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Evaluation of Replacement of Conventional Protein Supplements with Cowpea (Vigna Unguiculata) and Alfalfa (Medicago sativa) Hay on Milk Yield and Milk Composition of Lactating HFxArsi Crossbred Cows fed maize stover as basal diet

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Abstract

*The study was conducted at Adami Tulu Agricultural Research Center to evaluate the effect of substitution of conventional protein supplements with cowpea and alfalfa hays on milk yield and milk composition of HF x Arsi crossbred cows fed maize stover as basal diet. Five cows of similar parity but different body weight and milk yield were arranged in 5*5 Latin square design (LSD). The animals were given concentrate mixes of 61% wheat bran + 38% LSC+1% salt (T1); 59% wheat bran + 40% noug seed cake + 1% salt (T2); 60% wheat bran + 39% alfalfa + 1% salt (T3); 61% wheat bran + 38% cowpea + 1% salt (T4); and 70% wheat bran+20% CSC + 9%NSC+1% salt (T5). The mean crude protein intake (CPI) was higher (P<0.05) for cows fed T1 and T2 followed by T4 and T5. Metabolizable energy intake was high in forage supplied groups than cows supplemented with conventional protein sources. Milk yield was significantly high (P<0.05) in cows supplemented with T5, followed by those supplemented with T4. Treatment effects were also significantly affected (P<0.05) milk fat and milk protein contents. Cows in T5 gave the highest net benefit (Birr 76.06 per cow/day), followed by cows in T4, T3 and T2, while cows in T1 gave the lowest net benefit (Birr 39.55.71 per cow/day). Thus from the present study, it can be concluded that alfalfa and cowpea hay can, both biologically and economically, replace protein supplements (Except CSC) without significant reduction in milk yield while improving the fat in the milk of crossbred dairy cows fed basal diet of maize stover.*

Key words: milk yield, milk composition, alfalfa, cowpea, crossbred cows

Introduction

Inadequate nutrition in terms of quantity and quality is one of the major constraints limiting livestock production in Ethiopia (Adugna, 2007; Berihanu *et al*., 2009). The ruminants in the smallholder sector in the country depend on natural pasture and fibrous crop residues for their survival, growth, reproduction and production. Natural pastures and crop residues are characterized by high fiber (>55%), low crude protein (<7%) and metabolizable energy (ME) contents (Zewudie *et al*., 2011; Girma *et al*., 2014). Consequently, their intake level is limited and they hardly satisfy even the maintenance requirements of animals.

Previous research results have indicated that improved fodder species generally have higher herbage yield potential. In addition to their productivity, most of the improved forage crops are also nutritionally superior to that of natural pasture and crop residues (Alemayehu and Getnet, 2012). They also have a long growing season and help to extend the green feed period so as to provide useful nutrients mainly in rural areas where availability and accessibility of agro-industrial by products is limited. Moreover, improved fodder crops especially the legumes can complement crop production through maintaining soil fertility via fixation and accumulation of nitrogen and also help to prevent soil erosion and replenish degraded land when integrated into natural resource management schemes (Getnet *et al*., 2016).

Cowpea (*Vigna unguiculata)* is an annual legume grown throughout the semiarid tropics, where it is valued as both human and livestock food. It is drought tolerant, can be grown on relatively poor soils, and fixes nitrogen, thereby improving soil fertility. In addition to grain, cowpea can produce good yields of fodder for ruminant feeding systems.

Alfalfa is a perennial forage legume known for its high forage quality and positive effects on soil fertility (Campiglia *et al*., 1999). It was also reported to withstand long periods of water deficit by impeding its vegetative growth (Annicchiarico *et al*., 2010) and accessing water from depth through its deeper root system (Volaire, 2008). The current and projected decrease of agricultural water resources further implies the persistently growing interest for water saving forage production strategies through introducing drought tolerant forage legumes such as alfalfa.
Therefore, the objective of this study was to evaluate the effect of replacement of protein supplements with cowpea and alfalfa hay without affecting voluntary feed intake, feed conversion ratio and milk yield and composition of lactating HF x Arsi crossbred cows fed maize stover as basal diet.

Objectives

- To evaluate the effect of replacement of conventional protein supplements with cowpea and alfalfa hay on milk yield and milk composition of HF x Arsi crossbred cows
- To evaluate the profitability of replacement of conventional protein supplements with cowpea and alfalfa hays.

Materials and Methods

Description of the Study Area

The study was conducted at Adami Tullu Agricultural Research Center (ATARC) which is located at 167 km south of Addis Ababa, Ethiopia, at an altitude of 1650 meter above sea level. The center is situated at latitude of 7° 9N and 38° 7E longitude. The soil type is fine, sandy loam with sand, clay in the proportion of 34, 48 and 18%, respectively. The average soil pH is 7.88 (as cited by Assefa *et al.*, 2012).

Experimental Animals and Management

A total of five HF x Arsi crossbred cows were used for the experiment. Experimental cows with similar (first) parity, at early stage of lactation but different body weight and milk yield, were selected for study purpose. All cows were weighed and treated with a broad-spectrum anti-helminthics (Albendazole 2500 mg) prior to start the experiment. The calves were separated from their dams seven days after parturition and managed under bucket feeding condition. The cows were placed in an individual pen and stall-fed in a house with concrete floor. The cows were hand-milked twice daily at approximately 12-hour intervals in milking room.

Feed Preparation and Feeding

Cowpea (*Vigna unguiculata*) acc.No.87D-1802 and Alfalfa (*Medicago sativa*) Magna 788 hay were produced on ATARC Dairy Research Team's experimental site. The forages were harvested at 50% flowering stage, dried and stored. Maize stover was also chopped and used as a basal feed throughout the experimental period. The quantity of concentrate mix offered daily was at the rate of 0.5 kg/liter of milk produced by each cow and offered with equal portions during the morning and evening time. The amounts of cowpea and Alfalfa given were calculated based on the amount of CP in the concentrate diet making the feeds iso-nitrogenous. Representative and composite samples of all experimental feeds were taken for laboratory analysis.

Experimental Design and Treatments

At the beginning of the experiment, five cows were randomly assigned in a switch over 5*5 Latin square design. There were five periods each consisting 30 days. During the first 15 days of each period, animals were acclimatized to the experimental diet and the remaining 15 days were used to collect data. Hence, the experiments took 150 days; being started in May 2017 and finished in October, 2017. The experimental animals were initially randomly allotted to one of the five dietary treatments given below. The animals were given concentrate mixes of 61% wheat bran + 38% LSC+1% salt (T1); 59% wheat bran + 40% noug seed cake + 1% salt (T2); 60% wheat bran + 39% alfalfa + 1% salt (T3); 61% wheat bran + 38% cowpea + 1% salt (T4); and 70% wheat bran+20% CSC + 9%NSC+1% salt (T5).The treatments were:

T1: Maize stover + Wheat bran + LSC + Salt

T2: Maize stover + Wheat bran + NSC + Salt

T3: Maize stover + Wheat bran + Alfalfa hay + Salt

T4: Maize stover + Wheat bran + Cowpea hay + Salt

T5: Maize stover + Wheat bran + CSC + NSC + Salt

Feed intake, body weight change and milk yield and composition

The basal feed was offered *ad-libitum* for those animals feeding concentrate only and given additionally for animals feeding forage hays. The quantity of concentrate mix offered daily was at the rate of 0.5 kg/liter of milk produced by each cow and it was offered with equal portions during the morning and evening milking. Adjustments for concentrate offer was made at the end of each period and for each treatment based on the actual milk produced. The amounts of Cowpea and Alfalfa hay given was depending on the percentage of crude protein and metabolizable energy in the concentrate feed and equivalent CP contents were adjusted depending on the nutrient in the formulated concentrate mix and nutrient in the Cowpea and Alfalfa hays. Feed offered and refused was measured and recorded for each cow to determine daily feed and nutrient intake. Experimental animals were offered water twice a day throughout the experimental period.

The cows were hand milked twice a day at 6:00AM and at 6:00PM, starting the 7^{th} day post calving. The daily milk yield data of individual cows was measured using a graduated plastic cylinder of 1000ml. About 100 ml milk samples in the morning and afternoon was taken every two weeks during the experiment from each cow after the milk was thoroughly and gently mixed. The afternoon milk samples were kept in a refrigerator at 4^oC overnight. Both morning and afternoon milk samples were transported with an ice box at 4^oC to Hawassa University dairy laboratory. In laboratory morning and afternoon milk samples of each cow was pooled for chemical analysis.

Feed sampling and chemical analysis

Feed samples were analyzed for DM and Ash using the standard procedures of AOAC (1990). Nitrogen (N) content was determined by Kjeldahl method and Crude Protein (CP) was calculated as N*6.25 (AOAC, 1995). The organic matter was calculated as difference between 100 DM and ash content. Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Neutral Detergent Fiber (NDF), and *In vitro* Digestible Organic Matter in the Dry Matter (IVDODM) was determined by the modified Tilley and Terry method (Van Soest and Robertson, 1985). Metabolizable Energy (ME) content of a particular feed was estimated from IVDOMD and as per the following equations:

ME (MJ/kg DM) = 0.015*IVDOMD (g/kg) (MAFF, 1984**).**

Partial Budget Analysis

A simple partial budget analysis was conducted by using marginal analysis of dietary treatments cost based on calculation of the total cost of supplement feed and the basal diets. Milk sales price and labor cost incurred during the entire experimentation process were also considered. The milk price was fixed based on the prevailing milk price in the study area. The prices of the maize stover and ingredients used to form concentrate mix were obtained from the current market price during the experimental period. The price of Cowpea and Alfalfa hays were fixed based on the opportunity cost of land if used for major crop in the area including production costs.

Statistical Analysis

Voluntary DM and nutrient intakes, milk yield and compositions, and digestibility were subjected to GLM procedure for Latin Square Design using Statistical Analysis System SAS, 2002). Treatment means were separated using Least Significant Difference (LSD). The models used for the analysis of data were: $Y_{ijk}=\mu + B_i + P_j + T_k + E_{ijk}$, Where; μ=Overall mean; Bi= body wt effect; P_j= Period effect; E_{BiPi}= Experimental error.

Results and Discussion

Chemical Composition of Experimental Feeds

The DM content was almost similar for all ingredients used in the present study Table1. The OM content was relatively higher in CSC and wheat bran, followed by LSC and least in cowpea hay. The neutral detergent fiber concentration showed much variation with the highest value recorded for maize stover followed by CSC and cowpea hay, respectively.

Table 1. Chemical composition and nutritive value of feeds used to feed HF x Arsi crossbred cows

Feeds offered	DM	OM	CP	NDF	ADF	Lignin	ME (MJ Kg^{-1} DM)	IVDMD%	Ca	P
Linseed cake	92.8	91.5	29.8	25.1	9.52	5.2	10.04	67.1	0.4	0.19
Noug seed cake	92.2	89.08	32.1	34.7	26.7	7	9.5	63.0	1.08	0.21
Cotton seed cake	92.5	94.2	34.5	65.1	31.0	6.7	8.9	60.5	0.2	1.09
Wheat bran	90.5	95.7	17	38.2	9.4	2.54	11.7	77.8	0.17	0.82
Alfalfa hay	89.9	89.4	18.66	37.7	21.5	5.6	13.1	87.35	-	-
Cowpea hay	88.9	86.5	18.5	60.7	53	13.6	10.5	70.1	-	-
Maize stover	91.8	90.8	7.3	72.5	45	6.6	8.4	56.3	-	-

Cotton seed cake, Noug seed cake and Linseed cake have higher CP concentrations relative to maize stover. All conventional protein sources (CSC, NSC and LSC), Cowpea and Alfalfa hays have CP contents greater than 15%, a level that is usually required to support lactation and growth (Norton, 1982). The low levels of NDF in linseed cake, wheat bran and Alfalfa hay are indicative of high cell soluble matter. Crude protein content of cottonseed cake used in this study was lower than the expected value of above 36%, and it was similar to the value for whole cottonseed reported elsewhere (Smith *et al.*, 1981; NRC, 1989), which might be due to mechanical methods used for oil extraction. The IVDMD of cowpea hay (70.1%) observed in the current study is greater than 55-60% reported by Solomon and Kibrom (2014) for different accession of cowpea and similar with 72.1% reported by Tesfaye *et al*., (2016). The difference might have resulted from the variations in Cowpea accession used in the present trial. The IVDMD of Alfalfa hay lies within the range of 84.55 – 87.5% IVDMD reported by Geleti *et al*., (2014) for different Alfalfa accessions. Based on chemical and digestibility values suggested by Singh and Oosting (1992), both forage hays used in the present study can fully replace the conventional protein supplements. Thus, there is an enormous potential for cowpea and alfalfa hay to be used as a supplement to low quality basal feeds.

Dry Matter and Nutrients Intakes

Dietary treatments were significantly ($P<0.05$) affected nutrient intakes of experimental cows Table 2. Total replacement of conventional protein supplements with cowpea and alfalfa hay had significantly ($P<0.05$) increased total DM intake over cows received noug seed cake and linseed cake.

Table 2. Mean (±SE) dry matter and nutrient intakes of HF x Arsi crossbred cows fed *ad libitum* of maize stover and supplemented with Cowpea and Alfalfa hay as a replacement to protein sources.

Parameters	Treatments					SL
	T1	T2	T3	T4	T5	
Dry matter intake						
TDMI (kg/day)	$6.5\pm0.0.2^{b}$	5.3 ± 0.42^{c}	6.5 ± 0.29^{b}	6.91 ± 0.52^{a}	7 ± 0.36^{a}	*
DMI (%BW)	2.5±0.24	2.6±0.32	2.7±0.47	2.8±0.25	2.5±0.28	ns
Nutrient intake						
OM (kg/d)						
CP (kg/d)	1.3 ± 0.26^{a}	1.3 ± 0.48^{a}	1.17 ± 0.36^{d}	1.25 ± 0.25^{b}	1.19 ± 0.37^{c}	*
ME (MJ/d)	48.7 ± 0.52^{e}	66.9 ± 0.89^{c}	81.7 ± 0.35^{a}	71.1 ± 0.32^{b}	52.9 ± 0.28^{d}	*

$^{a-e}$ means within rows having different superscript are significantly different at; (*) = $P<0.05$; SL = significance level; SE = standard error; ns = not significant; TDMI = total dry matter intake, BW= body weight; CP = crude protein; ME= metabolizabe energy.

The mean crude protein intake (CPI) was higher ($P<0.05$) for cows fed T1 and T2 followed by T4 and T5. The lower crude protein intake was observed in T3. The overall CPI was higher than the projected CP requirement (ARC, 1990). Addition of forage legume to a basal diet of low nitrogen content will increase the nitrogen content of the total diet, which in turn is likely to increase feed intake and the rate of degradation of the basal diet in the rumen (Tesfaye *et al*., 2016 2012).

The highest MEI (81.7 MJ/cow/day) obtained for T3 is below the estimated daily ME (97.6 MJ/head/day) requirement of lactating cows weighing 400 kg and producing 8-10 kg milk (ARC, 1990). Total ME intake across all the treatments were sufficient to meet the daily requirement for ME of cows with a mean daily milk yield of 6.54 liter in the present trial. Metabolizable energy intake was high in forage supplied groups than cows supplemented with conventional protein sources.

Milk Yield and Composition

Milk yield was significantly high ($P<0.05$) in cows supplemented with T5, followed by those supplemented with T4. There was no significant difference ($P>0.05$) in milk yield among animals supplemented with T1, T2 and T3. The observed difference for milk yield between the treatments groups might be related to the amount of CP and ME intakes of animals.

Treatment effects were also significantly affected ($P<0.05$) milk fat and milk protein contents. The value of milk protein is high due to the amount of protein intake. The value of milk fat is also high because of the amount of roughage intake is high since roughage and milk fat has positive correlation. The high level of fat reported in this study (Table 3) compared to other studies for poor quality basal feeds supplemented with forage legumes (Mpairwe, 1998) were probably associated with higher and better utilization/intake of dietary fiber (Table 2) from which the precursor for mammary lipid synthesis is derived (Susmel *et al*., 1995).

Table 3. Milk yield and composition of the experimental cows

Variables	Treatments					SL
	T1	T2	T3	T4	T5	
Milk yield (kg/d)	6.41 ± 0.25^{b}	6.63 ± 0.44^{b}	6.59 ± 0.55^{b}	6.72 ± 0.47^{ab}	7.47 ± 0.15^{a}	*
Milk fat (%)	4.54 ± 0.008^{b}	4.85 ± 0.005^{b}	5.39 ± 0.24^{a}	5.26 ± 0.05^{a}	4.5 ± 0^{b}	*
Milk Protein (%)	3.02 ± 0^{a}	2.83 ± 0.004^{c}	2.9 ± 0^{b}	2.77 ± 0^{d}	2.77 ± 0^{d}	*
SNF (%)	13.21 ± 0.26	13.18 ± 0.02	13.92 ± 0.32	13.72 ± 0.25	13.25 ± 0.38	ns

Partial Budget Analysis

The economic feasibility of this study was analyzed using partial budget analysis approaches. According to this analysis, cows in T5 gave the highest net benefit (Birr 76.06 per cow/day), followed by cows in T4, T3 and T2, while cows in T1 gave the lowest net benefit (Birr 39.55.71 per cow/day) (Table 4).

Table 4. Partial budget analysis for the experimental cows

Variables	Treatments				
	T1	T2	T3	T4	T5
Milk yield (kg/cow/d)	6.41	6.63	6.59	6.72	7.47
Gross benefit (ETB /cow/d)	128.2	132.6	131.8	134.4	149.4
Cost of LSC ((ETB/cow/d)	26.25	-	-	-	-
Cost of NSC (ETB/cow/d)	-	20.46	-	-	3.85
Cost of wheat bran (ETB/cow/d)	20.4	20.35	17.88	19.44	18
Cost of Alfalfa hay (ETB/cow/d)	-	-	18.84	-	-
Cost of cowpea hay (ETB/cow/d)	-	-	-	15.1	-
Cost of CSC (ETB/cow/d)	-	-	-	-	11.49
Cost of Maize stover (ETB/cow/d)	4	4	2	2	2
Other costs (ETB /cow/d)	3	3	3	3	3
Labor cost (ETB /cow/d)	35	35	35	35	35
Total variable cost (ETB /cow/d)	88.65	82.81	76.72	74.54	73.34
Net benefit (ETB cow/d)	39.55	49.79	55.08	59.86	76.06

ETB = Ethiopian Birr

Generally, those cows supplemented with CSC, alfalfa and cowpea hay with basal diet of maize stover optimize both biological and economic benefits as compared to cows consumed other treatment rations. In general, it can be understood from the present trial that if farmers establish and use cowpea and alfalfa hay, the net benefit of dairy producers can be improved through improving milk yield and milk fat contents of dairy cows.

Conclusion and Recommendations

The daily DM intake were significantly ($P<0.05$) differed among the treatments with the highest intake observed when cows were fed cowpea hay (T4) followed by alfalfa (T3) and T2 (LSC). Apparent DM digestibility of T3 (87.35%) was higher than T5 (60.05 %). Milk yield was significantly high ($P<0.05$) in T4 and T5 whereas, no significant difference ($P>0.05$) was observed in milk yield among the dietary treatments of T1, T2 and T3. This implies that alfalfa and cowpea hay can totally replace conventional protein supplements without any significant reduction in milk yield but improve the fat composition of milk of dairy cows. The results of the present study lead to acceptance of the fact that cowpea and alfalfa hays can be a significant intervention protein supplements in a small scale dairy farms in association with maize stover. Furthermore, from the present study, it can be concluded that alfalfa and cowpea hay can both biologically and economically replace protein supplements (Except CSC) without significant reduction in milk yield while improving the fat in the milk of crossbred dairy cows fed basal diet of maize stover. However, there is a need for further study at on farm level to determine the acceptance of these improved forages by dairy producers.

