (PW); ear length (EL). Data on the mature body weight was taken using the prepared format and 100 kg x 500 g Salter weighting balance suspended from a portable tripods where as data on the linear body measurements were collected using the prepared format and 2 m x 10 cm tailors measuring tape (Workneh and Rowlands, 2004). In each peasant associations, one goat flock was taken to collect information on phenotypic characteristics of the animal. Each experimental animal was identified by sex, site and flock number. Finally, the data collected from each site was checked for any mistake, coded and entered into the computer for further analysis.

Data analysis

Data analysis was done separately for different data types. The linear body measurement and body weight data were analyzed using the General Linear Model/Least-square mean procedure of statistical package for social science (SPSS, version 16) where as the qualitative morphological data using the frequency occurrence procedure. Cross tabulation procedure/Pearson chi-square test was employed to test the effect of sex and location (district) on the qualitative trait while the General Linear Model (GLM) procedure was employed to test the effect of sex and location on linear body measurements and body weight, separately. The model for GLM for different linear body measurements and body weight is as follows

$$Y_{ijk} = \mu + S_i + L_j + e_{ijk}$$

Where, Y_{ijk} = the observed k (body weight or linear body measurements in the i^{th} sex and j^{th} location; μ = overall mean; S_i = the effect of i^{th} sex (i= intact male or female); L_j = the j^{th} location effect (j = 1, 2, 3 or 4); e_{ijk} = random residual error.

Results and discussion

The Phenotypic characteristics of goats in the study area were observed, recorded and measured for both female and male sample population separately. The least square means and standard errors of the quantitative and the frequency occurrences of the qualitative characters were extracted from the sample goat population. The analysis of variance for the effect of sex and location on the quantitative traits and the chi-square test of the qualitative traits for the effect of sex and location showed no significant phenotypic variations between the different goat types in the different locations or districts ($p>0.05$) but there was a significant morph metric variation between the different goat types in female and male population ($p<0.05$).

Figure1. Buck (Right) and Doe (Left).

The frequency of occurrences of the qualitative traits for female sample population

Three patterns of coat colour were observed and recorded with 52.02 % plain, 34.43% patchy, and 13.55% spotted. White plain (50.18%), Arda (21.98%), and Sora (15.75%) were the dominant coat colour types frequently observed from the female sample population. Three variations of hair types were observed at frequencies of 80.59% for smooth and short hair, 12.82% for fur with hairy thighs and 6.59% for fur with hairy on abdomen and back. The head profile ranged from markedly concave through straight to convex but it was mostly concave (56.41%). Ear form varied between horizontal, semi-pendulous and forwarded. They have mostly horizontal and semi-pendulous ears. There is no any hairy goat observed in all the study sites since hairy goats are usually found in the highlands. Horn scurs observed not only in the kids but also in mature male and female goats. Almost all female goats in the population were without ruff and only 7.33% had ruff which indicated that the presence of ruff is the typical characteristics of male goat. The frequency occurrence of the qualitative traits for female sample population is presented in Table 1.

The frequency occurrences of the qualitative traits for male sample population

Out of 159 male goats, 50.94% were with plain, 33.96% patchy and 15% spotted coat colour patterns. White plain (45.28%), Arda (19.5%), Sora (16.35%) and plain red were the major coat colour types frequently observed from the male sample population. Three variations of hair types were observed at frequencies of 72.96% for smooth and short hair, 17.61% for fur with hairy thighs, and 9.43% for fur with hairy on abdomen and back. Nearly 56.6% of the male population had concave head profile while 25.77% had straight head profile and the rest had convex head profile.

Table 1. The frequency occurrences of the qualitative traits for female sample population.

Character and Attribute	N	%	Character and Attribute *(Horn shape contu)*	N	%
Coat colour Pattern			Curved	100	36.63
Plain	142	52.02	Spiral	13	4.76
Patchy	94	34.43	Overall	273	100
Spotted	37	13.55	Horn Orientation		
Overall	273	100	Backward	165	60.44
Coat colour Type			Upward	69	25.27
White	137	50.18	Scurs	23	8.42
Arda	60	21.98	Pooldness	16	5.86
Sora	43	15.75	Overall	273	100
Red	14	5.13	Ear form		
Mendile	12	4.4	Horizontal	138	50.55
Black	7	2.56	Semi-pendulous	72	26.37
Overall	273	100	Forward	63	23.08
Head profile			Overall	273	100
Concave	154	56.41	Ruff		
Straight	70	25.64		20	7.33
			Present		
Convex	49	17.95	Absent	253	92.67
Overall	273	100		273	100
			Overall		
Hair type			Beard		
short & smooth	220	80.59		71	26.01
			Present		
hairy thighs	35	12.82	Absent	202	73.99
Hairy abdomen	18	6.59		273	100
			Overall		
Overall	273	100	Wattle		
Horn shape				37	13.55
			Present		
Straight	160	58.61	Absent	236	86.45
				159	100
			Overall		

N = Number of mature female goats with that particular trait *Arda* = Red plain coat colour on white dominant or vis-versal, *Sora*= Mixture of red and black in spotted form on white dominant plain, *Mendile* = White plain coat colour on black dominant or vis-versa.