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On Station Performance Evaluation of Borana Cattle under Rangeland Conditions of Borana Zone, Southern Oromia, Ethiopia

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Abstract

The study was conducted at Yabello Pastoral and Dry land Agriculture Research Center to evaluate the performance of Borana cattle breed and suggest appropriate husbandry practices. The mean birth weight was 22.81±0.34 kg for males and 21.02±0.36 kg for females, and the average weaning weights at 7 months was 102.07±1.26 kg for males and 93.81±1.16 kg for females. Mean yearling weight for male and female was 141.52±1.74 kg; and 126.28±1.67 kg, respectively. Moreover, the 24-months live body weight was 203.08±2.41 kg for males and 185.17±2.38 kg for females. Average age at the first calving and calving interval was 48.39±1.41 and 17.91±1.01 months, respectively. The overall average calving rate of Borana cows was calculated to be 69.45±11.59%. The mean lactation milk yield was 440.98±23.38 L with average 210 days of lactation length. The result indicated that promising growth, reproductive and milk production performances of Borana cattle breed in its native niche are favorably comparable in the literatures to Borana cattle breed evaluated in the other parts of Ethiopia. However, shortage of feed throughout dry season was a major constraint during animal performance evaluation and less productivity of the animals was recorded in this season. Therefore, dry season based feed supplementation is a paramount suggestion to evaluate the production potential and improve the production and reproductive performance of the breed.

Keywords: Borana cattle, Growth, Milk production, Range condition, Reproduction

Introduction

Ethiopia has the largest livestock population in Africa and home to a variety of indigenous cattle breeds. The population of indigenous cattle breeds was estimated to be about 56.71 million heads (CSA, 2015). Livestock production constitutes to be an important sub-sector of the agricultural production in Ethiopia, contributing 45% of the total Agricultural Gross Domestic Product (IGAD, 2010).

In Ethiopia, the reported per capita consumption of milk and meat is 16 L and 13.9 kg/year, respectively; being lower than the African and the world per capita averages which are 27 and 100 kg/year, respectively (Yilma *et al*., 2009). These per capita consumptions are also below the average reported for the Sub-Saharan Africa (EEA, 2005). In the country, the productivity of indigenous cattle breeds is low. However, they acquired the merits of adapting to different harsh environmental conditions due to thousands of years of natural selection (e.g. heat tolerance, resistance to diseases. In addition, they have the ability to thrive long periods of feed and water shortages (Baker and Gray, 2004) and such conditions greatly differ between locations and production systems.

Cattle are certainly the most important livestock species among the Borana pastoralists (Coppock, 1994). Borana cattle are originated in Borana rangeland and have unique traits that make them suitable for the harsh environment in the low lands and have ever been part of pastoralists (Hailemariam *et al*., 1998). Borana cattle are superior to most of the highland breeds and recommended as one of most suitable breed of cattle for arid and semiarid regions of the world (Hailemariam *et al*., 1998). Research works in the highland region of crop live-stock mixed farming system showed that the Borana cattle are predominantly serving as dam line in most small holder dairy cross breeding programmes (Hailemariam *et al*., 1998) and the breed was evaluated for its performance in different parts of the country.

Growth performance of an animal at various stages of the growth directly influences profitability in beef production systems (Newman and Coffey 1999), carcass weight (Pariacote *et al*., 1998), reproductive and milk production traits (Burrow 2001). The expression of these traits is dependent on the animal's inherent growth ability and production environment (Davis 1993). They also form the basis of selection in many of the genetic improvement programs due to their early expression and ease of measurement.

Reproductive traits describe the animal's ability to conceive, calve down and suckle the calf to weaning successfully (Davis 1993). These traits are important since they affect the herd size and off take. The traits regularly considered include age at first calving, calving interval and calving rate. The efficient of reproduction is very important for productivity of dairy cattle and it is mainly depends on reproductive performance (Washburn *et al*., 2002). The milk production of dairy cattle also depends on genetic and environmental factors. Besides their genetic factors, the performance of dairy animals is affected by various environmental factors and these factors may suppress the true genetic abilities of those animals.

Evaluation on performances of Ethiopian indigenous cattle breeds was conducted in different places and time. Results showed that birth weight of Ogaden 21.5±0.29 kg (Getinet *et al.,* 2009) and Horro 17.2±2.25 kg (Demissu *et al.,* 2013) were stated. Weaning weight 91.7±1.67 kg for Ogaden breed (Getinet *et al*., 2009), and 99.9±3.92 kg (Asheber 1991) and 100.9±0.8 kg (Giday 2001) for Fogera cattle breed were recorded. Moreover, age at first calving of 51.8±0.72 (Tesfa *et al*., 2016), 52.4±0.17 (Almaz 2012) and 52.3±1.77 (Belay, 2014) months for Fogera cattle breed and 32.8±0.9 months for Arsi breed (Enyew *et al*., 1998) were reported.

Evaluation and improvement program on the Borana cattle should have been placed in the Borana area, where the people can relate to the breed. Attempt to evaluate and improve the Borana cattle would have directly benefits the Borana people themselves (Azage, 2003). Different scholars reported that the Borana cattle breed was evaluated in different research center for its performance in different times. However, Borana cattle breed have never been evaluated for its performance in its own environmental condition. Therefore, this study was designed to evaluate the performance and suggest appropriate husbandry practices for Borana cattle breed.

Materials and Methods

Description of Study Area

The study was conducted in Borana zone at Yabello Pastoral and Dry land Agriculture Research Center. The center is located about 568 km South of Addis Ababa on Addis-Moyale road. The Borana plateau, the portion of the Southern Ethiopia rangelands, comprises an area of about 95,000 km^2 which is about 14.6% of the lowland areas or about 8.5% of the country's total area, the climate is generally semi-arid with annual rainfall range of 500 mm in the South and 700 mm in the North, the altitude ranges from 1000m in the South to 1500m in the Northwest, the rainfall is bimodal but erratic in distribution. Fifty –nine percent (59%) of annual precipitation occurs from March to May and 27% from September to November, annual mean daily temperature varies from 19 to 24^oC. There are four major seasons identifies the Borana plateau. These include: (1) - Ganna (March-May), the long rainy season; (2) Adoolessa (June–August), the cool dry season; (3)-Hagayya (September- November), the short rainy season; and (4) Bona (December-February), the warm dry season (Coppock, 1994).

Borana Cattle Breed

Borana cattle is predominantly distributed in the semi-arid and arid areas of Southern Ethiopia, There are two sub-types of the Ethiopian Borana cattle, namely the large framed Qorti and the smaller framed Ayuna/Geleba (Reda, 2000; Zander and John, 2004; Edea *et al*., 2006). Though, there is no any accurate estimation of population size, there is a general concern of genetic erosion of the Borana cattle of Qorti sub-type. Crossbreeding or replacement with highland cattle, change in ecology and lack of breed development programs were some of the major reasons for the genetic erosion or dilution (Zander and Drucker, 2008). Borana breed is large Ethiopian cattle known for its fast growth, high milk yield, heavy muscling, high degree of heat tolerance, resistance to ticks, feed and water shortage that needs calm environment, but the Ethiopian highland cattle breeds (small body size) are poor in these traits. Basically, Borana breed is a beef animal, with large and wide frame; it is also a good milk animal providing most of the staple for the pastoral community. Among local cattle populations, Borana cattle breed is recommended as one of the most suitable types of cattle for arid and semi-arid regions of the world (Haile-Mariam *et al*., 1998; (Ojango *et al*., 2006).

Acquisition and Experimental Animal Management

Thirty heifers and three bulls of Borana cattle breed were purchased from Did-tuyura ranch so as to ensure that they were unrelated to each other in order to avoid or minimize inbreeding. During purchasing, all animals were identified (by ear tag) and their history and pedigree information were recorded from the record keeping of the breeding program at the ranch. All animals were treated against internal and external parasite following acquisition, and all kept separated both during day and night so that there is no interbreeding.

The feeding program of the experimental animals was based on natural grazing. Hay was conserved and provided when there was drought, but if the drought situation was critical, concentrate and limiting minerals (salt) supplementation afternoon after grazing or morning before grazing was used. Experimental animals were allowed to graze freely during the daytime from 8:00 AM to 4:00 PM and sheltered in the barn during night time. The source of water was the pipe water. Mating of the herd was natural mating in which each bull mated to an average of 15-20 identified cows during breeding time. The bull was allowed to run with cows for two months. Mating was designed to have birth during the main rainy season (March/April) and short rainy season (September/October) when there is enough forage. Experimental animals were vaccinated against major diseases, de-wormed and sprayed against internal and external parasites, respectively. Milking procedure was partial suckling.

Data collection and management

Detail record keeping of animals was taken at study site on new born calves identification, birth date, sex, dam ID, sire ID, parity, traits; such as calving rate, birth weight, monthly weight, weaning weight, yearling weight and milk yield and management practice like feeding, health care, occurrences of disease, and other relevant parameters were recorded and managed in data record sheet and book. Finally, required data were transferred to software for analyzing.

Statistical Analysis

Quantitative data were subjected to the General Linear Model (GLM) procedure of SAS (SAS, 2004). Calving rate was calculated as percent numbers of cows calve per number of cows mated. Depending on the trait, fixed effects such as sex of the calf, parity of the dam, birth year, and birth season were used in the statistical models. These factors were included on the basis of their direct influence on the coefficient of determination (R^2) and the overall number of observations per trait. The presence of any significant differences was checked by using TUKEY Kramer multiple comparison tests. The following statistical models were used:

Model 1: Growth performance traits:

$$Y_{ijklm} = \mu + B_i + P_j + S_k + X_l + e_{ijklm}$$

Model 2: Reproductive performance traits:

1. Age at first calving: $Y_{ijk} = \mu + B_i + S_j + e_{ijk}$
2. Calving interval: $Y_{ijk} = \mu + B_i + P_j + e_{adl}$

Model 3: Production performance trait

1. Milk yield: $Y_{jkl} = \mu + P_j + R_k + e_{jkl}$

Where: Y_{ijklm} = the dependent variable, μ = Overall mean, B_i= effect of ith birth year, P_j = effect of jth parity of the dam, R_k= effect of kth calving year, S_j = effect of jth birth season, X_l= effect of lth sex of the calf and $e_{ijklm=}$ random error associated with each observation.

Results and Discussion

Growth Performance

The result showed that overall least square means of birth weight was 21.91±0.55 kg, with 22.81±0.34 kg for males and 21.02±0.36 kg for females (Table 1). The birth weight recorded in the present study is less than those reported for previous works of Borana calves in Ethiopia: 23.9±0.08 kg by Kassa and Arnason (1986), 25.2 kg by Mekonnen (1987), 26.6 kg by Yohannes *et al.* (2001b), 23.7 kg by Amsalu (2003) and 23.3±0.36 kg by Aynalem *et al.* (2010). The arid to semi-arid agro-pastoral characteristics of the natural habitat of the Borana cattle breed of the study area is markedly different from the cooler and wetter agro-ecology and this is expected to affect growth performance of the breed.

The least square mean analysis of birth weight indicated that there was significant difference (P<0.01) between sex. Male calves were heavier by 1.79 kg than female calves; which might be due to the physiological difference between male and female calves. The current study also indicated that significantly higher (P<0.001) birth weight of 23.01±0.57 kg and 22.81±0.57 kg for parity 4 and 3 and 25.13±0.61kg and 24.03±0.68 kg for year of 2013 and 2012; However, in the current study, season of the birth had shown non-significant (P>0.05) effect on the birth weight of Borana cattle breed at Yabello pastoral and dry land agriculture research center.

The overall least square means of live weights based on a partial suckling regime at 7 months of age was 97.22±1.77 kg, with 102.07±1.26 kg for males and 93.81±1.16 kg for females (Table 2).

The result of the present study is higher than the reports of Amsalu 2003 (94.2±3.9 kg), Yohannes *et al*., 2001b (79.4± 2.7 kg), Aynalem *et al.*, 2010 (79.0±1.51 kg) for the same Ethiopian Borana breed. The variation of weaning weight values of the calves might be attributed to the difference of management, weaning age, weaning season, agro-ecological zone, and production objective of the breeds. Sex of the calf had shown a significant (*P*<0.01) effect on the weaning weight of Borana calves. Male calves had better weaning weight than female calves. Parity of dam, year of birth and season of birth had no significant (*P*>0.05) effect on weaning weight of Borana cattle breed calves.

Table 1. Least square means and standard errors (LSM±SE) of birth weight

Effect	N	LSM±SE (Kg)
Overall	**176**	**21.91±0.55**
Parity of dam		***
1	50	20.97±0.43^{c}
2	49	20.73±0.46^{c}
3	36	22.81±0.57^{ab}
4	28	23.01±0.57^{a}
5	13	22.07±0.79^{b}
Year of birth		***
2007	33	22.17±0.59^{c}
2011	14	23.93±0.83^{abc}
2012	11	22.62±0.93^{c}
2013	29	25.13±0.61^{a}
2014	21	24.03±0.68^{ab}
2015	18	21.09±0.66^{bc}
2016	28	20.96±0.55^{cd}
2017	22	19.99±0.58^{d}
Season of birth		**NS**
Long rainy season	103	22.79±0.45
Cool dry season	19	21.93±0.62
Short rainy season	34	21.66±0.49
Dry season	20	21.29±0.65
Sex of calf		**
Male	83	22.81±0.34
Female	93	21.02±0.36

*LSM with different letters within a factor differ significantly, *** = P<0.001, ** = P<0.01, NS = Non-significant and N = Number of observation*

The overall least square mean of yearling calves was 133.90±2.33 with 141.52±1.74 for males and 126.28±1.67 for females (Table 3). The difference was highly significant between males and females at the specified ages as well as among birth year and season. However, no significant difference was observed on dam parity of yearling weight. The overall least square mean weight at 24 months of age was 194.12±3.32 kg with 203.08±2.41 kg for males and 185.17±2.38 kg for females. Significant differences of 24 months age live weight were observed between males and females as well as weighting seasons and years.

Table 2. Least square means & standard errors (LSM±SE) for weaning weight at seven months of age

Effect	N	LSM±SE (Kg)
Overall	**173**	**97.22±1.77**
Parity of dam		**NS**
1	49	96.66±1.69
2	47	96.52±1.73
3	36	99.58±1.98
4	28	101.25±2.24
5	13	92.15±3.29
Year of birth		**NS**
2007	33	96.03±2.07
2011	24	99.44±2.43
2012	29	98.29±2.21
2013	12	98.50±3.44
2014	9	96.22±3.97
2015	18	103.88±2.81
2016	28	96.03±2.25
2017	20	93.90±2.66
Season of birth		**NS**
Long rainy season	33	98.67±2.08
Cool dry season	31	95.37±2.15
Short rainy season	33	98.03±2.08
Dry season	76	96.81±1.37
Sex of calf		******
Male	81	102.07±1.26
Female	92	93.81±1.16

*LSM with different letters within a factor differ significantly, ** = P<0.01, NS = Non-significant and N = Number of observation*

Table 3. Least square means and standard errors (LSM±SE) of weight at yearling age

Effect	N	LSM±SE (Kg)
Overall	**164**	**133.90±2.33**
Parity of dam		**NS**
1	48	130.72±2.19
2	46	131.95±2.35
3	36	131.46±2.75

4	27	135.55±2.78
5	7	139.83±4.72
Year of birth		**
2007	33	131.51±3.05^{cd}
2011	14	141.31±4.27a
2012	11	133.11±4.88^{bcd}
2013	28	136.27±3.19^{abc}
2014	21	133.39±3.45^{abcd}
2015	18	137.73±3.39^{ab}
2016	28	125.65±2.78^{d}
2017	11	132.25±3.79^{bcd}
Season of birth		**
Long rainy season	102	138.49±1.99^{a}
Cool dry season	19	126.08±2.88^{b}
Short rainy season	26	142.82±2.84^{a}
Dry season	17	128.22±3.69^{b}
Sex of calf		***
Male	75	141.52±1.74
Female	89	126.28±1.67

*LSM with different letters within a factor differ significantly, *** = P<0.001, ** = P<0.01, NS = Non-significant and N = Number of observation*

Table 4. Least square means and standard errors (LSM±SE) of weight at 24 months of age

Effect	N	LSM±SE (Kg)
Overall	**143**	**194±3.32**
Parity of dam		**NS**
1	42	193.72±3.24
2	45	192.76±3.26
3	36	195.29±3.12
4	20	194.71±3.79
Year of birth		***
2007	33	198.73±4.04^{ab}
2011	25	195.74±4.44^{ab}
2012	29	201.86±3.83^{a}
2013	20	201.57±4.02^{a}
2014	18	185.33±4.25^{b}
2015	18	181.51±4.58^{b}
Season of birth		**
Long rainy season	95	198.39±1.84^{a}
Cool dry season	14	180.10±3.86^{b}

Short rainy season	18	202.48±4.24[a]
Dry season	16	195.51±5.04[a]
Sex of calf		**
Male	66	203.08±2.41
Female	77	185.17±2.38

*LSM with different letters within a factor differ significantly, *** = P<0.001, ** = P<0.01, NS = Non-significant and N = Number of observation*

Reproductive Performances

The overall mean age at first calving of Borana cattle breed was 48.39±1.41 months. Significant differences of age at first calving of Borana cattle were observed among dam's parity and year of birth. The age at first calving of Borana cattle was considered too late compared to reports of 45.2 months (Kassa and Arnason, 1986) and 45 months (Mukasa-Mugerwa, 1989) for the same breed of Ethiopian Borana cattle. However, longer calving interval of 56.85 months (Yifat *et al*., 2012) was recorded for the same breed of Ethiopian Borana cattle than the present study.

The study of this Borana cattle breed has been under control mating, and those heifers which failed to come to heat or did not conceive during the breeding time were delayed until the next mating time, and this is expected to have contributed to the late average age at first calving. A seasonal calving herd is important for superior reproductive performance where the calving season is synchronized with the availability of low-cost feed (e.g., grazed grass). In seasonal calving herds, compromised reproduction is synonymous with the necessity for involuntary culling (Shalloo *et al.*, 2014). In addition, the prolonged age at first calving of Borana cows in our study compared to literature results of same breed could be attributed to factors such as poor nutrition and different management practices. With good nutrition it is expected that heifers would exhibit fast growth and attain higher weights at relatively younger age leads to prevent the delayed puberty.

The overall calving interval of Borana cows was 17.91±1.01 months, which is within the estimated calving interval for zebu cattle ranging from 12.2 to 26.6 months (Gebrekidan *et al.*, 2012). In the present study, significant difference of calving interval of Borana cattle was observed between years of birth, whereas no significant different was recorded among dams' parity. Shorter calving interval of Borana cows was recorded for the year 2007 than 2012. Lower calving interval of 15.83 and 15.35 months were reported by Azage, (1981) and Mekonnen, (1987) at Abernossa ranch, respectively. On the other hand, longer calving interval of 20.47 months was reported by Yifat *et al*. (2012) for the same breed of Borana cows at Tatesa cattle breeding center. The difference in calving interval across the year of birth might be due to the variation in rainfall distribution and feed resource availability across the year.

Table 5. Least square means and standard errors (LSM±SE) of age at first calving

Effect	N	LSM±SE (Months)
Overall	**40**	**48.39±1.41**
Year of birth		***
2007	29	45.55±0.08
2012	11	51.23±1.57
Dam Parity		**
1	19	50.18±0.80[a]
2	13	47.29±1.25[b]
3	6	47.61±1.62[b]
4	2	48.48±2.56[b]

*LSM with different letters within a factor differ significantly, *** = P<0.001, ** = P<0.01, NS = Non-significant and N = Number of observation*

Table 6. Least squares means and standard errors (LSM±SE) of calving interval

Effect	N	LSM±SE (Months)
Overall	**97**	**17.91±1.01**
Birth year		*
2007	90	16.71±0.40
2012	7	19.12±1.51
Dam Parity		**NS**
1	33	18.66±0.77
2	26	16.41±1.04
3	25	18.26±1.05
4	13	18.31±1.26

*LSM with different letters within a factor differ significantly, * = P<0.05, NS = Non-significant and N = Number of observation*

The calving rate of Borana cattle in six years breeding time is indicated in the Fig. 1. The average calving rate of this herd was calculated to be 69.45±11.59%. The calving rate of Borana cattle was decreased from calving year of 2012 to 2016 calving year, whereas slight increment in calving year of 2017 than 2016 of calving year. The observed difference of Borana cows calving rate across the years may be due the fact that environments like nutritional requirement and other management practices affects the performance of reproductive traits like calving rate, age at first calving, calving interval and others than the genotypic influences.

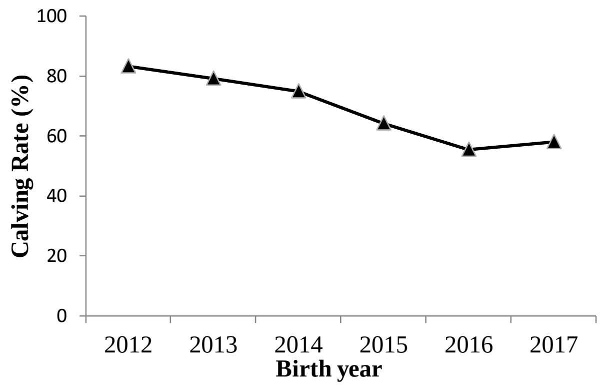

Figure 1. Borana cattle calving rate

Production Performance

The lactation performance from the first to fifth parities of Borana cows evaluated at Yabello pastoral and dry land agriculture research center is given in Table 7. The average 210 days milk yield for Borana cows was 440.98±23.38 L. This economically important trait varied widely among cows' parity and calving years. The highest 210 days milk yield was observed for 2nd parity (473.37±22.97 L) and for 2013 calving year (535.71±25.17 L). Lower 210 days milk yield was found for 2014 and 2017 of calving years. The cows calving during different year showed a wide variation in 210 days of milk yield. The performance of Borana cows at different calving years showed wide variations that may be due to differences in rain distribution across the year that affected the availability of feed in which the evaluation of the experiment was conducted under range condition. In the current study, the average lactation milk yield of Borana cows is less than the report of EARO (1999) and Haile *et al*. (2009a) who found the average lactation milk production of the indigenous cows' ranges from 480–825 L under optimum management.

A second lactation yield was 16 to 19% more than a first lactation while a third lactation (e.g., mature cow) yields approximately 28 to 31% more than a first lactation (Horan *et al*., 2005; Walsh *et al*., 2007). This indicates the milk yield of cow increased with the maturity of udder but when the cows becomes older milk production reduce and structure of udder may change because of fat deposition. In our experiment, the second lactation cows' milk yield was about 15.38% greater than the first lactation cows' milk yield. However, lactation milk yield of Borana cows from third to fifth parities fluctuated than normal milk yield increment with the passage of time through calving years. The absence of increment in milk yield with the advancement of lactation number (figure 2) may be attributable to descend in rain fall across the years shown in the figure 3 that leads to shortage of animal feed. In addition, maturity of udder greatly influenced by feeding and management practices of cows (Javed *et al*., 2003). Moreover, Tadesse and Dessie (2003) reported that changes in climatic and other management condition change the milk yield of cow.

Table 7. Least squares means and standard errors (LSM±SE) of lactation milk yield

Effect	**N**	**LSM±SE (L)**
Overall	**127**	**440.98±23.38**
Cow Parity		**
1	38	410.37±17.68[b]
2	27	473.37±22.97[a]
3	28	464.66±23.13[b]
4	23	427.45±21.93[b]
5	11	429.30±30.36[b]
Calving year		***
2012	19	479.95±26.43[b]
2013	23	535.71±25.17[a]
2014	21	363.78±26.73[d]
2015	17	420.23±22.79[bc]
2016	28	475.18±18.73[b]
2017	19	370.75±21.48[cd]

*LSM with different letters within a factor differ significantly, *** = P<0.001, ** = P<0.01 and N = Number of observation*

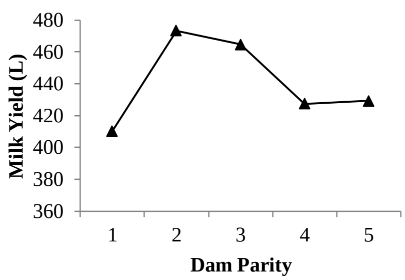

Figure 2. Cows' milk yield (L) across parity

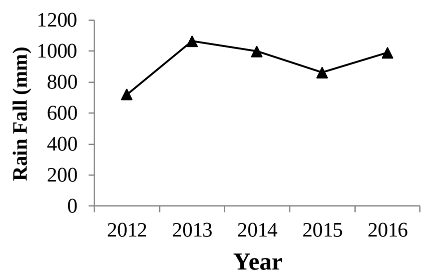

Figure 3. Rain fall (mm) of five years (YPDARC)

Conclusion and Recommendation

The study was conducted at Yabello Pastoral and Dry land agriculture research center under range land condition to evaluate the performance of Borana cattle breed and suggest appropriate husbandry practices. Birth weight of Borana cattle was 22.81±0.34 kg for male and 21.02±0.36 kg for female calves. Significant difference (*P*<0.01) of calve birth weight was observed between male and female calves which might be due to the physiological difference between male and females calves. Live weights based on a partial suckling regime at 7 months age was 102.07±1.26 kg for males and 93.81±1.16 kg for females. Sex of the calf had shown a significant (*P*<0.01) effect on the weaning weight of Borana calves. Male calves had better weaning weight than female calves. Yearling weight of Borana cattle male calves was 141.52±1.74 kg, whereas 126.28±1.67 kg for females . The difference was highly significant between males and females at the specified ages as well as among birth year and season. However, no significant difference was observed on dam parity of yearling weight. Live weight at 24 of months of age was 203.08±2.41 kg and 185.17±2.38 kg for males and females, respectively. Significant differences of 24 months age live weight were observed between males and females as well as birth seasons and years.

The overall mean age at first calving of Borana cattle breed was 48.39±1.41 months. Significant differences of age at first calving of Borana cattle were observed among dam's parity and birth of years. The overall calving interval of Borana cows was 17.91±1.01 months. In the present study, significant difference of calving interval of Borana cattle was observed between years of birth, whereas no significant different was recorded among dams' parity. The average calving rate of this herd was calculated to be 69.45±11.59%.

The average 210 days milk yield for Borana cows was 440.98±23.38 L. This economically important trait varied widely among cows' parity and calving years. The cows calving during different year showed a wide variation in 210 days' of milk yield. The performance of Borana cows at different calving years showed wide variations that may be due to differences in rain distribution of the year that affected the availability of feed in which the evaluation of the experiment was conducted under range condition. The second lactation cows' milk yield was about 15.38% greater than the first lactation cows' milk yield. However, lactation milk yield of Borana cows from third to fifth parities fluctuated than normal milk yield increment with the passage of time through calving years.

It was concluded that promising growth, reproductive and milk production performances of Borana cattle breed in its native niche is favorably comparable to Borana cattle breed evaluated in the different parts of Ethiopia. Because of most breeding cows were controlled to calve at growing time of natural pasture starting from mid-March, animals bred between June and July of breeding season gave higher milk yield and live weight at their yearly and two years. Thus, annual calving season for cows should be adjusted to main rainy season in order to manage the animals and reduce feed shortage of lactating cows and calves. However, shortage of feed during dry season was a major constraint on animal performance evaluation, and less milk production and live weight were recorded during this dry season than wet season. Therefore, dry season based feed supplementation and health related management is a paramount suggestion to evaluate the production potential and improve the performance of the breed.

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Study on Prevalence of Bovine Brucellosis in Cattle Herd of Adami Tulu Agricultural Research Center

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Abstract

A cross sectional sero-prevalence study was conducted from 2016 to 2017on 472 cattle in Adami Tulu Agricultural Research Center, Oromia Regional State, Ethiopia; to investigate the status of bovine brucellosis in breeding herds and identify its potential risk factors. Sera samples were tested using Rose Bengal Plate Test (RBPT) and Indirect Enzyme-linked Immunosorbent Assay (I-ELISA). The overall sero-prevalence was 34.3%. The study also revealed that sero-positivity to brucellosis was significantly higher in local breeds, female and older animals ($p<0.0001$) than crossbreds, male and younger animals respectively. This study therefore, showed a high prevalence of the disease that's risk for both humans and cattle under the breeding program of the center. Hence, considering the economic and public health importance of brucellosis, avoiding mixing of cattle without screening for brucellosis, application of test and slaughter strategy and hygienic measures are recommended to control the disease. It is also recommended to further investigate the disease in the synthetic breeding program areas to identify the prevalence and formulate strategic control measures.

Key words: *Adami Tulu, Research Center, Bovine, Brucellosis, nucleus breeding, prevalence.*

1. Introduction

Brucellosis is an infectious contagious bacterial disease caused by members of the genus Brucella, an important zoonosis and a significant cause of reproductive losses in animals. It is usually caused by *Brucella abortus* in cattle, *B. melitensis* or *B. ovis* in small ruminants, *B. suis* in pigs and *B. canis* in dogs (Dwight, 1999; OIE, 2009).

Brucellosis occurs worldwide in domestic animals such as cattle, sheep, goats, camels and pigs and creates a serious economic problem for both intensive and extensive livestock production systems in the topics and a threat to public health. It has been shown that brucellosis causes heavy economic losses in livestock industry. Economic losses stem from breeding efficiency, loss of offspring, reduced meat and milk production as well as impediment to free animal movements and export of animals and their products (OIE, 2008; Ayayi, *et al*., 2009).

The disease is also important zoonosis causing debilitating disease in humans. *B. abortus*, *B. melitensis*, *B. suis*, *B. canis* and marine mammal Brucella species are human pathogens. Most cases are caused by occupational exposure to infected animals or the ingestion of unpasteurized dairy products. Epidemiology of brucellosis is complex In that important factor that contribute to the prevalence and spread in livestock include farming system and practice, farm sanitation, livestock movement, mixing and trading of animals, and sharing of grazing ground (Radostitis, 2006).

Because of the major economic impact on animal health and risk of human disease, most countries have attempted to apply resources to eradicate the disease from the domestic animal population. Amongst the control program methods are vaccination of young or mature animals and slaughter of infected and exposed animals, usually on the basis of serological test results (Radostitis, 2006).

In Ethiopia, the distribution of crossbred dairy cows to increase milk production is not without risk of brucellosis and other potential diseases and/or problems that might lead to abortion (Edao, *et al*., 2018). The synthetic breed development initiated at Adami Tulu Agricultural Research Center (ATARC) with aim to distribute selected bulls for on-farm breeding program. Previous studies in pastoral and agro-pastoral areas of East Showa Zone showed the prevalence rates of 18.6%, 10%, 8.7% and 5.1% bovine brucellosis in Arsi Nagele, Adami Tulu, Fentale and Lume districts, respectively (Hunduma and Regasa, 2009).

In order to achieve the desired goal of breed improvement program the nucleus breeding stocks and the participating herds have to be free from brucellosis. Hence, it is important to determine the prevalence of the disease in the nucleus breeding herd in order to undertake control and preventive measures. Therefore, the study was conducted with the objective to determine the prevalence of brucellosis in nucleus breeding cattle of ATARC.

2. Materials and Methods

2.1. Study area

The study was conducted at Adami Tulu Agricultural Research Center (ATARC) located 167 km South of Addis Ababa, the capital city of Ethiopia. ATARC is situated in the Rift Valley at 7º9'N latitude and 38º7'E longitude. The area has an altitude of 1650 meters above sea level and receives annual rainfall of about 700 millimeters.

2.2. Study Population

The target population was a herd of cattle selected from various areas of Arsi, East Shoa and West Arsi zones for breed improvement at Adami Tulu Agricultural Research Center, which consists of both local and cross breeding cows, calves, heifers and bulls. A total of 472 animals were sampled; of which 314 were Arsi breed and 158 cross breeds. Out of 472 animals sampled, 398 were females while 74 were males. All the study animals were greater than 6 months of age and none of them were vaccinated against brucellosis.

2.3. Study design

Cross sectional study design was employed in the current study. All animals with the age above 6 months were screened by Rose Bengal plate test and positive animals were sampled for serological test by Indirect- ELISA.

2.4. Sample size

Census sample was taken from all animals positive for brucella by RBPT in Adami Tulu Agricultural Research Center.

2.5. Sampling methods and sample handling

Blood samples were collected into sterile plain vaccutainer tubes of 10ml from each animal. During sampling breed, sex, age and source of the animals were recorded. The blood samples collected from the animals were allowed to clot at the room temperature prior to serum separation. The clotted blood was centrifuged at 3000g/minute for 5 minutes. Then after, serum samples were decanted and stored at -20^{o}C until they were transported to the laboratory for analysis.

2.6. Serological Test

All serum samples were screened by Rose Bengal Plate Test (RBPT) at Asella Regional Diagnostic Laboratory for the presence of Brucella antibodies using procedure described by Alton *et al*. (1975). All sera samples which tested positive to RBPT were further tested using Indirect Enzyme-linked Immunosorbent Assay (I-ELISA) at Sebeta National Animal Health Diagnostic Center (NAHDC) according to standard procedures described by Nielsen *et al*. (1996).

2.7. Data Analysis

Statistical analysis was performed using the Statistical Package for Social Science (SPSS) Version 20 (SPSS 2011). Animals were considered to be brucella positive if they were positive to the RBPT and confirmed by I-ELISA test. The sero-prevalence rate was calculated by dividing the number of RBPT and I-ELISA positive animals by the total number of animals tested under each category. Chi- square test was used to measure the association between the sero-prevalence and categorical variables. A P-value of ≤ 0.01 and 99% confidence interval (CI) was used to determine statistical significance.

3. Results

3.1. Prevalence of Brucella abortus with respect to breed, sex, age groups & source of animals

Out of 472 total serum samples screened for brucellosis using RBPT 191 (40.5%) samples were positive for brucella. Further confirmation of positive samples to RBPT by I-ELISA revealed that 162(34.3%) positive results. The distribution of prevalence of brucellosis among breed, sex, age groups and source of animals as tested using RBPT and I-ELISA (Table 1).

Table 1: Prevalence of brucellosis and its distribution among breed, sex, age groups and source of animals as tested using RBPT and I-ELISA.

Factors		**Animals tested**	**RBPT +ve (%)**	**I-ELISA +ve (%)**
Breed	Local	314	161(51.3%)	135(43.0%)
	Cross	158	30(19.0%)	27(17.1%)
Sex	Female	398	187(47.0%)	159(39.9%)
	Male	74	4(5.4%)	3(4.1%)
Age group	6mon - 3yrs	120	7(5.8%)	6(5.0%)
	[3yrs – 6yrs]	93	41(44.1%)	34(36.6%)
	>6yrs	259	143(55.2%)	122(47.1%)
Source	Asella	85	59(69.4%)	50(58.8%)
	ATARC	162	33(20.4%)	29(17.9%)
	Adami Tullu JK	100	35(35.0%)	34(34.0%)
	Bora Dembel	93	42(45.2%)	32(34.4%)
	Shashemene	32	22(68.8%)	17(53.1%)
Overall		472	191(40.5%)	162(34.3%)

3.2. Association of Prevalence of Bovine Brucellosis with Risk Factors

In the present study, it was found that brucellosis was significantly associated ($p<0.001$) with breed, sex, age and source of the animals (Table 2). The study also revealed that local, females and older animals were highly infected than cross breed, male and younger animals respectively.

Table 2: Association of brucellosis with breed, sex, age groups and source of animals in ATARC as tested using I-ELISA.

Categories	**I-ELISA +ve (%)**	**X2**	**P-value**

Breed	Local	135(43.0%)	31.29	0.000
	Cross	27(17.1%)		
Sex	Female	159(39.9%)	35.67	0.000
	Male	3(4.1%)		
Age group	6mon - <3yrs	6(5.0%)	64.75	0.000
	[3yrs – 6yrs]	34(36.6%)		
	>6yrs	122(47.1%)		
Source	Asella	50(58.8%)	47.04	0.000
	ATARC	29(17.9%)		
	Adami Tullu JK	34(34.0%)		
	Bora Dembel	32(34.4%)		
	Shashemene	17(53.1%)		
Overall		162(34.3%)		

4. Discussion

The sero-prevalence of Brucella antibodies determined with RBPT and I-ELISA were 40.5% and 34.3.0%, respectively. With high specificity of I-ELISA as confirmatory test for the disease (Ali and Hesam, 2016), the overall sero-prevalence of bovine brucellosis in the study area was 34.3%. This is in agreement with previous finding of Alem and Solomon (2002); who reported a sero-prevalence of 50% by the same diagnostic test in Did Tuyura Ranch, Borana Zone of Oromia Region. The finding is also comparable with previous report by Meyer (1980) whose result was 39% and 22% by Tariku (1994) in Dairy Farm in Northeastern Ethiopia. The current finding is higher than previous reports; 1.66% by (Kasahun., *et al.*, 2010) in Sidama Zone, 3.1% by (Nuraddis, *et al.*, 2009) in Jimma, 3.19% by (Gebretsadik., *et al.*, 2007) in Tigray Region and 11.2% by (Hunduma and Regassa, 2009) in East Showa Zone. A lower sero-prevalence than the current result was also documented in previous findings of Tolosa (2004) who reported 0.77% in south western Ethiopia and Yayeh (2013) who reported a prevalence of 0.14% in north Gondar Zone.

The difference in sero-prevalence of bovine brucellosis is generally due to the difference in management systems, age and sex among dairy farms (Kebede *et al.*, 2008; Desalegn and Gangwar, 2011). In the current study also females and older animals were significantly infected than male and younger animals. This might be due to the fact that sexually matured and pregnant cattle are more susceptible to infection with Brucella organisms than sexually immature animals of either sex (Radostits *et al.*, 2006). On the other hand, younger animals tend to be more resistant to infection and frequently clear of infections, although latent infection may occur. This may be due to the fact that sex hormones and erythritol, which stimulates the growth and multiplication of Brucella organisms, tend to increase in concentration with age and sexual maturity (Radostits *et al.*, 2006).

5. Conclusion and Recommendation

The current study showed a higher prevalence rate than the previous reports which is a risk for both susceptible animals and humans. All the risk factors in ATARC showed a statistical significance association with prevalence that played a role for the existence of the disease in the study area. Hence, considering the economic and public health importance of brucellosis, avoiding mixing of cattle without screening for brucellosis, test and slaughter policy and hygienic measures were recommended to control the disease. It is also recommended to further investigate the prevalence and associated risk factors of the disease in the synthetic breeding program areas to design the different control options for the disease.

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Meat Animals Research Results

Evaluation of Different Feeding Options for Yearling Arsi Bulls to Attain Export Market Weight

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Abstract

The study was conducted at Adami Tulu Agricultural Research Center on yearling Arsi bulls. Twenty four bulls were purchased from the surrounding area. The objectives of the study were to evaluate and identify the most economical feeding options for yearling Arsi bulls for them to attain export market weight and to evaluate the carcass characteristics. Three feeding treatments (T_1= Grass hay + 20% Molasses + 40% Wheat bran + 40% Noug seed cake, T_2 = Grass hay + 20% Maize grain + 45% Wheat bran + 35% Noug cake and T_3 = Grass hay + 65% Wheat bran + 35% Cotton seed cake) were evaluated during the fattening period. Complete Randomized Block Design was implemented to assign eight Arsi bulls to each of the three treatments. All the experimental bulls were supplemented with their respective feed rations at 2.5% of their body weight per day during the whole experimental period. The result of the fattening trial revealed that there is no significant difference in final body weight and carcass characteristics among the bulls received the dietary rations. Furthermore, the study indicated that the yearling Arsi bulls fed on the three dietary rations did not attain export market weight in 238 days of feeding. Therefore, their growth performance should be further evaluated with other feeding options to know their fattening potential. Partial budget analysis indicated that feeding option one (T_1) is more economical as compared to bulls fed on feeding options T_2 and T_3. However, as there was no significant difference among the treatments, any of the feeding options can be used depending on availability of the ingredients in the area.

Key words: *Yearling Arsi bulls, Export market weight, Carcass characteristics*

Introduction

Livestock is an important sector in both highland mixed smallholder farming and low land agro-pastoral systems (Ayeneshet *et al*., 2018). The livestock sub sector plays vital roles as sources of food, income and foreign exchange to Ethiopian economy contributing about 12 and 33% of the total and agricultural GDPs, respectively. The sector contributes about 15% of the total export earnings and 30% of the agricultural employment. Despite the importance of cattle among the farming communities and to the national economy at large, this sector has remained under-developed and, in many cases, underutilized (Gebretnsae *et al., 2017*).

The average Ethiopian beef yield per animal of 135 kg is by far less than 146 kg for Africa, and 205 kg for the whole world (Negassa *et al.*, 2011; Yesihak and Webb, 2015; Zekarias, 2016). The total herd off take is estimated at 7% annually for cattle, 33 and 37% for sheep and goats, respectively. In Ethiopia, the current per capita consumption of meat is 13.9 kg/year, being lower than the African and the world per capita averages, which are 27 and 100 kg/year, respectively (Tsigereda *et al*., 2016). This is due to the fact that livestock production in Ethiopia is subsistence oriented and characterized by low performance (Tsegaye and Mengistu, 2013).