The predominant ear form observed in above 49.69% of the sample population was horizontal and semi-pendulous. Horn shape was mostly either straight (52.2%) or curved (42.14%) with obliquely upward (20.75%) or backward (62.89%) oriented. Pooledness and presence of wattle is also observed among some goats. Most males have ruff and beard while most females were without ruff and beard which indicated that the presence of ruff and beared is the typical characteristics of male goat. The major qualitative traits of male population are presented in Table 2.

Table 2. The frequency occurrences of the qualitative traits for male sample population.

Character and Attribute	N	%	Character and Attribute *(Horn shape contu)*	N	%
Coat colour Pattern			Curved	67	42.14
Plain	81	50.94	Spiral	9	5.66
Patchy	54	33.96	Overall	159	100
Spotted	24	15	Horn Orientation		
Overall	159	100	Backward	100	62.89
Coat colour Type			Upward	33	20.75
White	72	45.28	Scurs	16	10.06
Arda	31	19.5	Pooldness	10	6.27
Sora	26	16.35	Overall	159	100
Red	14	8.81	Ear form		
Mendile	9	5.66	Horizontal	79	49.69
Black	7	4.40	Semi- Pendulous	43	27.04
Overall	159	100	Forward	37	23.27
Head profile			Overall	159	100
Concave	90	56.60	Ruff		
Straight	41	25.77	Present	125	78.62
Convex	28	17.61	Absent	34	21.38
Overall	159	100	Overall	159	100
Hair type			Beard		
short & smooth	116	72.96	Present	114	71.70
hairy thighs	28	17.61	Absent	45	28.30
Hairy abdomen	15	9.43	Overall	159	100
Overall	159	100	Wattle		
Horn shape			Present	30	18.87
Straight	83	52.20	Absent	129	81.13
			Overall	159	100

N = Number of male goats with that particular character state.

The head profile with Arsi-bale & Western highland goats (Hailu *et al.*, 2006) and Southern Ethiopia goat types (Workneh Ayalew, 1992); Hair type with central highland goats (Hailu *et al.*, 2006; Tesfaye *et al.*, 2007); Coat colour pattern with western highland & lowland goats, Central highland goats (Hailu *et al.*, 2006; Tesfaye *et al.*, 2007) and Southern Ethiopia goat types (Workneh Ayalew, 1992); Coat colour type with Hararghe highland goats, Short- and long-eared Somali goats and Western lowland goats (Hailu *et al.*, 2006); Horn shape and orientation with Arsi-bale and Central highland goats, Keffa goats, Short- and long-eared Somali goats, Western highland & lowland goats (Hailu *et al.*, 2006); The presence/absence of beard and ruff with Central highland goats, Western highland and lowland goats and Keffa goats (Hailu *et al.*, 2006); The presence/absence of wattle and pooldness with Arsi-bale goats, Central highland goats, Keffa goats (Hailu *et al.*, 2006) and Southern Ethiopia goat types (Workneh Ayalew, 1992); Ear form of goat types in the study area is concurrent with ear form of Long-eared Somali goats, Western highland and lowland goats (Hailu *et al.*, 2006). The frequency occurrences of the qualitative traits obtained in the study is concurrent with the reports of different authors for different goat breeds/types which indicated that the northwestern highland goat types are qualitatively similar with the above mentioned goat types by different authors.

Body weight (kg) and linear body measurements

The least square means (LSM)±standard errors (SE) of body weight (kg) and linear body measurements (cm) for the effects of sex and location of the female and male sample population are summarized in Table 3. The fixed effects of sex and location were considered. The overall mean body weight, body length, height at withers, and chest girth were 32.7±0.15kg, 48.2±0.17cm, 70.6±0.17cm, and 78.5±0.22cm, respectively. The overall mean ear length and pelvis width were 15.08±0.03 cm and 14.4±0.07 cm, respectively.