Currently, the government is trying to expand the sector to meet the increased meat demand from both foreign and domestic markets. However, this could not be fully realized as the traditional livestock fattening practices are not mostly market oriented (Belay and Menale, 2017). The effort made so far regarding fattening of beef cattle at different research centers is less targeted for export market weight demand. To solve the underlying constraints, different demand driven research proposals were developed by different agricultural research institutes to come up with feasible and promising fattening technologies for end users. Evaluation of different feed options on different breeds and age groups has played a vital role in improving body weights and the country's foreign currency earning by exporting meat and live animals (Mieso *et al.*, 2013; Girma *et al.*,2015; Tesfaye A.T *et al.*, 2017). In this regards, effects of different feeding options for yearling Arsi bulls targeting export market weight demand is not yet studied. Therefore, this study was designed to evaluate and identify most economical feeding options for Arsi cattle bulls to attain export market weight demand and yield quality carcass characteristics.

Materials and Methods

Description Study site

The experimental was conducted at Adami Tulu Agricultural Research Center, which is located in mid rift valley at 167 km from Addis Ababa, at altitude of 1650 m above sea level. The agro ecological zone of the area is semi-arid and sub humid with acacia woodland vegetation type. The mean annual rain fall is 760 mm and its mean minimum and maximum temperatures are 12.6 and 27^0c, respectably.

Experimental animals

A total of twenty four yearling Arsi bulls were purchased from Meki and Bulbula markets of the East Shoa Zone of Oromia Region. Purchased bulls were kept under quarantine in separate barn and they were treated against internal and external parasites before the commencement of the fattening trial. All experimental bulls were randomly assigned to one of the three dietary treatment groups.

Dietary rations and its ingredients

Dietary rations were formulated from different feed ingredients, namely molasses, wheat bran, Noug seed cake, maize grain and cotton seed cake. Three dietary rations were formulated in such a way that they contain similar amounts of energy and protein. The rations were: grass hay +

20% molasses + 40% wheat bran + 40% Noug seed cake, grass hay + 20% maize grain + 45% wheat bran + 35% Noug seed cake and grass hay + 65% wheat brain + 35% cotton seed cake. DM, total CP and TDN content of the experimental feeds are depicted in Table 1.

Table 1: Ingredients and chemical composition of the dietary rations

Dietary ration	Ingredient	DM%	CP%	TDN%
	Molasses (5.8, 72)	20	1.16	14.40
T_1	Wheat bran (13, 67)	35	5.52	26.80
	Noug seed cake (27, 72)	45	11.9	26.40
	Total	**100**	**18.58**	**67.6**
	Maize grain (10, 85)	20	2.00	17.00
T_2	Wheat bran (13, 67)	45	5.85	30.15
	Noug cake (29.75, 66)	35	10.41	23.10
	Total	**100**	**18.26**	**70.25**
	Wheat bran (13, 67)	65	8.45	43.55
T_3	Cottonseed cake (28, 75)	35	9.80	**18.25**
	Total	**100**		**69.8**

T= Treatment, DM=Dry matter, CP= Crude protein, TDN=Total digestible nutrient

Feeding the experimental bulls

Grass hay was provided *ad libtum* for all the experimental animals. Every day, all bulls were supplemented with concentrate feeds at the rate of 2.5% of their body weight throughout the fattening period. The amount of feed offered for bulls were adjusted every two weeks depending on weight change during feeding period. All experimental animals were individually fed with their corresponding rations for 21 days of adaptation and 238 days of feeding. Daily allocated feed per bull was divided into two equal amounts and offered twice per day, half in the morning and the remaining half in the afternoon.

Growth performance measurement

$$\mathbf{ADW} = \frac{(\boldsymbol{FBW-IBW})}{\mathbf{D}}$$

$$\boldsymbol{TWG = FBW - IBW}$$

Where: ADG = Average daily weight gain, TWG = Total weight gain, FBW = Final body weight,
IBW = Initial body weight and D = Total of fattening days

Carcass characteristics

At the end of the fattening period, nine bulls were slaughtered at Adami Tulu Agriculture Research Center slaughter house then the animals were skinned, all important internal organs such as kidney, heart, liver, lung, spleen, empty gut, heart fat, kidney fat, mesenteric and omental fat were eviscerated and the required carcass parameters were individually measured. The hot carcass was dissected symmetrically into right and left part. The right side carcass was set into cold chill room at - 4^{o}c for 24 hours, after which the carcass was measured again to evaluate the difference in weight change between the hot and the cold carcass of each slaughtered bull. To evaluate the chilled carcass characteristics, the right part of each slaughtered bull was cut into five major carcass parameters.

Partial budget analysis

All variable costs incurred in conducting the trial were recorded. Total variable costs such as animal purchase, transportation, feeds, labor and veterinary costs were included in partial budget analysis. At the end of the fattening period, the gross output/revenues were obtained from prices of the bulls as estimated by the help of people who have enough knowledge on the prices of fattened animals. Fixed costs incurred for feeding the animals were not included in cost benefit analysis.

Statistical analysis

Data on all live weights and carcass parameters were analyzed using the general linear model (GLM) of Statistical Analysis System (ver. 8). The estimated least squares means were separated using the Duncan's Multiple Range Test at $P< 0.05$.

Results and discussion

Effect of dietary rations on growth performance

Growth performances of the experimental bulls were analyzed at 60 days, 120 days and 238 days of fattening period. Final body weight, total and average daily weight gains of the bulls on these days are depicted in Table 2.

Table 2: Effect of dietary rations on growth performance of the bulls in each treatment

Fattening days	**Weight**	**T_1**	**T_2**	**T_3**
First day	IBW (kg)	106.8	106.2	108.3
	FBW (kg)	155.4±4.7	158.7±4.6	156.6±4.6
60 days	TWG (kg)	48.5±2.7	52.5±2.7	48.3±2.7
	ADG (g)	866.8±48.3	937.5±48.4	862.3±48.3
	FBW (kg)	202.1±5.2	201±5.6	185.5±5.2
120 days	TWG (kg)	$95.2±3.1^{a}$	$96.8±3.3^{a}$	$77.1±3.1^{b}$
	ADG (g)	$618.5±20.3^{a}$	$628.9±21.7^{a}$	$500.8±20.3^{a}$
	FBW (kg)	239.7±6.5	239±6.9	220.2±6.5

238 days	TWG (kg)	132.8±4.8[a]	134.8±5.1[a]	111.8±4.8[b]
	ADG (g)	558.3±20.2[a]	566.6±21.6[a]	470.1±20.2[b]

IBW = Initial body weight, FBW = Final body weight, ADG = Average daily weight gain, TWG = Total weight gain

The results show that there is no statistically significance difference in final body weight at all the three weighing days among the three treatments (T_1, T_2 & T_3). This is similar to the finding of Mieso *et al*., (2013) who conducted similar study on the yearling Borana bulls. Similarly, Girma *et al.,* (2015) reported that the three dietary rations have similar effect on final body weight of two years old Borana bulls. Total and average daily weight gains of these yearling Arsi bulls were significantly different among the three treatments at 238 days of fattening. In previous studies (Mieso *et al.,* 2013; Girma *et al.,* 2015; Tesfaye *et al.,* 2017) conducted on yearling Borana bulls, two years old Borana and Kereyu bulls fed similar dietary ration, no significant differences were reported in total weight gains among the treatment groups.
The current average daily weight gains of these Arsi bulls at the end of the fattening period is less than the finding of Girma *et al.,* (2015) who reported a daily weight gain of 777 g/day for Borana bulls in 224 days of fattening period. Furthermore, this study indicated that the yearling Arsi bulls did not attain export market body weight demand in 238 days of fattening period. However, yearling Borana bulls which were fed similar diets reached export market body weight demand within 224 days of fattening (Mieso *et al.,* 2013). This difference may be attributed to the naturally short skeletal dimension of Arsi cattle than Borana cattle breed.

Effects of dietary feeds on carcass components

The result of carcass evaluation of the bulls fed on the three different feed rations is illustrated in Figure1. In this trial, there were no significant differences in hot carcass and cold carcass among the three treatments. However, the carcass weight of bulls assigned to treatment one was higher than that of the other teatments. This finding was similar to the finding of Tesfaye *et al.,* (2017) for two years old kereyu breeds fed the same dietary rations. Furthermore, hot carcass weight of the expermental bulls was slghtly higher than that of the cold carcass.

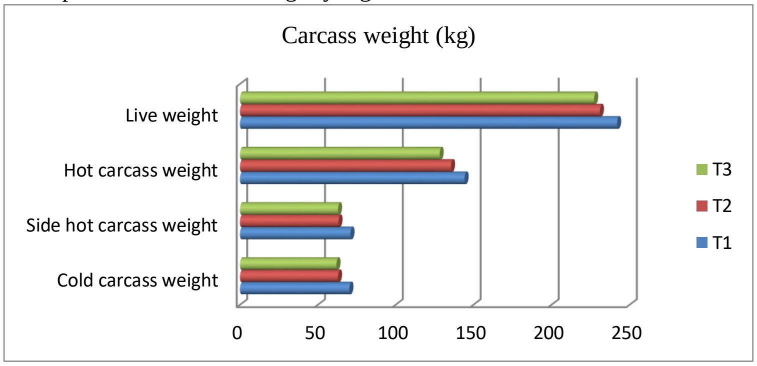

Figure 1: Carcass weight of yearling Arsi bulls

Effects of dietary feeds on edible organs and dressing percentage

Effects of the dietary rations on edible organs of the slaughtered bulls are indicated in Table 3. The mean weights of edible organs of the bulls are not significantly different among the bulls fed the three dietary rations. This result may associated with the fact that the bulls received the same percentage of total CP and TDN which might have the same effect on carcass characteristics of the bulls. This finding is similar with what is reported by Mieso *et al.*, (2013) for one year-old Borana bulls, by Girma *et al.*, (2015) for two years old Borana bulls and by Tesfaye *et al.*, (2017) for two years-old Kereyu bulls.

The dressing percentages of these bulls was comparable to the dressing percentage of two years old Kereyu bulls (56.3%), Ogaden bulls (56%) but slightly lower than that of the two years old Borana bulls (61%) reported by Tesfaye *et al.*, (2017), Yosep *et al.*, (2011) and Girma *et al.*, (2015), respectively. Though there was no statistical difference, the dressing percentage of bulls in treatment one was higher than that of the bulls in treatment two and three.

Table 3: Effects of different feeding options on edible organs of the bulls (kg) and dressing percentage

Carcass parameters	T_1	T_2	T_3
Tongue	0.83±0.08	0.81±0.08	0.83±0.1
Heart	0.9±0.06	0.85±0.064	0.78±0.1
Heart fat	0.9±0.16	0.8±0.16	0.7±0.16
Kidney	0.5±0.02	0.45±0.02	0.45±0.02
Liver	3.7±0.2	3.8±0.23	3.4±0.22
Hump	4.9±0.49	3.9±0.5	5.1±0.4
Empty Gut	6.4±0.43	4.7±0.4	5.8±0.43
Dressing %	59.6	58.8	56.4

Effects of dietary feeds on non-edible organs

Effects of the dietary rations on non-edible organs of the slaughtered bulls are indicated in Table 4. There was no statistically significant difference in non-edible organs among the experimental bulls fed on T_1, T_2, and T_3. However, the experimental bulls fed on T_2 have higher skin weight than the bulls fed on T_1 and T_3.

Table 4: Effects of different feeding options on non-edible organs of the bulls (Kg)

Organs	T_1	T_2	T_3
Tail	0.6±0.02	0.5±0.02	0.5±0.2
Hide	21.6±1.03	22.9±1.02	21±1.02
Feet	3.9±0.13	4.05±0.13	3.6±0,14
Lung	2.1±0.2	2.0±0.1	2.2±0.16

Spleen	0.7±0.1	0.7±0.1	0.6±0.1
Pancreas	0.1±0.03	0.2±0.03	0.2±0.03
Bladder	0.1±0.01	0.05±0.01	0.06±0.01
Small intestine	6.85±0.5	6.8±0.4	6.9±0.5
Large intestine	3.3±0.4	3.4±0.4	3.8±0.4

Economic return on yearling Arsi bulls fattening

The result of partial budget analysis of fattening the yearling Arsi bulls is given in Table 5. The analysis indicates higher gross margin per animal (31102.4 Birr) for experimental bulls fed dietary feed one than those fed dietary feed two (27702.4 Birr) and dietary ration three (24902.4 Birr). The results are in accordance with the results obtained from partial budget analysis of feeding two years old Borana bulls (Girma *et al.,* 2015). The bulls fed treatment three diet were less profitable as compare to those fed treatment one and two diets.

Table 5: Partial budget analysis of fattening yearling Arsi bulls

List of items	**T_1**	**T_2**	**T_3**	**Overall**
Feeds costs per bull (Birr)	8825	9250	9100	9058.333
Purchasing price per bull (Birr)	3000	3000	3000	3000
labor cost per bull (Birr)	694.2	694.2	694.2	694.2
Vet cost per bull (Birr)	93	93	93	93
Total variable cost per bull (Birr)	**12612.2**	**13037.2**	**12887.2**	**12845.53**
Total gross output per bull (Birr)	16500	16500	16000	16333.33
Gross margin per bull (Birr)	3887.8	3462.8	3112.8	3487.8
Total gross margin (Birr)	**31102.4**	**27702.4**	**24902.4**	**27902.4**

Conclusion and recommendation

Twenty four yearling Arsi bulls were randomly assigned for three dietary rations and kept on feeding for 238 days. Growth performances of the bulls were assessed during the fattening period. There is no statistically significant difference in final body weight and in most of the carcass characteristics which may be correlated with similarity of the bulls both in breed and age. Moreover, the same percentage of total CP and TDN were provided for all the experimental bulls. The yearling Arsi bulls did not attain export market weight in 238 days of feeding. Hence it needs to see other feeding options that would enable the bulls to attain the export market body weight demand in the shortest possible fattening period. However, numerically bulls fed on ration one are more profitable than bulls fed on rations two and three. Therefore, any beef cattle fatteners can preferably use feeding treatment one to fatten yearling Arsi bulls for local markets. However, as there were no significant differences in major parameters among the treatments, any of the feeding treatments can be used depending on availability of the feed ingredients in the area.

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Evaluation of different feeding options for growing two years old Arsi-Bulls to attain export market weight

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Abstract

The study was conducted at Adami Tulu agricultural research center on 27 two years-old Arsi bulls of 182 kg average initial body weight during the year 2016/17. The objectives of the study were: to evaluate and identify the most economical feeding options for two years aged Arsi bulls for them to attain 300kg export market weight and to evaluate the carcass characteristics of the animals. Three feeding treatments (T1=Grazing +20% molasses+ 40% wheat bran+ 40% Noug cake, T2 =Grazing +20% maize grain+45% wheat bran+35% Noug cake and T3= Grazing + 65% wheat bran+ 35% cotton seed cakes) *were evaluated. Complete Randomized Block Design was implemented to assign nine Arsi bulls to the three treatments. All the experimental bulls were supplemented with their respective feed rations at 2.5% of their body weight per day during the whole experimental period. The result of the fattening trials revealed that there is no significant difference in daily weight gain, total weight gain, final body weight and carcass characteristic of bulls received the three dietary feeds. for 195 fattening days. From the partial budget analysis it was observed that feeding on T1 to be more economical as compared to feeding on T2 and T3. Hence, for better economic return beef cattle fatteners can use dietary T1 for two years old Arsi bulls for them to attain export market weight of 250 to 300 kg.*

Key words= *Arsi bulls, Carcass, Feed option and export market weight*

Introduction

The livestock sub sector play vital roles as sources of food, income and foreign exchange to Ethiopian economy contributing about 12% and 33% of the total and agricultural GDP, respectively. Ethiopia holds the largest livestock population in Africa which is estimated at 59.5 million heads of cattle, 30.7million heads of sheep and 30.2 million heads of goats (CSA, 2016/17). Ethiopia provides about 45% of all domestic meat consumption with small surplus which generates export income mainly from the sale of live animals. However, the earning from exporting of live animals and processed meat is very small as compared to the potential of the country. As cited in Negassa et al. 2011, our country average beef yield per animal of 108.4 kg is by far less than 119 kg for the Sudan, 146 kg for Kenya, 127 kg for eastern Africa, 146 kg for Africa, and 205 kg for the whole world.. To improve this scenario various livestock research and development activities have been undertaken by different research institutions. Improving the growth performance of the fattening animals is one of the most important traits to obtain the required export market weight gains. Different feed options played a significant role to bring experimental animals to attain export market weight demand at different length of the fattening periods. In addition to the effect of dietary feeds, various fixed effects have their own role on growth performance and carcass characteristics of experimental bulls kept under a given environmental conditions. Among these factors breed and age of the experimental animals had important role on body weight gain of animals. The effort made so far regarding fattening of beef cattle at different research centers is less targeted for export market weight demand. To solve the underlying constraints, different demand driven research proposals were developed by different agricultural research institutions to come up with feasible and promising fattening technologies for end users. However, majority of the past research conducted on beef cattle production improvement were mainly targeted for domestic market demand. Evaluation of different feed options on different breeds and age groups has played a vital role in improving body weights and the county's foreign currency earning by exporting meat and live animals (Girma *et al.*, 2015, Mieso *et al*, 2013 and Tesfaye A.T *et al.*, 2017). In this regard effect of different feeding options for two years old Arsi bulls targeting export/local market weight demand is not yet studied. Hence, the current study was conducted to cover the following objectives and subsequently to generate promising fattening technologies for end users.

Objectives

- To evaluate the growth performance of two years old Arsi bulls fed on different feed options for the bulls to attain export market weight of 250-300 kg.
- To evaluate the carcass characteristics of two years old Arsi bulls fed on three different feeding options.
- To identify the most economical feeding options for two years old Arsi bulls to attain the targeted export market weight.

Materials and methods

Description of the study area

The experiment was conducted at Adami Tulu Agricultural Research Center, which is located in mid rift valley at 167 km from Addis Ababa city, Ethiopia at an altitude of 1650 m above sea level. The agro ecological Zone of the area is semi-arid and sub humid with acacia woodland vegetation type. The mean annual rain fall of the area is 760 mm and its mean minimum and maximum temperatures are 12.6 and 27^{o}C, respectively.

Experimental animals

For this experiment, 27 two years old Arsi bulls were purchased from Batu and Bulbula markets. The purchased bulls were kept under quarantine in separate barn and were treated against internal and external parasites before the commencement of the fattening trial. The animals were also vaccinated to control the most important diseases of the areas.

Dietary feeds/ treatments

The following three different feed options were used

T1 =Grazing +20% molasses+ 40% wheat bran+ 40% Noug cake

T2 =Grazing +20% maize grain+45% wheat bran+35% Noug cake

T3= Grazing + 65% wheat bran+ 35% cotton seed cakes.

The DM, total CP and TDN content of the experimental feeds is depicted in table1.

Table 1. Chemical composition of experimental diets

Type of feeds	Treatment	DM%	CP%	TDN%
Molasses	T1	20	1.16	14.4
Wheat bran	T1	40	5.52	26.80
Noug cake	T1	40	11.9	26.4
Total		**100**	**18.58**	**67.6**
Maize grain	T2	20	2	17
Wheat bran	T2	45	5.85	30.15
Noug cake	T2	35	10.41	23.1
Total		**100**	**18.26**	**70.25**
Wheat bran	T3	65	8.45	43.55
Cotton seedcake	T3	35	9.8	26.25
Total		**100**	**18.25**	**69.8**

Where:- *DM= dry matter , CP = crude protein and TDN= total digestible nutrient*

Feeding the experimental animals

In addition to hay feeding, every day all the experimental bulls were supplemented with concentrate feeds at 2.5% of their body weight throughout the fattening period. However, supplementations of bulls at 2.5% of their body weight were gradually adjusted every two weeks depending on the weight change of the bulls during the fattening period. All experimental animals were individually fed their respective diet for the whole experimental period. The daily allocated feed was divided into two equal amounts to offer twice per day, half in the morning and half in the afternoon. Feeding of the experimental bulls was extended to 195 days until the bulls had attained on average the required export body weights of 300 kg. Average daily weight gain (ADG) of the bulls was calculated using the following formula.

$$ADG = \frac{(FWT - IWT)}{D}$$

Where: FWT = Final body weight

IWT = Initial body weight

D = number of fattening days

Evaluation of Carcass Characteristics

At the end of the experimental period three fattened bulls were randomly selected from each treatment group and transported to be slaughtered at ELFORA abattoir at Debre-Zeit town. After the animals were slaughtered and skinned, all important internal organs such as kidney, heart, liver, lung, spleen, empty gut, heart fat, kidney fat, mesenteric and omental fat were eviscerated and all the required carcass parameters were individually measured. The rest hot carcass were dissected symmetrically into right and left parts with the help of modern electrical carcass cutting machine and the weight of each part of the entire carcass was measured before the carcass was put into cold chill room at -4^{o}c for about 24 hours. After 24 hours stay, the cold carcass parts were measured again to evaluate the difference in weight change between the hot and the cold carcass of each slaughtered animal. To evaluate the chilled carcass characteristics, the right parts of each slaughtered bull were cut into five major carcass parameters.

Partial budget analysis

All costs incurred for fattening the experimental bulls using the three dietary feeds were recorded in order to calculate economic returns of fattening the bulls. Total variable costs such as animal purchase, transportation, feeds, labor and veterinary costs incurred were collected. The gross output/revenues of experimental bulls were estimated at the end of the fattening period by the help of three persons who have enough knowledge on prices of fattened animals. Fixed costs incurred and the cost of grazing was not included in the analysis. Hence, this partial budget analysis indicates only gross margin of fattening bulls using three different feed options.

Statistical analysis

Data of all live weights and carcass parameters were analyzed using general linear model (GLM) of Statistical Analysis System (SAS, 2002). The estimated least squares means were separated using the Duncan's Multiple Range Test at $P< 0.05$.

Results and discussion

Effects of dietary feeds on weight gains

Least-square means (LSM) of final body weight (FBW), total weight gain (TWG) and average daily weight gain (ADG) of the bulls fed on different feed rations are indicated in Table 2. There is no statistically significant difference in ADG, TWG and FBW between T1, T2 and T3. However, experimental bulls fed on T1 gained more ADG (0.795 g), TWG (155.11 kg) and FBW (303.44 kg) than experimental animals fed on T1 and T3. This result is similar with the previous findings of Mieso G., *et al* (2013), who reported that feeding of one year-old Borana bulls with the same type of feed rations did not bring any significant difference among the three treatment groups

Table 2. Growth performance (Mean ± SE) of two years old Arsi bulls fed three different rations

Parameter	NO of fattening days	Treatments		
		T1	T2	T3
Live body weight	Initial	148.33 ± 5.63	147.89 ± 4.96	147.89 ±5.13
	60	220.00 ± 5.72	219.22 ±5.47	206.44 ± 3.34
	120	266.89 ± 7.71	259.78 ± 7.62	257.11 ±4.53
	195	303.44 ± 7.18	298.44 ± 7.84	299.44 ±6.52
TWG (kg)	60	71.67 ±10.22	71.33 ± 7.16	58.56 ±4.68
	120	118.56 ±11.82	111.89 ± 7.46	109.22 ± 3.05
	195	155.11±11.58	150.56 ± 7.64	151.56 ± 4.01
ADG(g)	60	1194.44 ±170.31	1188.89 ± 119.41	975.93 ± 78.08
	120	987.96 ± 98.50	932.41 ± 62.20	910.19 ± 25.45
	195	795.44 ±59.41	772.08 ±39.16	777.21 ± 20.57

Where:- *ADG = average daily gain, TWG= total weight gain*.

The daily weight gain (795.44 gm) of bulls fed on T1 is more or less similar with the finding of Adebabay K., *et al* (2013) who reported the daily weight gain of 880 gm for Fogera bulls fed with hay plus 6 kg of concentrate per head per day. The two years old Arsi bulls attained more or less the required 300 kg of export market weight demand at 195 fattening days which is longer time than that of Borana bulls, which reached the same weight at 154 days (Girma *et al* 2015). On the other hand, these two years old Arsi bulls attained the required export market weight within the shortest period of time when compared with the one year old Borana bulls, which reached the required weight at 224 fattening days (Mieso G., *et al* 2013).The trend of body weight change of the bulls over the whole fattening period is showed in Figure 1.

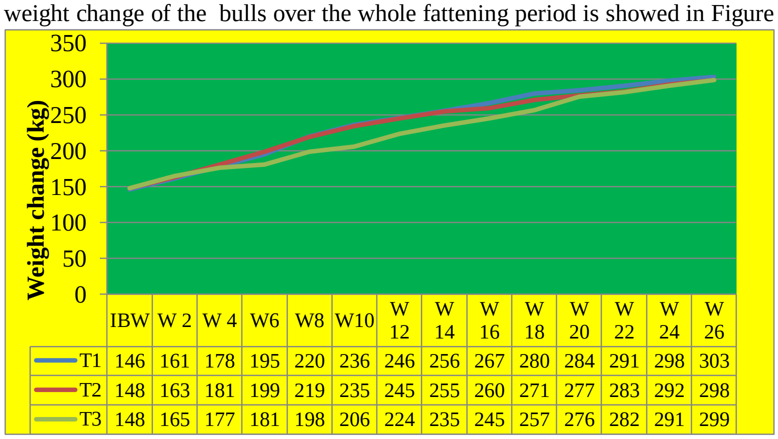

Figure 1. Body weight change of two years old Arsi bulls over the total fattening period

Where:- *IBW=initial body weight, W1= Week1, W2= week 2, W3= week 3, etc up to W26=week 26th*

Effects of dietary feeds on carcass components

The result of carcass evaluation of the two years-old Arsi bulls fed on the three different feed rations is indicated in Table 3. There is no significant difference in measurements of carcass parameters among the three dietary treatments. This may be because of the breed and age similarity of the bulls. Moreover, the bulls had received the same percentage of total CP and TDN which may have the same effect on carcass characteristics of the bulls. This finding is similar with what is reported by Mieso G., *et al* (2013) for one year-old Borana bulls, by Girma *et al*, (2015) for two years old Borana bulls and by Tesfaye *et al*, (2017) for two years-old Kereyu bulls.

Table 3. Carcass parameters evaluation of two years-old Arsi Bulls

Parameter	Treatments		
	T1	T2	T3
SWT	290.00 ± 8.66	311.67 ± 13.02	291.67 ± 7.26
HCW	178.33 ± 3.18	189.67 ±7.22	176.33 ± 5.90
DR%	61.54 ± 0.94	60.89 ± 0.88	60.44 ± 0.67
HQ	40.10 ±0.66	41.90 ± 2.40	37.47 ± 1.20
FQ	47.63 ± 2.54	51.43 ± 1.43	45.83 ± 1.13
Side wt	87.67 ± 2.03	93.67 ± 3.71	83.67 ± 1.76

S*WT= slaughter weight of the bulls, HCW=Hot carcass weight, DR= dressing percentage, HQ= Hind quarter, FR=Forequarter*

The bone, fat and muscle ratios of the bulls in the three treatments are indicated in figure 2.

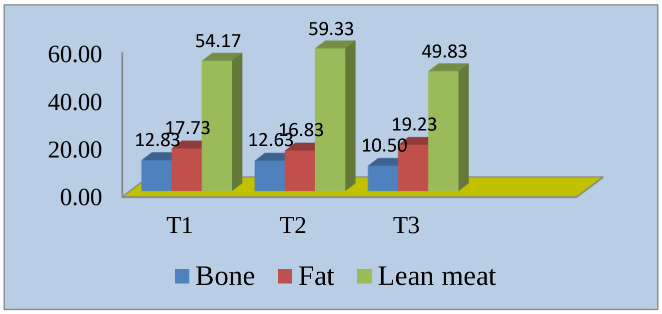

Figure 2**.** Muscle, fat and bone proportions of the bulls

The forequarter cuts (Table 4) of the carcasses were also not statistically different (p>0.05). This shows that the feed options used to fatten the bulls have similar effects on carcass characteristics of the animals. But the overall bone, fat trim and Lean trim showed statistically significant difference. This was in agreement with reports of Mieso G., *et al* (2013) and Girma *et. al* (2015)

Table 4. Forequarter Carcass parameters evaluation of two years-old Arsi Bulls

Variable	Treatments		
	T1	T2	T3
Forequarter	**47.63 ± 2.54**	**51.43 + 1.43**	**45.83 + 1.13**
Hump	2.20 ± 0.21	2.60 ± 0.26	3.00 ± 0.51
Ribeye roll	6.23 ± 0.38	6.67 ± 0.33	5.67 ± 0.42
Brisket	2.60 ± 0.38	3.10 ± 0.40	2.17 ± 0.35
Clod (cloud)	4.93 ± 0.38	4.93 ± 0.19	4.77 ± 0.43
Chuck tender	0.83 ± 0.03	0.97 ± 0.09	0.80 ± 0.06
Chuck roll	3.67 ± 0.42	3.80 ± 0.15	2.87 ± 0.32
Fore-shank	1.43 ± 0.09	1.67 ± 0.12	1.60 ± 0.20
Neck	12.53 ± 1.15	13.67 ± 1.62	12.10 ± 0.76
Bones	7.00 ± 0.30^{a}	7.00 ± 0.31^{a}	5.87 ± 0.13^{b}
Fat trim	9.60 ± 0.15^{ba}	7.87 ± 0.94^{b}	10.83 ± 1.02^{a}
Lean trim	29.17 ± 1.88^{ba}	34.00 ± 1.00^{a}	28.00 ± 1.53^{b}

^{abc} *=Treatments with different superscripts are significantly different @ p<0.05*

Most of the hind quarter different cuts of the carcass were also not statistically significant at p<0.05 (Table 5). This shows that the feed options used to fatten the bulls have similar effect on carcass characteristics of the animals. But the Flank steak Hard-shin Tri-tip Lean trim showed statistical difference.

Table 5. Hindquarter carcass parameters evaluation of the Bulls

Variable	Treatments		
	T1	T2	T3
Hind quarter	40.10 ± 0.66	41.90 ± 2.40	37.47 ±1.20
False lean	0.53 ± 0.03	0.63 ± 0.03	0.50 ±0.06
Flank steak	2.00 ± 0.00^{a}	1.77 ± 0.15^{ba}	1.43 ± 0.12^{b}
Sirloin	4.83 ± 0.13	5.10 ± 0.49	4.40 ±0.06
Tri tip	2.43 ± 0.03^{b}	2.97 ± 0.18^{a}	2.83 ± 0.15^{ba}
Ball tip	2.40 ± 0.15	2.13 ± 0.48	1.57 ±0.09
Tender loin	1.23 ± 0.07	1.20 ± 0.10	1.17 ± 0.07
Strip-loin	3.83 ± 0.18	3.47 ± 0.72	3.07 ± 0.47
Silver-side	5.40 ± 0.23	5.87 ± 0.34	5.50 ± 0.44
Top-side	4.93 ± 0.09	4.80 ± 0.12	4.63 ± 0.18
Thick flank	1.73 ± 0.03	1.97 ± 0.12	1.90 ± 0.06
Soft shin	1.17 ± 0.03	1.17 ± 0.03	1.10 ± 0.06

Hard shin	1.10 ± 0.00[ba]	1.27 ± 0.09[a]	1.03 ± 0.03[b]
Bones	5.83 ± 0.48	5.63 ± 0.48	4.63 ± 0.24
Fat-trim	8.13 ± 0.93	8.97 ± 0.43	8.40 ± 0.70
Lean-trim	25.00 ± 0.58[a]	25.33 ± 1.30[a]	21.83 ± 0.60[b]
Oxtail	0.33 ±0.03	0.33 ± 0.07	0.30 ± 0.00

NB: Treatments with different superscripts are significantly different @ $p<0.05$

Although slight variation were observed among bulls fed different rations for flank steak, tri-tip, hard shin and lean-trim, there were no significant difference for other cuts. These results are similar with report of Girma *et.al*. (2015). Study by Tesfaye and Tesfa (2007) on Kereyu bulls and Lemma *et.al*. (2007) on Borana bulls also indicated that there was no significant difference among the above listed carcass parameters for o Kereyu and Borana bull respectively.

Economic return on fattening of two years old Arsi bulls

The result of partial budget analysis of fattening of two years aged Arsi bulls fed on three different feeds ration for about 195 days for export market weight gain is indicated in Table 6. Its result showed that experimental bulls fed with T1 had higher gross margin per animal (3507.15) than bulls fed on T2 (2662.54) and T3 (2599.11). Feeding of bulls with T3 (2599.11) is less profitable as compare to T1 and T2. This is because of the high cost of cotton seed cake used in T3. But the cost of molasses used in T1 and the cost of maize grain used in T2 is relatively low as compare to other feeds items used in T3. Hence, fattening of two years old Arsi bulls for 195 days by using three different feeding rations for export/local market weight gain is profitable for all the three feeding rations in general.

Table 6. Partial budget analysis of two years old Arsi Bulls fed on different feed options

List of Items	**T1**	**T2**	**T3**
Number of bulls	9	9	9
Purchasing price/ bull	2596.67	2600	2622.22
Transportation/ animal	50	50	50
Cost of concentrate/ animal	7886.74	8156.76	8842.19
Labor cost per animal	706.03	706.03	706.03
Veterinary cost/animal	71	71	71
Total cost per animal	11310.44	11583.79	12291.44
Gross return per animal	14817.58	14246.33	14890.55
Gross margin per animal	3507.15	2662.54	2599.11

Conclusion and recommendation

There is no statistically significant difference in daily weight gain (DWG), total weight gain (TWG) and final body weight (FBW) and most carcass characteristics of the two years old Arsi bulls which had received the three different feed options for 195 fattening days. This may be because of the similarity of the bulls both in breed and ages. Moreover the same percentage of total CP and TDN were provided for all the experimental animals. On average the experimental bulls which had received dietary T1, T2 and T3 had attained 303.44 kg, 298.44 kg and 299.44 kg body weight, respectively at the end of the fattening period.. Therefore, cattle fatteners can use one of the three feed options, depending on availability and accessibility of the feeds, for fattening two years old Arsi bulls for export market/local as the animals could attain the required weight of 250-300 kg within 195 days of feeding..

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Evaluation of different feeding options for one year old Kereyu-Bulls to attain local/export market weight

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Abstract

The study was conducted at Adami Tulu agricultural research center to evaluate and identify the most economical feeding options for one year old Kereyu bulls for them to attain a 300 kg export market weight demand and to evaluate the carcass characteristics of the animals. Three feeding treatments (T1=Rhodes hay +20% molasses+ 40% wheat bran+ 40% Noug cake, T2 = Rhodes hay +20% maize grain+45% wheat bran+35% Noug cake and T3= Rhodes hay + 65% wheat bran+ 35% cotton seed cakes) were evaluated. Complete Randomized Block Design was implemented to assign nine Kereyu bulls to the three treatments. During the whole experimental period, all the experimental bulls were supplemented daily with their respective rations at the rate of 2.5% of their body weight.. The results revealed that there is no significant difference in daily weight gain, total weight gain, final body weight and carcass characteristic of the bulls received the three dietary feeds for 179 fattening days.

Key words: Kereyu bulls, export weight, carcass and concentrate feeds

Introduction

Ethiopia has the largest cattle population in Africa with an estimated 59.5 million heads of animals (CSA, 2016/2017). Cattle with their large number and diverse products contribute about 12% and 33% of the total and the agricultural GDPs, respectively. However, the earning from exporting of live animals and processed meat is very small as compared to the potential of the country. The average Ethiopian beef yield per animal of 135 kg is by far less than the 146 kg for Africa and 205 kg for the whole world (Asfaw *et al.*, 2011; Yesihak and Webb, 2015; Zekarias, 2016).

Different feed options fed to cattle of different age groups for different length of fattening periods played a significant role in bringing the animals to export market weight required.. In addition to the effect of dietary feeds, various fixed effects have their own role on growth performance and carcass characteristics of animals among these factors breed and age of the animals played an important role.

The effort made so far regarding fattening of beef cattle at different research centers less targeted the export market weight demand. Mainly they targeted domestic markets. To solve the underlying constraints different research proposals were developed by different agricultural research institutions in order to release feasible and promising fattening technologies for end users. To this end, previous studies (Girma *et al.,* 2015, Mieso *et al,* 2013 and Tesfaye A.T *et al.*, 2017) conducted to evaluate different feeding options on different cattle breeds of varied ages groups has played a vital role in improving the foreign currency earning the country can get from the sale of meat and live animal. Moreover, conducting such cattle fattening activities can bring a significant change on income of the fatteners. Hence, this study on evaluation of feeding options for one year old Kereyu bulls was developed to cover the following objectives.

Objectives

- To evaluate and identify the most economical feeding options for one year old Kereyu bulls fed on different feed options for the bulls to attain export market weight of 250 - 300kg.
- To evaluate the growth and carcass characteristics of Kereyu bulls.

Materials and methods

Description of the study area

The experiment was conducted at Adami Tulu Agricultural Research Center, which is located in mid rift valley at 167 km from the capital city Addis Ababa, Ethiopia at an altitude of 1650 m above sea level. The agro ecological Zone of the area is semi-arid and sub humid with acacia woodland vegetation type. The mean annual rain fall of the area is 760 mm and its mean minimum and maximum temperatures are 12.6 and 27^{o}C, respectively.

Experimental animals

For this experiment 24 one year old Kereyu bulls were purchased from Fantale market. The purchased bulls were transported to Adami Tulu agricultural research center and the animals were kept under quarantine in a separate barn and were treated against internal and external parasites before the commencement of the fattening trial. The animals were also vaccinated to control the most important diseases in the area.

Dietary feeds treatments

The following three different supplementary concentrate feeds were used.

T1 = Rhodes hay +20% molasses+ 40% wheat bran+ 40% Noug cake

T2 = Rhodes hay +20% maize grain+45% wheat bran+35% Noug cake

T3= Rhodes hay + 65% wheat bran+ 35% cotton seed cakes.

The DM, total CP and TDN content of the feeds is depicted in Table1.

Table 1. Chemical composition of the supplementary concentrate feeds

Type of feeds	Treatment	DM%	CP%	TDN%

Molasses	T1	20	1.16	14.4
Wheat bran	T1	40	5.52	26.80
Noug cake	T1	40	11.9	26.4
Total		**100**	**18.58**	**67.6**
Maize grain	T2	20	2	17
Wheat bran	T2	45	5.85	30.15
Noug cake	T2	35	10.41	23.1
Total		**100**	**18.26**	**70.25**
Wheat bran	T3	65	8.45	43.55
Cotton seedcake	T3	35	9.8	26.25
Total		**100**	**18.25**	**69.8**

Where:- *DM= dry matter, CP = crude protein and TDN= total digestible nutrient*

Feeding the experimental animals

In addition to hay feeding, every day all the experimental bulls were supplemented with the above mentioned concentrate feeds at the rate of 2.5% of their body weight throughout the fattening period. This provision of concentrate was adjusted every two weeks depended on the weight change of the experimental bulls during the whole fattening period. All experimental animals were individually fed their respective diet for the whole experimental period. The daily allocated feed was divided into two equal amounts to offer twice per day; half in the morning and half in the afternoon. Feeding of the experimental bulls was extended to 179 days until the bulls had attained, on average, the required export body weights of 250-300kg. Average daily weight gain (ADG) of the bulls was calculated using the following formula.

$$ADG = \frac{(FWT - IWT)}{D}$$

Where: FWT = Final body weight, IWT = Initial body weight, D = number of fattening days

E*valuation of Carcass Characteristics*

At the end of the experimental period three fattened bulls were randomly selected from each treatment group and slaughtered at Adami Tulu Agricultural Research Center abattoir. Then the animals were skinned, all important internal organs such as kidney, heart, liver, lung, spleen, empty gut, heart fat, kidney fat, mesenteric and omental fat were eviscerated and the required carcass parameters were individually measured. The hot carcass were dissected symmetrically into right and left parts with the help of modern electrical carcass cutting machine and the weight of each part of the entire carcass was measured before the carcass was put into cold room at -4^{o}c for about 24 hours. After 24 hours stay, the cold carcasses parts were measured again to evaluate the difference in weight change between the hot and the cold carcass of each slaughtered animal. To evaluate the chilled carcass characteristics, the right parts of each slaughtered bull were cut into five major carcass parameters.

Partial budget analysis

All costs incurred for fattening the experimental bulls using the three dietary feeds were recorded in order to calculate economic returns of fattening the bulls. Total variable costs incurred, such as animal purchase, transportation, feeds, labor and veterinary costs were collected. The gross output/revenues from the bulls were estimated at the end of the fattening period by the help of three persons who have enough knowledge on prices of fattened animals. Fixed costs incurred and the cost of grazing was not included in the analysis. Hence, this partial budget analysis indicates only gross margin of fattening bulls using the three different feed options.

Statistical analysis

Data of all live weights and carcass parameters were analyzed using the general linear model (GLM) of Statistical Analysis System (SAS, 2002). The estimated least squares means were separated using the Duncan's Multiple Range Test at $P< 0.05$.