The overall mean body weight, body length, height at wither, and chest girth obtained in this study were concurrent with the previous findings obtained in those reported by Nigatu Alemayehu (1994) for Central highland, Western low land and Western high land female goats which suggests that the similarity in quantitative character between the North western highland goats (NWH goat) and Central highland female goats, Western low land and Western high land female goats. The linear body measurements used for estimation of the body weight of NWHgoat can be also used for body weight estimation of Central highland female goats, Western low land and Western high land female goats.

Table 3. Least square means ± standard errors of body weight (kg) and linear body measurements (cm) for the effect of sex and location.

Effects and level	Body weight	Body length	Chest girth	Wither height	Pelvic width	Ear length
	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	32.7±0.15	48.2±0.17	78.5±0.22	70.6±0.17	14.4±0.07	15.08±0.03
CV%	21.79	12.94	5.68	3.98	9.14	22.48
Sex	*	*	*	*	*	NS
Male	40.6±0.3	55.3±0.31	81.9±0.41	71.8±0.29	15.4±0.15	15.5±0±.05
Female	28.1±0.14	44.1±0.16	76.4±0.21	69.9±0.14	13.9±0.07	14.9±0.02
Location	NS	NS	NS	NS	NS	NS
Achefer	34.4 ±0.20	49.1 ±0.23	79.3 ±0.29	71.0 ±0.21	14.8 ±0.09	15.1±0.03^{a}
Mecha	33.8 ±0.23	48.9 ±0.26	78.7 ±0.30	70.3 ±0.25	14.3±0.10	14.3±0.04^{b}
Gonji	34.1±0.32	50.1 ±0.35	79.7 ±0.42	71.2 ±0.34	14.8±0.16	15.6±0.06^{b}
B/ zuria	33.9±0.24	49.4±0.24	79.2±0.25	70.6±0.26	14.6±0.11	15.4±0.06^{b}

*Significant at 0.05, Ns = Non significant.

The average body weight for male population is (40.6±0.29kg) heavier than the average body weight of western low land male goat (35.5±0.20 kg) but almost equal to the average body weight of central high land male goat (41.3±0.31 kg) (Nigatu Alemayeh, 1994). The average height at wither was also higher than the average height at wither for western low land male goat but lower than the average height at wither for western high land male goat and it is close to the average height at wither for central high land male goat (Nigatu Alemayehu, 1994). The same is true for the average chest girth. According to the classification of goat based on height at wither suggested by (Devendra and Burns, 1993), goat types of the study area are classified as large breed goat types. The heavier body weight obtained is partly due to the higher chest girth and height at wither which contribute the higher proportion of the bones and muscles at the chest cavity.

Both the average ear length and pelvis width were higher than the reports of Nigatu Alemayehu, (1994) for goat types of north-western Ethiopia which ranges from 12.01±0.05 to 14.4±0.07 cm. According to the classification of goat based on ear length (Nigatu alemayehu, 1994), goat types of the study area are classified as long-eared goat types.

Effect of sex and location on qualitative traits

In the analysis of the effect of sex and location on the qualitative traits, the fixed effects of location and sex were considered.

Location Effect: Location (district) did not exert a significant source of variation in all qualitative traits (P>0.05) which indicated that goat types of the area are qualitatively similar.

Sex Effect: Sex of the animal did not exert a significant (p>0.05) influence on all the qualitative traits except the presence/absence of ruff and beard. Most males have ruff and beard while most females are without ruff and beard which indicated that the presence of ruff and beard are the typical characteristics of male goat (Table 4).

Table 4. Chi-square test of the qualitative traits for the effect of district and sex.

		Test	
Traits	Source of variation	X^2	P-value
Coat color pattern	District/Location	20.75	0.575
	Sex	3.05	0.877
Coat color type	District/Location	6.88	0.098
	Sex	4.29	0.077
Head /Facial profile	District/Location	.144	.996
	Sex	0.008	0.945
Presence or absence of wattle	District/Location	6.97	.102
	Sex	2.17	0.142
Presence or absence of beard	District/Location	5.93	.383
	Sex	85.47	<0.000
Presence or absence of ruff	District/Location	16.01	.377
	Sex	228.48	<0.000
Ear form	District/Location	0.041	0.890
	Sex	0.017	0.896
Horn shape	District/Location	7.18	.646
	Sex	1.52	0.217
Horn orientation	District/Location	8.19	.159
	Sex	1.30	0.996
Hair type	District/Location	4.33	.112
	Sex	3.39	0.082