Results and discussion

Effects of dietary feeds on weight gains

Least-square means (LSM) of final body weight (FBW), total weight gain (TWG) and average daily weight gains (ADG) of the bulls fed on the different rations are indicated in Table 2. The results showed that there are no statistically significant differences ($P>0.05$) in ADG, TWG and FBW among T1, T2 and T3. However, the experimental bulls fed on T3 gained more weights (ADG of 807.26g, TWG of 144.50kg) and attained higher FBW (291.63) than the experimental bulls fed on T1 and T2. This result agrees with the previous findings by Tesfaye et *al(2017*), for two years-old Kereyu bulls and Tewodros *et al*. (2017) for two years old Fogera bull fed with the same type of feeds. The final body weight attained in the present study was almost similar with what Tesfaye et *al (2017)*, reported for two years-old Kereyu bulls fed on the same feeding options .

Table 2. Body weight gain of one-year old Kereyu bulls fed on different feeds for 179 fattening days

Parameter	**T1**	**T2**	**T3**
ADG (g)	765.36 ±44	779 ±31.98	807.26 ±23.15
TWG (kg)	137 ±7.92	139.50 ±5.73	144.50 ±4.14
FBW (kg)	284.13± 12.96	286.75 ±10.27	291.63 ±6.24

Where ADG = average daily gain, TWG= total weight gain, FBW= Final body weight, T1= treatment one, T2= Treatment two and T3= Treatment three.

The daily weight gain (807.26 gm) of bulls fed on T3 is more or less similar with the finding of Tesfaye A.T., *et al* (2017) who reported the daily weight gain of 810 gm for two years old Kereyu bulls fed with similar ration. The one year old Kereyu bulls approached more or less the required 250 to 300 kg of export market weight demand at 179 days of feeding. This is duration is shorter when compared with the 224 fattening days taken by one year old Borana bulls to reach a 300 kg body weight (Mieso G., *et al* 2013). On the other hand, the final body weight of the one year old Kereyu bulls at 179 fattening days is similar with the FBW of attained by two years old Kereyu at 168 fattening days (Tesfaye A. T., et al 2017). The trend of daily weight gain of each experimental bulls fed on three different feeds over the whole 179 fattening days is indicated in figure 1. The weight change of one year old Kereyu bulls were steadily decreased as the number of the fattening period increased from 140 days to the end of the fattening period. This result disagrees with report of Mieso G., *et al* (2013) in which the ADG of one year old Borana bulls decreased as the number of the fattening period increased beyond 70 days.

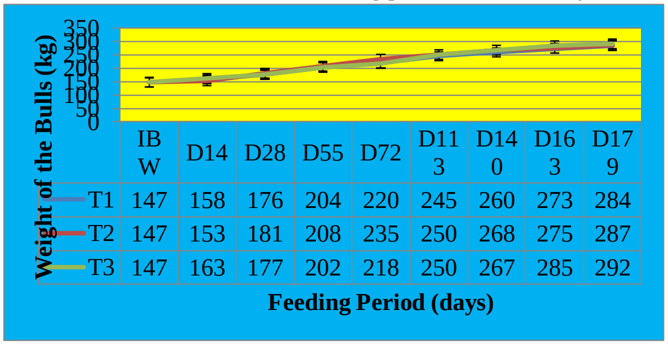

Figure 1. Body weight change of one year old Kereyu bulls over the total fattening period
Where: - IBW=initial body weight, D14= day 14, D28= day 28, etc up to D179=day 179th

Effects of dietary feeds on carcass components

The result of carcass evaluation of the bulls fed on the three different feed options is shown in Table 3. As the result reveals the carcass composition of the experimental bulls fed on different feed options did not vary statically. However experimental bulls fed T3 registered higher SWT, HCW, and lower Bone, lean and Fat parameters when compare to bulls fed on T1 and T2. Animals fed on T3 (Rhodes hay + 65%wheat bran+ 35% cotton seed cakes) had lower fat composition than animals fed on the other two treatments. This result is similar with the finding of Mieso *et al* (2013), who indicated the absence of significant difference in carcass components among yearling Borana bulls

Table 3. Carcass parameters of yearling Kereyu bulls fed the three feed options

Parameter	Treatments		
	T1	T2	T3
SWT	295.75 ± 16.66	293.25± 17.04	297.00 ± 3.34

HCW	149.25 ± 11.84	147.00 ± 14.75	151.00 ± 1.09
LEAN	52.51 ± 2.80	52.48±2.07	49.33±1.84
BONE	14.78 ± 0.33	12.83±0.21	12.28±0.33
FAT	16.91±2.35	16.06±1.16	12.29±0.57
Dressing %	50.29	49.77	50.84

Where:- SWT = Slaughter weight, HCW = Hot carcass weight , T1 = treatment one, T2 = Treatment two and T3 = Treatment three.

The bone, fat and muscle ratios of the bulls fattened for 179 days on the three different feeds option is indicated in Figure 2.

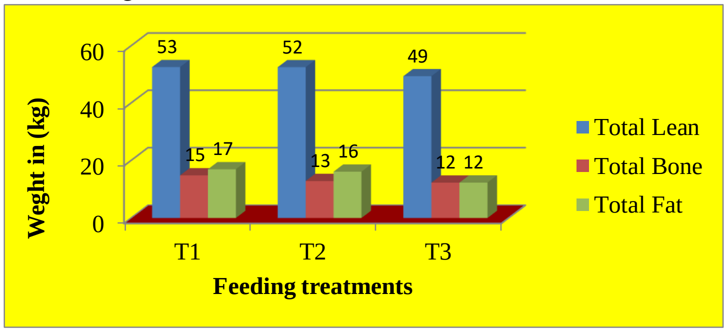

Figure 2. Fat, muscle and bone proportions of the bulls

Dietary effect on non-edible parts (Offals)

Even if slight variations were observed among bulls fed different rations in some non-edible parts; there were no significant differences in all of the offal measurements among the bulls. This is indicated in Table 4.

Table 4. Least square mean of offal measurements of yearling Kereyu bulls fed the different feeds

Parameter	Treatments		
	T1	T2	T3
Tail	0.81±0.01	1.03±0.15	0.69±0.01
Feet with hooves	5.65±0.36	4.70±0.21	4.74±0.08
Lung and Trachea	2.89±0.31	2.71±0.15	2.36±0.10
Heart fat	0.53±0.06	1.00±0.13	0.93±0.23
Spleen	1.01±0.05	1.01±0.10	0.93±0.05
Kidney fat	4.04±0.57	4.45±0.46	3.54±0.59
Bladder	0.11±0.01	0.13±0.01	0.10±0.04
Liver + Bile	4.21±0.41	4.20±0.53	3.65±0.26
Pelvic fat	1.24±0.26	1.50±0.15	1.40±0.24
Omental fat	3.58±0.24	4.13±0.29	3.44±0.42

Testicle	0.64±0.06	0.50±0.03	0.46±0.04
Penis	0.50±0.02	0.44±0.03	0.44±0.02
Scrotal fat	2.06±0.23	2.40±0.02	1.64±0.16

This result is similar to what has been reported by Tesfaye and Tasfa (2007) for Kereyu bulls fattened on different finishing rations

Economic return on fattening of one year old Kereyu bulls

The result of partial budget analysis of fattening the one year old Kereyu bulls fed on the three different feeds for 179 days is indicated in Table 5. The results showed that experimental bulls fed on T1 had higher gross margin per animal (4813.00) than bulls fed on T2 (4521.23) and T3 (3638.30). Feeding with T3 is found to be less profitable as compare to feeding with T1 and T2. This is because of the high cost of cotton seed cake used in T3. But the cost of molasses used in T1 and the cost of maize grain used in T2 are relatively low as compare to other feed items used in T3. In general, fattening one year old Kereyu bulls for 179 days for export/local market by using any of the three different feeding rations is profitable. .

Table 5. Partial budget analysis of fattening yearling Kereyu Bulls on different feed options

List of Items	**T1**	**T2**	**T3**
Number of bulls	8	8	8
Purchasing price/ bull	2144.75	2069.75	2125
Transportation/ animal	300	300	300
Cost of concentrate/ animal	6439.23	6722.83	7271.16
Labor cost per animal	787.5	787.5	787.5
Veterinary cost/animal	59	59	59
Total cost per animal	9730.48	9939.08	10542.66
Gross return per animal	14543.48	14460.31	14180.96
Gross margin per animal	4813.00	4521.23	3638.30

Conclusion and recommendation

From the result of the experiment, it can be concluded that even if there are numerical differences, there are no statistically significant differences in daily weight gain (DWG), total weight gain (TWG), final body weight (FBW) and carcass characteristics among the one year old Kereyu bulls received the three different feed options for 179 fattening days. This may be because of the similarity of the bulls both in breed and age. Moreover the same percentage of total CP and TDN were provided for all of the experimental animals. Economic analysis of the different dietary treatment groups showed that, all the three feeding options are profitable for fattening growing Kereyu bulls and to obtain the required export market weight. Therefore, cattle fatteners can use one of the three feed options, depending on availability and accessibility of the feeds, for fattening one year old Kereyu bulls for export/local markets as the animals could attain the required weight of 250-300kg within 179 days of feeding.

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Effect of different mixture of molasses and atella on growth responses of two year old Arsi-Bale rams

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Abstract

The study was conducted at Adami Tulu Agricultural Research Center on two years old Arsi-Bale rams. Twenty four rams were purchased from the Maki, Batu and Bulbula markets. The study was carried out to evaluate the effects of feeding different mixture of molasses and atella on growth responses of two years old Arsi-Bale rams. Four feeding treatments (T_1 = Grazing + 10% molasses + 40% wheat bran + 50% noug seed cake, T_2 = Grazing + 30% atella + 50% wheat bran + 20% noug seed cake, T_3 = Grazing + 10% molasses + 40% atella + 25% wheat bran + 25% noug seed cake and T_4 = Grazing + 65% wheat bran + 35% noug seed cake) were evaluated during the fattening period. Complete Randomized Block Design was implemented to assign six rams to each of the four treatments. Average daily live weight gains of 81.9, 76.6, 59 and 91.6 grams were recorded for rams in treatments one, two, three and four, respectively. Significant differences in final body weight, total weight gain and average daily weight gains were observed between treatments three and four. With respect to the levels of atella in the rations, comparatively, higher level resulted in lower growth rate of the rams than the lower level. The partial budget analysis indicated positive gross margins for all treatment groups, with higher values for treatment four and lower values for treatment two. Therefore, fatteners can use one of the feed mixtures for two years old Arsi-Bale rams based on the accessibility and availability of the ingredients to be used to formulate the rations.

Keywords: *Molasses and atella mixture, Arsi-Bale rams, Sheep fattening*

Introduction

Ethiopia has above 30 million heads of sheep (CSA, 2017). Beside large population, sheep production is very low. Carcass yield of local small ruminants remained at about 8 kg per head which was below the East African (11 kg) and the world (12 kg) average carcass yield (Getahun L, 2008). In Ethiopia, the current per capita consumption of meat is 13.9 kg/year, being lower than the African and the world per capita averages, which are 27 kg/year and 100 kg/year, respectively (Tsigereda *et al*., 2016).

The traditional livestock fattening practices mostly depend on the natural pasture (Belay and Menale, 2017). Under such systems, livestock production mostly depends on increase of animal numbers rather than targeting higher carcass weight per animal. Productivity increment through increase of animal numbers alone is unlikely to meet the current meat demand of country (Shapiro *et al*., 2015). Therefore, improving the live weight gain of animals through fattening is an important issue to increase meat production. Livestock fattening is also an emerging sector for employment and income generation for the poor, especially the landless, destitute and widowed women and a hence is a tool for poverty reduction (Zemene *et al.,* 2016).

The live weight gain of our sheep is affected the availability of feeds. To this end, using different feed mixtures is an important issue to increase the meat production in our country. However there is limited information on the use of different mixtures for fattening, particularly, for our local sheep. Hence, this study was conducted to evaluate the effects of different mixtures of molasses and atella on the growth responses of two years old Arsi-Bale rams.

Materials and Methods

Description Study site

The study was conducted at Adami Tulu Agricultural Research Center, which is located in mid rift valley, at 167 km from Addis Ababa, at an altitude of 1650 m above sea level. The agro ecological zone of the area is semi-arid and sub humid with acacia woodland vegetation. The mean annual rain fall of the area is 760 mm. Its mean minimum and maximum temperatures area 12.6 and 27^0c, respectably.

Experimental animals

Twenty four Arsi-Bale sheep were purchased from the Meki and Bulbula markets of the East Shoa Zone of Oromia Region. Experimental animals were treated for both internal and external body parasites. Purchased rams were kept under quarantine in separate barn and they were treated against internal and external parasites before the commencement of the fattening trial. All experimental rams were randomly assigned to one of the four treatment groups.

Experimental feeds

The following four different feed mixtures were used:

T_1 = Grazing + 10% molasses + 40% wheat bran + 50% noug seed cake

T_2 = Grazing + 30% atella + 50% wheat bran + 20% noug seed cake

T_3 = Grazing + 10% molasses + 40% atella + 25% wheat bran + 25% noug seed cake

T_4 = Grazing + 65% wheat bran +35% noug seed cake

Feeding of experimental animals

After 14 days of adaptation period, rams were provided with their respective supplementary feed according to their requirements at the rate of 2.5% of their body weight. The amount of feed given to each animal was adjusted every two weeks during the fattening period. Each dietary treatment was offered twice daily (half in the morning and half in the afternoon after 8 hours grazing) for the respective groups of animals. All the experimental rams were individual fed on their corresponding rations for the fattening period.

Growth performance measurement

$$\mathbf{ADW} = \frac{(\boldsymbol{FBW} - \boldsymbol{IBW})}{\mathbf{D}}$$

$$\boldsymbol{TWG = FBW - IBW}$$

Where: ADG = Average daily weight gain, TWG = Total weight gain, FBW = Final body weight, IBW = Initial body weight and D = Total of fattening days

Economic returns on rams fattening

All variable costs incurred in conducting the trial were recorded. Total variable costs such as animals purchase, transportation, feeds, labor and veterinary costs were included in the partial budget analysis. The gross output/revenues were obtained from the estimated prices of the rams at the end of the fattening periods which was done by the help of persons who have enough knowledge on prices of fattened animals. The fixed costs incurred for feeding animals were not included in cost benefit analysis.

Statistical analysis

Data on live weights and carcass parameters were analyzed using general linear model (GLM) of Statistical Analysis System (ver. 8). The estimated least squares means were separated using the Duncan's Multiple Range Test at $P< 0.05$.

RESULT AND DISCUSSION

Effects of molasses and atella mixtures on growth performance of rams

Effects of different mixture level of molasses and atella on growth performance of rams are indicated in Table 1. The current study showed significant difference in final body weight, total weight gain and average daily weight gains between animals fed treatments T_3 and T_4. Animals in T_4 (65% wheat bran + 35% noug seed cake) have the highest mean values of the above mentioned parameters as compared to those in T_2, T_1 & T_3. No statistically significant differences in final body weight, total and average daily weight gains among rams fed T_1, T_2 and T_3. However, rams fed on feed mixture T_1 (mixture of molasses with concentrate) were attained the higher body weight gain as compared to those fed on feed mixture groups T_2 and T_3.

Table 1: Effect of different mixture level of molasses and atella on growth performance of Arsi-Bale rams

Feed mixtures	IBW(kg)	FBW(kg)	TWG(g)	ADG(g)
T_1	24.2	30.3 ± 0.8^{ab}	6142.8 ± 384.7^{ab}	81.9 ± 5.1^{ab}
T_2	24	29.7 ± 0.74^{ab}	5750 ± 359.9^{ab}	76.6 ± 4.8^{ab}
T_3	23.9	28.4 ± 0.8^{a}	4428.6 ± 384.8^{a}	59 ± 5.1^{a}
T_4	24.21	31 ± 0.75^{b}	6875 ± 359.9^{b}	91.6 ± 4.8^{b}

[a,b,=] *Values in a column followed by different superscripts are significantly different (P<0.05)*

The rams fed the higher percentage of attela mixed with molasses, Wheat bran and Noug seed cake (T3 vs T2) were attained lower total weight gain than the others groups. This may correlate to the level of protein since it has low protein and higher energy nutrient than all treatments. However weight gains of rams fed T_3 are relatively similar to Abera sheep (65 g/day) that were supplemented with concentrate feed 100 gram per day (Mereset, 2016). Similarly study conducted at Debre Zeit Agricultural Research Center (Getahun, 2014) also indicated that Black Head Ogaden sheep which fed teff straw ad-libtum and 450 gram concentrate per day had average daily weight gain of 65.2 g/day. Atella is byproduct of traditional tella/local ketikela and considered as non-conventional livestock feeds (Solomon Demeke, 2007). Quality of Atella might not consistency because it matters by ingredients, time and skills of makers.

Partial budget analysis

Table 2: Partial budget analysis of fattening two years old Arsi-Bale rams

List of items	**T1**	**T2**	**T3**	**T4**	**Overall**
Feeds costs per ram (Birr)	198	185.65	150.25	210.5	186.1
Purchasing price per ram (Birr)	1400	1400	1400	1400	1400
Labor cost per ram (Birr)	109.5	109.5	109.5	109.5	109.5
Veterinary cost per ram (Birr)	25	25	25	25	25
Total variable coast per ram (Birr)	**1732.5**	**1720.15**	**1684.75**	**1745**	**1720.6**
Total gross output per ram (Birr)	2100	2100	2000	2200	2100
Gross margin per ram (Birr)	367.5	379.85	315.25	455	379.4
Total gross margin (Birr)	**2205**	**2279.1**	**1891.5**	**2730**	**2276.4**

Partial budget analysis of fattening two years old Arsi-Bale rams are presented in Table 2. Experimental rams fed atella mixture have total less variable cost than other treatment groups due to relatively less cost of atella. Even though high variable cost was incurred in T_4 the gross profit margin is also higher than rams fed molasses and atella mixture. The Arsi-Bale rams fed on T_4 were gained more body weight during fattening period.

Conclusion and Recommendation

The 24 Arsi-Bale rams were fed on different levels of Atella and molasses mixture for 75 days. Rams fed on T_4 have attained higher body weight gains followed by T_2 and T_1 respectively. This may be because of the high percentage of total CP and TDN in noug cake that is provided experimental animals in T_4. On average the experimental bulls which had received dietary T_1, T_2, T_3 and T_4 had attained 30.3 kg, 29.7 kg, 28.4 kg and 31.00 kg body weight, respectively at the end of the fattening period. Finally, further study is needed to know the optimum level of atella and molasses mixture in the feed rations. The partial budget analysis indicates that all groups of Arsi-Bale rams had positive gross margin. Therefore, fatteners can use one of the T_4, T_2 and T_1 based on the availability of the feed resources in the area to fatten two years old Arsi-Bale rams for local markets.

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Effect of Different Varieties of Vetch Hay Supplementation on Feed Intake, Digestibility, Body Weight Change and Carcass Characteristics of Arsi-Bale Sheep Fed a Basal Diet of Fodder Oat Hay

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ABSTRACT

Different species and varieties of fodder oats and vetches were identified to successfully adapt and perform in the highlands of Bale. However, their feeding value was not well evaluated. Therefore, animal experiment was conducted using thirty five yearling intact male Arsi-Bale sheep with initial body weight of 21.4±0.6 Kg (Mean± SD) with the objectives of investigating the varietal differences of vetch hay supplementation on feed intake, digestibility, body weight change and carcass characteristics of Arsi-Bale sheep and to evaluate the potential of fodder oat and vetch hay based feeding for sheep. The sheep were blocked into seven blocks of five animals based on their initial body weight and animals within each block were randomly assigned to one of the five treatment diets. The treatment diets were; ad libitum fodder oat hay alone (T1) and ad libitum fodder oat hay supplemented with 350g DM hay of four vetch varieties, namely; Gebisa, Lalisa, Abdeta and Vicia sativa for T2, T3, T4 and T5, respectively. After 21 days of quarantine period and 15 days of acclimatization to the experimental diets and pens, feeding and digestibility trials were conducted for 90 and 7 days, respectively. Finally carcass evaluation was conducted by slaughtering all animals. The crude protein (CP) contents of fodder oat, Gebisa, Lalisa, Abdeta and V.sativa hay were 8.9, 21.1, 19.5, 18.0 and 18.4%, respectively. Total dry matter (DM) intake was significantly higher (P<0.05) for T2 as compared to T1, T3 and T4. The CP intake, DM digestibility, average daily body weight gain (ADG) and hot carcass weight (HCW) were significantly highest (P<0.001) for T2. The proportion of muscle (61.5-63.9%) and fat (16.1-19.8%) were not significantly different (P>0.05) among treatments, while proportion of bone (18.5-21.0%) was significantly higher (P<0.01) for T1 as compared to T2, T3 and T4. In conclusion, supplementation of Gebisa vetch variety (T2) induced highest growth performance and carcass characteristics of sheep than all other treatments and is therefore, recommended.

Key words: *Arsi-Bale sheep; Body weight; Carcass; Feed intake; Fodder oat; Vetch hay*

1. INTRODUCTION

Livestock production plays important role in Ethiopia's economy in general and smallholder farmers in particular. Sheep are among the major economically important components of the livestock subsector. Despite their numeric and economic importance as well as the tremendous potential, the livestock sub sector has remained under utilized due to a multitude of constraints (Azage *et al.*, 2010). Among livestock production constraints, shortage of feed resources in quantity and quality and poor feeding systems were repeatedly reported as a major constraints hampering livestock production and productivity in different parts of Ethiopia (Dawit *et al*., 2012; Zewde and Elias, 2015; Endale *et al*., 2016). One of the alternatives to improve livestock feeding, and thereby their productivity could be the cultivation of improved forage crops and offer to animals during critical periods in their production cycle and when other sources of feeds are in short supply (Alemayehu, 2002). Forage species such as vetch and fodder oat are high potential feed sources to fill the gap of feed shortage.

Two oat varieties namely; Bonsa and Bona-bas (Dawit and Teklu, 2011) and three vetch varieties namely; Gebisa, Lalisa and Abdeta (Dawit *et al.*, 2011) were released from Sinana Agricultural Research Center for their superiority in terms of yield and quality based on chemical analysis only without evaluating their feeding value by feeding to animals. However, chemical analysis alone will be of limited value in predicting the nutritive value of feed resources, which may contain antimicrobial compounds that inhibit intake and digestibility or materials toxic to animals (El Hassan *et al*., 2000). Therefore, the objectives of this study were:

- To investigate the effect of varietal differences of vetch hay on feed intake, digestibility, body weight change and carcass characteristics of Arsi-Bale Sheep
- To evaluate the potentials of fodder oat and vetch hay based feeding for sheep

2. MATERIALS AND METHODS

2.1. Description of the Experimental Area

The experiment was conducted in 2016/2017 at Sinana Agricultural Research Center (SARC), which is located in Bale Zone of Oromia National Regional State, South Eastern Ethiopia. The research center is situated 463 km southeast of Addis Ababa at 07^0 07' N latitude and 40^0 10' E longitude and at an altitude of 2400 m above sea level. The area is characterized by bimodal rainfall pattern with total annual precipitation ranging from 750 to 1000 mm and the mean annual maximum and minimum temperature are 21^0C and 9^0C, respectively (SARC, 2014).

2.2. Experimental Feeds Preparation

The experimental feeds, all varieties of vetch and fodder oat, were sown according to their respective agronomic practices during the main rainy season (August-December) of the area on a plot size of $1200m^2$ for each vetch varieties and $7500m^2$ for oat. The vetch varieties were harvested at 50% flowering, while fodder oat was harvested at heading stage during which they give optimum performance in terms of dry matter yield and nutritive value (SARC, 2015). The harvested fresh forages were field-cured and stored as hay under a roofed shelter to protect from rain and intense sun light. During the feeding period, the oat and vetch hays were chopped to about 3-5 cm in length to make uniform for sampling and easier to be seized by the animals.

2.3. Experimental Animals and their Management

Thirty-five yearling intact male Arsi-Bale sheep with similar body weight were purchased from the nearby markets at Alemgena, Hisu and Selka. The age of the sheep was estimated based on dentition and asking information from the owners of the sheep. The sheep were held in quarantine for 21 days and observed for any health problem. During this time, the sheep were vaccinated against ovine pasteruolosis, anthrax and sheep pox and dewormed against internal and external parasites. The animals were placed in individual pens equipped with a bucket and a feeding trough in a well-ventilated concrete floor experimental barn.

2.4. Experimental Design and Treatments

A randomized complete block design consisting of five treatments and seven blocks was used for the study. The treatment diets (Table 1) were randomly assigned to each sheep in the blocks. The basal diet (fodder oat hay) was offered *ad libitum* to all experimental animals based on previous few days' intake at about 15% refusal while the supplementary feeds were offered in two equal meals at 8:00 AM and 4:00 PM in separate feeding troughs. Drinking water and common salt block were freely available to all experimental sheep throughout the experimental period.

Table 1. Dietary treatments

Treatments	**Fodder oat hay**	**Vetch hay supplements (DM g/day)**			
		Gebisa	**Lalisa**	**Abdeta**	***Vicia sativa***
T1	*Ad libitum*	0	0	0	0
T2	*Ad libitum*	350	0	0	0
T3	*Ad libitum*	0	350	0	0
T4	*Ad libitum*	0	0	350	0
T5	*Ad libitum*	0	0	0	350

2.5. Feeding Trial

After an acclimatization period of 15 days to the experimental diets and pens, the feeding trial was conducted for 90 days. The daily feed offered and refusals were weighed and recorded for each sheep. Daily dry matter and nutrient intake were calculated as the difference between the feed offered and refused. Samples of feed offered were collected per batch while samples of refusal were taken from each sheep daily and pooled per animal individually over the experimental period and stored in plastic bags. Sub-samples of feed offered and refusals were taken after thorough mixing for determination of nutrient composition, and the sub-samples taken were dried at 60°C for 72 hours in a forced draft oven to make it ready for grinding and chemical analysis.

2.6. Body Weight Change and Feed Conversion Efficiency

Body weight of the animals was taken at the beginning of the feeding trial and at 10 days interval during the 90 days of feeding. All animals were weighed in the morning hours before feed provision using weighing balance with a sensitivity of 100 grams. Average daily body weight gain was calculated as the difference between final live weight and initial live weight divided by the number of feeding days. Feed conversion efficiency was determined by dividing the daily average body weight gain (ADG) by daily total DM intake of the animal.

$$\text{Average daily body weight gain} = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Number of feeding days}}$$

$$\text{Feed conversion efficiency} = \frac{\text{Average daily body weight gain in gram}}{\text{Daily dry matter intake in gram}}$$

2.7. Digestibility Trial

Digestibility trial was conducted at the end of the feeding trial and all sheep were harnessed with a fecal collection bag to collect feces for determination of digestibility. The sheep were accustomed to the fecal collection bags for three days. This was followed by collection of feces for seven consecutive days. During this period, feed offered and refused were recorded and samples of feed offered were pooled per treatment, while samples of feed refused were pooled per animal individually. Fresh feces were collected into a fecal collection bag fitted to the animal. The total fecal output was collected by emptying the bag twice per day at 6:00 AM and 6:00 PM per animal and were weighed and recorded for each sheep throughout the digestibility trial. The feces was weighed fresh, thoroughly mixed and 20% of the feces were sampled for each sheep and stored in a deep freezer at -18°C. The samples were pooled per animal across the collection period and 20% of the composite sample was taken, weighed and partially dried at 60°C for 72 hours. The partially dried fecal samples were milled by Wiley mill to pass through a 1mm sieve and stored in airtight polyethylene bags pending chemical analysis. Apparent digestibility of DM and other nutrients were determined as a percentage of the nutrient intake not recovered in the feces using the following formula (McDonald *et al.*, 2010).

$$\text{Percent apparent digestibility} = \frac{(\text{Nutrient intake} - \text{Nutrient in feces}) \times 100}{\text{Nutrient intake}}$$

2.8. Carcass Parameters

At the end of the experiment, the sheep were fasted overnight, weighed and slaughtered for carcass evaluation. The weights of each edible offal components were recorded. After removal of edible and non-edible offal components, the hot carcass of each sheep was weighed and recorded. The main carcass components were split down at the vertebral column having the two sides as symmetrically as possible and stored in a deep freeze at -4^{0}C for 24 hours for properly partitioning the carcass in to bone, muscle and fat. The right part of the frozen carcass was divided in to five main primal cuts namely: leg, loin, rack, breast and shank and shoulder and neck. The carcass was cut perpendicular to the backbone between the 12th and 13th ribs to measure the cross-sectional area of the rib eye (*longissimus dorsi*) muscle area. The five main primal cuts were partitioned to bone, muscle and fat and each part was weighed and recorded. The dressing percentage was calculated as the proportion of hot carcass weight to slaughter and empty body weight.

2.9. Laboratory Analysis

Samples of feed offered, refusals and feces were ground to pass through a 1 mm sieve mesh. Analysis for DM, ash and N contents was done according to AOAC (2005) procedures. Total nitrogen (N) content was determined by using Kjeldahl method and crude protein (CP) was calculated as N×6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by using the procedures of Van Soest and Robertson (1985). The energy value of the treatment feeds was estimated according to McDonald *et al*. (2010) as metabolisable energy (ME, MJ/Kg DM) = 0.016 x DOMD; where DOMD (g) indicates digestible organic matter per kilogram of dry matter.

2.10. Statistical Analysis

The statistical model used for data analysis was:

$$\mathbf{Y_{ij} = \mu + T_i + B_j + E_{ij},}$$

where: Y_{ij} = Response variable; μ = Overall mean; T_i = Treatment effect; B_j = Block effect; E_{ij} = Random error

Data collected were subjected to analysis of variance (ANOVA) using the GLM procedure of SAS (SAS, 2004) version 9.1. When significant, Duncan's Multiple Range Test (DMRT) was employed to locate differences between the treatment means.

3. RESULTS AND DISCUSSION

3.1. Chemical Composition of Experimental Feeds and Refused Feed

The 8.9% CP content of fodder oat hay used in this study was slightly lower than the 11.5% CP content of the same variety reported by Dawit and Teklu (2011) and 10.6% reported by SARC (2015). Although the CP content of fodder oat hay used in this study was lower than previous reports, it was higher than the 7% CP required for microbial protein synthesis in the rumen that can support at least the maintenance requirement of ruminants (Van Soest, 1994). The CP content of Abdeta and Lalisa vetch varieties was also lower than the 24.8% and 24.1% CP content of the same varieties, respectively reported by Dawit *et al.* (2011). The lower CP content of experimental feeds registered in this study might be due to losses of the leaf fractions which contain high CP while curing the experimental forages in the field.

Table 2. Chemical composition of experimental feeds and refused feeds

Feed offered	DM%	Ash	OM	CP	NDF	ADF	ADL	HC	Cell
					%DM				
Fodder oat hay	87.2	10.6	89.4	8.9	53.7	30.0	2.7	23.7	27.3
Vetch hay supplements									
Gebisa	87.5	15.0	85.0	21.1	36.5	27.1	5.0	9.4	22.1
Lalisa	87.1	15.7	84.3	19.5	48.3	36.9	7.7	11.3	29.2
Abdeta	86.6	11.9	88.1	18.0	39.6	28.8	4.6	10.8	24.1
V. sativa	87.7	17.9	82.1	18.4	42.1	32.0	6.4	10.1	25.7
Fodder oat hay refusal									
T1	84.7	9.9	90.1	7.3	59.0	33.4	2.9	25.6	30.5
T2	84.3	9.9	90.1	7.5	56.5	32.9	2.5	23.6	30.4
T3	84.2	10.1	89.9	7.5	57.4	33.4	2.9	24.0	30.5
T4	83.4	10.4	89.6	7.4	58.6	32.7	2.8	25.9	29.9
T5	84.9	9.9	90.1	7.5	56.5	32.6	3.3	23.9	29.3

ADF=Acid Detergent Fiber; ADL=Acid Detergent Lignin; Cell=Cellulose; CP=Crude Protein; DM=Dry Matter; HC=Hemicelluloses; NDF=Neutral Detergent Fiber; OM=Organic Matter;.

The CP content of fodder oat hay refusal in this study was lower by 15.7% for T2, T3 and T5 and by 18 and 16.9% for T1 and T4, respectively, as compared to the CP content of the offered fodder oat hay. Fodder oat hay refusals in all treatments had comparatively higher contents of NDF, ADF and cellulose than the basal fodder oat hay offered (Table 2) indicating the selective nature of sheep in feeding more nutritious and palatable portion (leafy part) of the hay than the lignified parts.

3.2. Dry Matter and Nutrient Intake

All sheep readily consumed the dietary supplement without any refusal across the experiment. The sheep in T1 consumed highest ($p<0.001$) amount of fodder oat hay. This could be due to an effort to satisfy their nutrient requirements. Among the supplemented groups, sheep in T2 consumed significantly higher (P<0.001) fodder oat hay than sheep in T3 and T4. In addition, sheep in T2 had higher (P<0.05) total DM intake than sheep in T1, T3 and T4. This was attributed to higher oat hay intake by those sheep in T2, as the level of supplementation on DM basis was the same for all supplemented treatments. Regarding the effect of supplementation on total DM intake, supplementation of vetch varieties increased the total DM intake by 16.1, 6.4, 7.4 and 12.2% for T2, T3, T4 and T5, respectively as compared to T1. This might be due to the fact that supplementation of vetches increased the nitrogen content of the total diet, which in turn increased feed intake and the rate of degradation of the basal diet in the rumen (Topps, 1997).

The result of total DM intake in this study was by far higher than the DM intake previously reported for Arsi-Bale sheep by different authors (Dawit and Solomon, 2009; Ermias *et al.*, 2013; Teklu, 2016). This could be attributed to the better palatability of the basal and supplementary feeds used in this study.

Table 3. Average daily dry matter and nutrient intake of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Intake	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Oat hay DM (g/day)	951.0^{a}	783.1^{b}	665.9^{c}	677.1^{c}	732.8^{bc}	22.19	***
Supplement DM (g/day)	-	350	350	350	350	-	-
Total DM (g/day)	951.0^{c}	1133.1^{a}	1015.9^{bc}	1027.1^{bc}	1082.8^{ab}	17.04	*
DM (%BW)	3.2	3.2	3.2	3.2	3.3	0.03	ns
DM (g/Kg $W^{0.75}$)	75.0	78.6	76.1	76.0	78.4	0.85	ns
OM (g/day)	843.5^{b}	992.1^{a}	887.0^{b}	912.3^{ab}	937.3^{ab}	14.59	*
CP (g/day)	99.9^{c}	154.5^{a}	136.8^{b}	133.4^{b}	139.9^{b}	3.38	***
NDF (g/day)	460.3^{c}	526.4^{ab}	502.0^{abc}	469.0^{bc}	520.3^{ab}	8.07	*
ADF (g/day)	253.0^{b}	307.1^{a}	306.3^{a}	285.6^{a}	312.8^{a}	5.21	***
ADL (g/day)	23.8^{e}	40.2^{b}	43.6^{a}	33.7^{c}	29.4^{d}	1.27	***
HC (g/day)	207.3^{ab}	219.3^{a}	195.4^{ab}	183.4^{b}	207.6^{ab}	3.71	*
Cell (g/day)	229.9^{b}	266.9^{a}	262.7^{a}	251.6^{ab}	275.4^{a}	4.25	**
ME (MJ/day)	8.0^{c}	10.5^{a}	8.5^{bc}	8.9^{b}	9.0^{b}	0.19	***

$^{a, b, c, d, e}$ *means with different superscripts in a row are significantly different; ***= (P<0.001); **= (P<0.01); *= (P<0.05).*

Supplementation of vetch varieties has increased CP intake by 54.7, 36.9, 33.5 and 40% for T2, T3, T4 and T5, respectively, as compared to T1. The highest CP intake (154.5 g/day) in sheep supplemented with Gebisa vetch variety (T2) could be attributed to the highest DM intake of the sheep in the treatment and the highest CP content of Gebisa compared to other vetch varieties (Table 2; Table 3).

The variation among treatments in CP intake in this study was reflected in DM and nutrient digestibility, body weight gain, feed conversion efficiency and carcass characteristics (Table 4;

Table 5; Table 6). When the overall CP intake in this study was observed, it was by far higher than the CP intake previously reported for Arsi-Bale sheep by different authors (Dawit and Solomon, 2009; Ermias *et al.*, 2013; Biruk, 2017). This might be attributed to high DM intake of experimental animals in this study and better CP concentration of the basal diet used for this experiment as it was improved forage with better CP content, lower fiber content and better digestibility than natural grass hay or straw as it was the case in most of the earlier studies.

Supplementation of the vetch varieties increased ME intake by 31.3, 6.3, 11.3 and 12.5% for T2, T3, T4 and T5, respectively. The highest ME intake (10.5 MJ/day) was recorded for those sheep supplemented with Gebisa vetch variety (T2). Similar trend of total DM intake was observed across all treatments as the total DM intake was steadily increasing with a decreasing rate throughout the experiment (Figure 1).

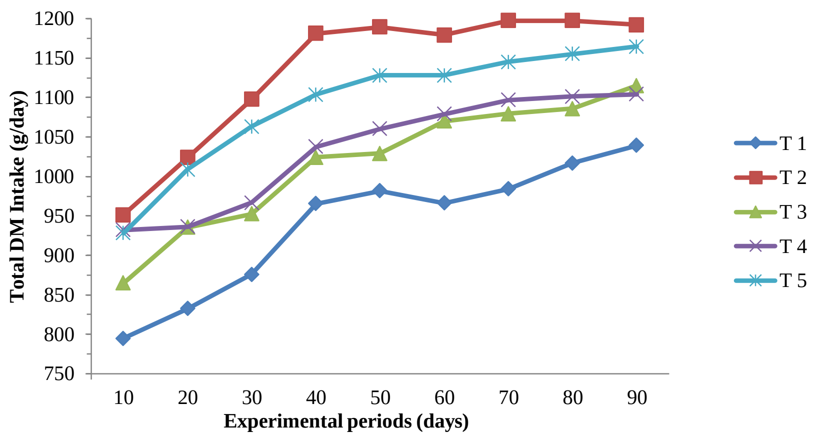

Figure 1. Trends in total dry matter intake of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

3.3. Apparent Dry Matter and Nutrient Digestibility

Supplementation of the vetch varieties increased DM digestibility by 11.6 and 1.9% for T2 and T3, respectively and by 3.6% for T4 and T5 compared to the control. Among the supplemented groups, supplementation of Gebisa vetch variety (T2) induced the highest (65.2%) DM digestibility. This might be associated with the low NDF and ADF concentration of Gebisa vetch variety (T2) and high CP intake of T2 compared to other treatments (Table 2; Table 3).

Improvements in DM and nutrient digestibility due to supplemental protein and/or energy has been well documented by various authors (Dawit and Solomon, 2009; Hunegnaw and Berhan, 2016; Teklu, 2016). This is obviously a result of increased nutrient supply to rumen microbes for their proliferation to be present abundantly to colonize and digest the DM and other nutrients consumed (McDonald *et al*., 2010).

Table 4. Apparent dry matter and nutrient digestibility of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Apparent	**Treatments**						
Digestibility (%)	T1	T2	T3	T4	T5	SEM	SL
DM	58.4^{c}	65.2^{a}	59.5^{bc}	60.5^{b}	60.5^{b}	0.48	***
OM	58.9^{c}	65.9^{a}	59.8^{bc}	61.2^{b}	60.1^{bc}	0.51	***
CP	67.3^{c}	77.6^{a}	71.5^{b}	71.3^{b}	72.8^{b}	0.66	***
NDF	41.4^{b}	49.7^{a}	42.6^{b}	43.0^{b}	44.0^{b}	0.70	***
ADF	36.4^{c}	45.8^{a}	42.0^{b}	42.7^{b}	42.0^{b}	0.69	***
HC	47.7^{d}	60.7^{a}	52.6^{c}	55.4^{bc}	57.4^{ab}	0.96	***
Cell	48.8^{c}	58.5^{a}	51.5^{bc}	54.6^{ab}	56.8^{a}	0.83	***

$^{a, b, c}$ means with different superscripts in a row are significantly different; ***= (P<0.001).

3.4. Body Weight Change and Feed Conversion Efficiency

Supplementation of the vetch varieties increased the ADG of sheep by 68.9, 25.9, 33.6 and 44.3% for T2, T3, T4 and T5, respectively, as compared to the control. Among supplemented groups, the highest ADG (152.5 g/day) was recorded for those sheep supplemented with Gebisa vetch variety (T2). Supplementation of the vetch varieties also improved FCE by 42.1, 16.8, 24.2 and 27.4% for T2, T3, T4 and T5, respectively. Among supplemented groups FCE was highest (P<0.001) for those sheep supplemented with Gebisa vetch variety. This could be attributed to relatively higher DM and nutrient intake of sheep supplemented with Gebisa vetch variety as well as to the higher digestibility of the feed.