Conclusions and recommendations

Goat types of the area are phenotypic ally characterized as large goat breed types with mean height at wither 71.8±0.29 and 69.9±0.14 cm for buck and for doe, respectively; long-eared with mean ear length 15.5 ± 0.05 and 14.9±0.02 cm for buck and for does, respectively, and have predominantly concave facial profile. Their body is mostly covered by smooth and short hair. The most observed coat colour pattern is plain followed by patchy and spotted. The predominant coat colour type observed and recorded were white plain followed by plain red colour in some parts on white plain dominant or vis-versal (*Arda*), a mixture of red and black in spotted form on white dominant plain (*Sora*), and plain red colour. Both males and females have horns and the horns are mostly straight and oriented back ward. Polledness, scurs and presence of wattles were also observed among some goats. In general, females had smaller mean values of body weight, chest girth, height at wither, body length, ear length and pelvis width than males. Most males have ruff and beard while most females are without ruff and beard. Emphasis should be given on the economic importance of the qualitative traits.

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References

Alemayehu Reda. 2003.Characterisation (Phenotypic) of Indigenous Goats and Goat Husbandry Practices in East and South-Eastern Ethiopia. MSc thesis, Alemaya University of Agriculture, Ethiopia. 135 pp.

Carl Jansen. 1996. Goat keeping in the tropics. Agrodok-series No.7.

Devendra, C., and Burns, M. 1983. Goat production in the Tropics. Common wealth Agricultural Bureaux, Farnham House, slough, UK. 1983. 183pp.

Hailu D., Meiso G., Nigatu, A., Fufa D.,and Gemeda D. 2006.The effect of environmental factors on preweaning survival rate of Borana and Arsi-Bale Kids. Small ruminant research 66: 291-294.

Kosgey, L.S. and Okeyo A.M. 2007. Genetic improvement of small ruminants in low input, smallholder production systems: Technical and infrastructural issues. Small Ruminant Research 70: 76-88.

Nigatu Alemayehu. 1994. Characterization of Indigenous Goat Types of Eritrea, Northern and Western Ethiopia. MSc thesis, Alemaya University of Agriculture, Alemaya, Ethiopia. 136 pp.On 22 Sept, 2008.

Tesfaye Getachew, Sisay Lemma, Dereje Taddese, Abebe Mekoya and Solomon Gizaw. 2007. On-farm monitoring of growth and reproductive performance of Central highland goats in North-shewa. Amhara Agricultural Research Institute, Debreberhan Agricultural Research Center, Ethiopia.

Woreda Office of Agriculture and Rural Development. 2001. Semen Achefer, Mecha, Gonji kulela and Bahirdar Zuria.

Workneh Ayalew and J. Rowland. 2004. Design, execution, and analysis of the livestock breed survey in Oromiya Regional State, Ethiopia. OADB (Oromiya Agricultural Development Bureau). Addis Ababa, Ehtiopia, ILRI (Internatyional Livestock Research Institute), Nairobi, Kenya.

Workneh Ayalew. 1992. Preliminary Survey of Indigenous Goat Types and Goat Husbandry Practices in Southern Ethiopia. MSc thesis, Alemaya University of Agriculture, Alemaya, Ethiopia. 153 pp.

INSTRUCTION TO AUTHORS

Authors are requested to pay special attention to the instructions given below for preparation of their manuscript.

1. **Content of the paper**

The papers should be organized in the following manner:

a) **Title:** The title should be concise but informative. Not more than 13 words.

b) **Author(s)** name(s), and the name(s) and address(s) of the center/institution(s) where the work was carried out should follow the title.

c) **Abstract:** The abstract should be condensed to a maximum of 200 words and should be intelligible by it self. It should have objectives, methodologies, results, and a conclusion in a single paragraph.

d) **Introduction:** This section of the manuscript should indicate the explanation or fundamental hypothesis on why the study or the research was conducted. Gaps found in previous related literatures and objectives should also be stated.

e) **Materials and methods:** Description of the environment, materials used, procedures followed, experimental design and statistical analysis applied are briefly explained here. Year of accomplishment should also be indicated. This has to enable others to repeat one’s experiment.

f) **Results and discussion**: *Result*-is the core of the paper. Simply and clearly stated presentation of what is found with the investigation as related to what is stated in the introduction part. It includes un repetitive presentation of representative data. *Discussion*- should explain what the result means and its practical significance and implication for future study. Discusses whether it agrees or disagrees with previously published work. Based on this conclusions are stated with evidence and recommendations can be given for follow up.

g) **Acknowledgments:** Acknowledgments, if any, may be given immediately following results and discussion section very briefly.

h) **References:** Only publications cited in the text should be given in the references. All literatures cited should be closely relevant to the author’s work. Exhaustive list should be avoided, not more than 10 except under special condition.

References should be arranged in alphabetical and chronological order (from older to recent). Checking the accuracy of references is the responsibility of authors. In the text, references should be presented in the author-year style. E.g. (Tan, 1978) or Tan (1978); (Lim and Aziz,1979) or Lim and Aziz (1979). When there are three or more authors (Tan *et a*l.,1979) Tan *et al*., (1979).

References should be listed according to the following format. *Note*: names of Ethiopian authors are written fully.

Journal Article

Mabbayad, M.O. and Moody,K. (1985). Improving butachlor selectivity and weed control in wet -seeded rice. *Journal of Plant Protection in the Tropics* 2(2): 117-124.

Beyene Chichaibellu, Coppock, C.E. and McDowell R.E.(1977). Laboratory evaluation and estimation of nutritive values of some Ethiopia feedstuffs. *J. Assoc. Adv. Agric. Sci Africa* 4(2):9-23.

Book

Quinn, G.P., and Keough M.J (2002). Experimental design and data analysis for biologists. Cambridge university press, Cambridge.

Edited works (Chapter in a book or paper in a proceedings)

Loegering, William Q. (1984). Title of the chapter/paper . P. 165-192. *In* William R. Bushnell and Alan P. Roelfs (eds.) title of the book/the proceedings Academic Press, Orlando, Florida.

Un Published reports

Huxley, P.A.(1986) Rationalizing research on hedgerow intercropping: an overview. ICRAF Working Paper 40. Nairobi:ICRAF. P66-75.

Personal communications are not included in a reference list. They are simply listed in the text as: (Anthony Youdeowei, Pers.comm.) or simply as (personal communication).

2. The format

The manuscript has to be typed on one side only, double spaced on A4 sized paper and margins of 25, 30, 35 and 25 mm on top, bottom, left and right margins respectively. The font type has to be *times new roman* through out . The font size of the text has to be 12 unless an otherwise specified below. Scientific names have to be written following standard binomial nomenclature.

Except under special recommendation, the manuscript should not be more than 3500 words excluding illustrations. Or totally a maximum of 5-7 pages.

The title of the manuscript has to be bold and centered, only the first letter written in upper case except under special condition. Author(s) name(s) and the institution to which they are affiliated should be written centered with font size of 10. Main Headings (introduction, materials and methods etc) should be left justified and bolded starting with capital letter. Sub-headings are typed alike the main headings but they are italicized and are not bolded. Figures and illustrations should be in a form suitable for edition and reproduction. They have to be black and white and with high contrast.

Tables should be numbered consecutively as Table 1, Table 2, etc., in the order in which they are first cited in the text. Each table, with its heading, should be typed on a separate sheet A table should be self explanatory and concise. Table-footnotes should be marked with superscript * (asterisk) and the foot note has to be italicized with font size of 10.

Authors are advised not repeat information in the text presented in the tables or in charts or graphs. Submission of un manageable and oversized tables may lead to rejection.

All measurements must be reported SI units or metric system. Negative exponentials, like Kg ha^{-1} are recommended in stead of writing as Kg/ha. Point has to be used for decimal as 10.5 to say ten point five. Every three digits have to separated by space as 10 556. Abbreviations or short hand forms have to be first fully spelt out before they are used in abbreviated/shorthand form in the rest part of the text. The ISO designation for

Ethiopian currency is ETB and this has to be used whenever the currency is expressed. Gregorian calendar should be used for dates, months and years.

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Two hard copies of manuscript should be submitted to the respective directorates or secretaries of the respective editorial committees not latter than 45 days after the papers are presented on the conference. The range includes time required for postal transfer. Soft copy should be submitted with in the same time on diskette or as attachment to e-mail.

4. Correspondence

Where a paper has joint authors, one author must accept responsibility for all correspondence. The Editorial committee or the institute shall take no responsibility for the loss of the manuscripts in the process of mailing. The authors are advised to retain copies of their submission.

5. Editorial Committees

Each directorate has its own editorial committee (for crops, livestock and natural resources management research that includes forestry, soils and water management and agricultural mechanization). Each editorial committee is led by the head of the respective directorate. All the three editorial committees are accountable to the deputy director general of the institute in order to maintain uniformity in the publication of proceedings and to monitor the overall activities of the annual conference and its regular implementation. The final decision on the papers presented is made by the respective editorial committees taking into consideration the inputs from the participants during the annual conference. Accepted papers will be further evaluated and commented by senior reviewers and sent back to the authors for corrections. The final editorial work will be done by members of the respective editorial committee which will be made ready for printing.