The body weight parameters and feed conversion efficiency obtained in the current study by T2 were outstanding when compared with the experiments previously conducted on Ethiopian sheep breeds using different supplementary feeds of forage and concentrate sources. This might be attributed to the outstanding CP intake (Table 3) and important nutrients such as vitamins and minerals found in green feeds like fodder oat and vetch, though this study did not addressed such parameters. Therefore, this study showed that fodder oat and vetch hay based feeding is an advantageous potential feeding strategy that should be given due attention by producers and policy makers as well as livestock professionals in order to, particularly, enhance productivity of sheep under small holder production system, where these feeds can be produced, relatively, easily.

Table 5. Body weight change and feed conversion efficiency of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Parameters	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
IBW (kg)	21.4	21.3	21.4	21.4	21.4	0.10	ns
FBW (kg)	29.5^{d}	35.1^{a}	31.6^{c}	32.2^{bc}	33.1^{b}	0.38	***
BWC (kg)	8.1^{d}	13.7^{a}	10.2^{c}	10.9^{bc}	11.7^{b}	0.37	***
ADG (g/day)	90.3^{d}	152.5^{a}	113.7^{c}	120.6^{bc}	130.3^{b}	4.11	***
FCE (g ADG/g TDMI)	0.095^{c}	0.135^{a}	0.111^{b}	0.118^{b}	0.121^{b}	0.003	***
PCE (g ADG/g TCPI)	0.902^{ab}	0.987^{a}	0.826^{b}	0.905^{ab}	0.933^{a}	0.015	**

$^{a, b, c, d}$ means with different superscripts in a row are significantly different; ***= (P<0.001); **= (p<0.01).

The trends in body weight change showed steady increase across the growth period in all experimental treatments though the rate of increment was declining as experimental day advances (Figure 2).

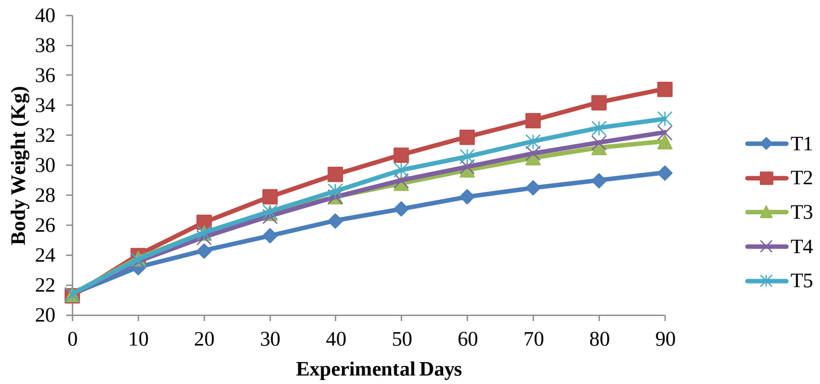

Figure 2. Trends in body weight change of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

3.5. Carcass Characteristics

3.5.1. Main Carcass Parameters

Slaughter body weight (SBW), hot carcass weight (HCW), chilled carcass weight (CCW), empty body weight (EBW) and rib eye muscle area (REMA) were highest (P<0.001) for T2 (Table 6). This might be attributed to the highest DM and nutrient intake of the sheep and the higher digestibility of the feed, which resulted in highest body weight parameters and feed conversion efficiency of sheep in that treatment (Table 3: Table 4; Table 5).

The SBW, HCW, CCW, EBW and REMA obtained by supplementation of the vetch varieties in the current study were by far higher than the values previously reported for Arsi-Bale sheep under different feeding regimes (Ermias *et al.,* 2013; Alem, 2014; Teklu, 2016). Therefore, the result of the current study strongly showed that fodder oat and vetch hay based feeding for livestock is good potential feeding strategy which should be scaled up widely to farmers and livestock investors.

Table 6. Main carcass parameters of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
SBW(kg)	28.9^{c}	34.7^{a}	31.1^{b}	31.8^{b}	32.9^{b}	0.42	***
HCW(kg)	12.4^{c}	15.9^{a}	13.6^{b}	14.1^{b}	14.4^{b}	0.23	***
CCW(kg)	12.2^{d}	15.7^{a}	13.4^{c}	14.0^{bc}	14.3^{b}	0.23	***
EBW(kg)	23.6^{d}	29.1^{a}	25.3^{c}	26.1^{bc}	27.2^{b}	0.38	***
Dressing percentage							
SBW basis	43.0	45.9	43.7	44.5	43.9	0.41	ns
EBW basis	52.6	54.7	53.7	54.2	53.1	0.32	ns
BFT (cm)	0.3	0.4	0.4	0.4	0.4	0.02	ns
REMA (cm^2)	11.5^{c}	14.9^{a}	12.2^{bc}	12.8^{b}	13.3^{b}	0.27	***

[a,b,c,d] means with different superscripts in a row are significantly different; *= (p<0.5); *** = (P<0.001).

3.5.2. Edible Offal Components

Most of the edible offal components in this study were not significantly affected (P>0.05) by treatments except blood, tongue, kidney and total edible offal components (Table 7). The result revealed that weight of the majority of offal components (organs) did not vary among sheep of the same breed, age and sex though their body weight and other main carcass parameters differ as a result of varying feeding regimes. Riley *et al.* (1989) indicated that differences in internal organs are more influenced by age, breed and sex of the animals rather than the plane of nutrition. This supports the current result.

Table **7**. Edible offal components of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Blood (g)	1102.1^{b}	1357.1^{a}	1317.3^{a}	1199.7^{ab}	1303.7^{a}	26.87	*
Liver (g)	353.9	472.4	415.7	413.3	428.0	13.75	ns
Kidney (g)	84.4^{c}	99.9^{a}	89.6^{bc}	90.4^{bc}	94.3^{ab}	1.50	**

Heart (g)	110.6	132.4	117.0	115.1	121.1	2.40	ns
Tongue (g)	106.9^{b}	164.7^{a}	100.1^{b}	115.3^{b}	138.0^{ab}	6.70	*
Ret-rum (g)	662.4	766.4	682.1	731.4	764.9	16.66	ns
Om-ab (g)	285.0	259.3	269.4	273.3	281.7	15.98	ns
SI (g)	846.4	975.0	816.9	920.1	898.4	20.76	ns
LI (g)	180.1	156.3	150.4	162.7	175.9	12.81	ns
Testicle	330.7	418.9	362.9	391.3	371.1	9.55	ns
Kidney fat (g)	98.3	168.3	138.0	156.0	140.6	9.48	ns
Heart fat (g)	43.0	63.4	66.1	73.7	50.6	3.77	ns
Omental fat (g)	135.6	286.14	159.7	233.7	208.0	25.68	ns
Scrotal fat (g)	74.6	109.1	79.3	97.4	95.9	4.80	ns
Pelvic fat (g)	42.4	66.7	53.7	62.3	57.0	3.41	ns
TEOC (kg)	4.5^{c}	5.5^{a}	4.8^{bc}	5.0^{abc}	5.1^{ab}	0.10	*

^{a,b,c,} means with different superscripts in a row are significantly different; *=(P<0.05); **=(P<0.01).

3.5.3. Primal Cuts

The highest leg, rack and breast and shank muscle from dissected half carcass was obtained from those sheep supplemented with Gebisa vetch variety (T2). This might be associated with the highest feed intake and digestibility by those sheep, which resulted in the highest growth performance and carcass parameters. Bone from leg significantly differed (P<0.001) among treatments in the order of T2=T5>T1=T3=T4. Fat from breast and shank significantly differed (P<0.001) among treatments in the order of T2=T4=T5>T3=T1. The treatment supplemented with Gebisa (T2) had the highest leg total from the dissected half carcass (2368.6 g). The loin total of T2 was significantly higher (P<0.01) than loin total of T1 but similar (P>0.05) with loin total of T3, T4 and T5. The proportion of muscle, bone and fat in individual primal cuts were not significantly different (p>0.05) among treatments except the proportion of bone from leg and the proportion of fat from breast and shank. Additionally, this study revealed the presence of highest proportion of muscle in loin compared to other primal cuts whereas breast and shank showed the lowest proportion of muscle. Moreover, the lowest proportion of bone was recorded from loin. This conforms with the general knowledge that the carcass from loin is more ideal than the carcass from other primal cuts.

Table 8. Primal cuts of dissected half carcass of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Primal cuts			Treatments					SEM	SL
			T1	T2	T3	T4	T5		
Leg	Muscle	g	1219.6^{c}	1577.7^{a}	1277.7^{c}	1321.0^{bc}	1426.6^{b}	30.48	***
		%	65.8	66.6	64.8	65.1	66.7	0.39	ns
	Bone	g	358.0^{b}	412.3^{a}	349.9^{b}	352.4^{b}	406.4^{a}	7.48	**

		%	19.4^{a}	17.4^{b}	17.8^{b}	17.4^{b}	19.1^{a}	0.26	**
	Fat	g	274.0^{c}	378.6^{a}	343.7^{ab}	354.6^{ab}	302.1^{bc}	11.44	*
		%	14.8	16.0	17.4	17.5	14.3	0.48	ns
Leg total (g)			**1851.6^{d}**	**2368.6^{a}**	**1971.3^{cd}**	**2028.0^{bc}**	**2135.1^{b}**	**40.54**	*****
Loin	Muscle	g	368.1^{b}	543.6^{a}	447.7^{ab}	513.3^{a}	481.3^{a}	17.08	**
		%	69.7	91.1	80.7	88.6	76.2	3.56	ns
	Bone	g	88.6	116.6	95.6	96.0	109.7	3.84	ns
		%	16.9	14.2	14.4	11.9	14.2	0.65	ns
	Fat	g	105.4	162.2	130.3	189.1	182.3	9.93	ns
		%	19.3	19.4	19.2	23.2	23.5	0.88	ns
Loin total (g)			**562.1^{b}**	**822.1^{a}**	**673.3^{ab}**	**798.4^{a}**	**773.3^{a}**	**25.75**	****
Rack	Muscle	g	539.4	607.0	565.3	595.9	684.6	24.28	ns
		%	63.8	60.5	61.6	59.8	60.3	0.74	ns
	Bone	g	197.3	242.6	211.0	221.3	256.4	8.75	ns
		%	23.1	23.9	23.1	22.3	23.1	0.34	ns
	Fat	g	114.3	166.1	136.3	177.0	187.6	9.89	ns
		%	13.2	15.6	15.3	17.9	16.6	0.66	ns
Rack total (g)			**851.0**	**1015.7**	**912.6**	**994.1**	**1128.6**	**39.01**	**ns**
Breast and shank	Muscle	g	341.6^{b}	449.9^{a}	322.7^{b}	325.4^{b}	379.7^{b}	13.65	**
		%	54.3	50.0	51.6	47.1	48.5	0.86	ns
	Bone	g	146.9^{c}	185.3^{a}	146.4^{c}	153.3^{bc}	176.3^{ab}	4.78	**
		%	23.7	20.8	23.4	22.4	22.6	0.49	ns
	Fat	g	137.9^{b}	260.4^{a}	160.9^{b}	211.6^{a}	222.7^{a}	10.28	***
		%	22.0^{b}	29.1^{a}	25.0^{ab}	30.5^{a}	28.9^{a}	0.88	*
Breast and shank total (g)			**626.3^{c}**	**895.6^{a}**	**630.0^{c}**	**690.3^{bc}**	**778.7^{b}**	**24.57**	*****
Shoulder and neck	Muscle	g	1057.4^{b}	1402.6^{a}	1169.0^{b}	1185.6^{b}	1116.3^{b}	37.79	*
		%	61.3	67.7	62.5	62.5	61.9	0.95	ns
	Bone	g	391.1	369.0	388.6	370.7	370.6	9.92	ns
		%	22.7	17.9	20.6	19.6	21.3	0.45	ns
	Fat	g	275.3	296.0	315.7	341.6	282.9	14.25	ns
		%	16.1	14.3	17.0	18.0	16.7	0.81	ns
Shoulder and neck total (g)			**1723.9**	**2067.6**	**1873.3**	**1897.9**	**1769.7**	**44.38**	**ns**

^{a,b,c,d} means with different superscripts in a row are significantly different; *=(P<0.05); **=(P<0.01); ***=(P<0.001).

Supplementation of the vetch varieties increased the amount of muscle by 31.4, 8.6, 11.4 and 17.1% for T2, T3, T4 and T5, respectively, compared to un-supplemented treatment. Among supplemented treatments, the highest amount of muscle from dissected half carcass (4.6 kg) was obtained from those sheep supplemented with Gebisa vetch variety (T2). The overall proportion of muscle and fat did not significantly differ (P>0.05) among treatments. However, the overall proportion of bone varied significantly (P<0.01) being higher in T1 than in T2, T3 and T4. In general, muscle comprised the highest proportion (61.5-63.9%) followed by bone (18.5-21.0%) and fat (16.1-19.8%).

According to Ameha (2008), the ideal carcass can be described as the one that has a minimum amount of bone, a maximum amount of muscle and an optimum amount of fat. Therefore, the highest proportion of muscle in T2 and bone in T1 suggested that supplementation enhanced carcass quality and among supplemented treatments supplementation of Gebisa (T2) induced production of more ideal carcass than other treatments. The weight of muscle (3.5-4.6 kg) and fat (0.9-1.3 kg) from the dissected half carcass in this study was much higher than the one from the study of Teklu (2016) in which 2.6-2.7 kg and 0.3-0.4 kg of muscle and fat, respectively were reported for carcass of the same breed of sheep fed Faba bean straw with concentrate mixture at a ratio of 70:30.

Table 9. Mean weight of muscle, bone and fat and their proportions of dissected half carcass of Arsi-Bale sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Parameter		Treatments					SEM	SL
		T1	T2	T3	T4	T5		
Muscle	kg	3.5^{c}	4.6^{a}	3.8^{bc}	3.9^{b}	4.1^{b}	0.08	***
	%	62.8	63.9	62.4	61.5	62.0	0.48	ns
Bone	kg	1.2^{b}	1.3^{a}	1.2^{b}	1.2^{b}	1.3^{a}	0.02	*
	%	21.0^{a}	18.5^{c}	19.7^{bc}	18.7^{c}	20.1^{ab}	0.25	**
Fat	kg	0.9^{b}	1.3^{a}	1.1^{ab}	1.3^{a}	1.2^{a}	0.04	*
	%	16.1	17.6	17.9	19.8	18.0	0.49	ns

^{a,b,c,} means with different superscripts in a row are significantly different; *=(P<0.05); **=(P<0.01); ***=(P<0.001).

The proportion of muscle in the current study (61.5-63.9%) was slightly higher than the value of 58.8-62.2 % reported by Teklu (2016), within the range of 51.09-76.77% lean meat observed for Arsi-Bale goats with different age group and feeding regime (Mesfin, 2007) and slightly lower than 63-67.4% lean meat reported for Borana and Arsi-Bale goats under different durations of feedlot management (Hailu *et al.*, 2005). The proportion of bone in this study (18.5-21.0 %) was lower than earlier findings: 25.7-30.9% reported by Hailu *et al*. (2005), 25.11-35.89% reported by Mesfin (2007) and 27.9-30.9% reported by Teklu (2016). The result of this study showed that the carcass produced from Arsi-Bale sheep fed fodder oat and vetch hay based diet is of maximum muscle, optimum fat and minimum bone. Therefore, it can be concluded that fodder oat and vetch hay based feeding strategy is explicitly of high potential not only in terms of producing high carcass yield, but also in terms of producing the ideal carcass.

4. CONCLUSIONS AND RECOMMENDATIONS

There was a significant difference between vetch varieties in terms of feed intake, digestibility, body weight gain, feed conversion efficiency and carcass characteristics of sheep.

Supplementation of Gebisa vetch variety (T2) induced highest growth performance and carcass characteristics than all other treatments. Based on these findings Gebisa can be recommended as the best variety for use as supplementary feed in roughage based ruminant diets. The dietary treatments used in this study induced outstanding biological performance in terms of feed intake, digestibility, body weight gain, feed conversion efficiency and carcass characteristics of sheep, suggesting that fodder oat and vetch hay based feeding is explicitly a feeding strategy of high potential and effort should be made to introduce and scale up the production of these forages in the farming system.

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Growth Performance Evaluation of Sheep under farmers management at Fentale District, Oromia Regional State, Ethiopia.

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ABSTRACT

On Farm growth performance evaluation of sheep population found in Fantale districts of east Shoa zone of Oromia regional state was conducted with the objective of assessing the growth performance of sheepunder farmers' management condition in Fantale districts in East Shoa zone of Oromia Regional State. The study was a monitoring study which took place for two years (2015-2016). Body weights (BW, WW, SMW and YW) records and per-weaning and post-weaning performance were assessed from 113 heads of sheep. The data were analyzed using the GLM procedures of SAS. The overall least square means (±SE) for birth, three, six and nine month weights (kg) of goat kids at Fantale district monitoring site were 2.84± 0.04, 7.95±.0.04,11.81±0.21 and 17.13±0.18 respectively. Birth weight was significantly (P<0.05) influenced by birth type of the lamb, whereas weaning weight is influenced by year of birth of lamb. In general, sheep breed in Fantale district monitored site significantly (p<0.05) comparable in all the parameters (in birth weight, three, six and yearling weight) compared with other sheep breed in Ethiopia. To increase in the production and reproductive efficiency of sheep in the study site and reduce the mortality of lamb improvement of management system is very crucial.

Key words: *Growth performance; Reproduction; weaning weight; Yearling weight*

INTRODUCTION

In Ethiopia, sheep are the second numerous farm animals after cattle with about 14 traditional sheep populations and nine identified sheep breeds (Solomon G. et al., 2007) and with a population of around 30.69 million heads of sheep (CSA, 2016/17). According to Solomon G. et al. (2008) sheep production systems in Ethiopia are classified into five sub systems, viz. Highland cereal–livestock system, Lowland crop–livestock system, Agro-pastoral and pastoral systems, Sub-alpine sheep-barley system and Highland perennial crop system.

Indigenous sheep in Ethiopia play multifarious roles viz. sources of income, meat, skin, manure and coarse hairy fleece. They are also means of risk avoidance (during crop failures) especially under marginal productivity under low and erratic rainfall, severe land erosion, frost, and water logging problems (Zewdu et. al., 2008). Thus, sheep reared by the smallholder farmers provide support to the economic stability and compliment the crop production (Tsedeke, 2007). Sheep rearing also play an important role in cultural, social livelihoods and religious values for large and diverse human population (FAO, 1999). Rearing of sheep can result in enhancement of farm family nutrition by enhancement in productivity at the farm. The low productivity of livestock breeds in general and sheep in particular may be due to different factors such as reproduction efficiency, poor nutrition (of the animal), prevalence of diseases, especially among livestock reared under challenging conditions (Tesfaye, 2008). Understanding the genetic performance of livestock is quite relevant for the developing countries where specific adaptive attributes the livestock genetic resources make them all the more important especially under the unforeseen climate changing conditions (Workneh *et al.*, 2004).

Designing a suitable breeding scheme for the smallholder livestock production system has remained a challenge hitherto especially in the developing world (Aynalem *et al*, 2013). Until recently, livestock breeding in Ethiopia had adopted exclusively the conventional hierarchical breeding schemes (Gizaw *et al*., 2013). The conventional hierarchical breeding schemes of the past had several drawbacks (Gizaw and Getachew, 2009). Such breeding systems fail to consider the different intangible, socio-economic, and cultural roles that livestock plays in each situation.

Knowledge the reproduction and growth performances are important to develop sustainable genetic improvement schemes especially under smallholder situations (Kosgey, 2004). The previous approaches on livestock breeding and development were based on top down approach where all the stakeholders were rarely consulted by the researchers (Solomon, *et al*, 2007).Thus, the knowledge gap usually led to the setting up of unrealistic breeding goals in the design of livestock genetic improvement programs, the consequence of which often endangered the conservation of indigenous animal genetic resources (Zewdu*et.al*., 2006). The productivity of local sheep under village management condition is alleged to be poor. The lambs with higher growth performance and better condition score are sold to fetch a premium price whereas unthrifty ram lambs remain in a flock for breeding. These might contribute to poor performance of sheep in the village management condition.

The growth performance of sheep has not been documented in the central eastern part of Oromia, which is Fantale. Reproductive performances of sheep together with, survival and growth traits are important determinants of productivity of sheep in a meat livestock farming and needs to be recorded for genetic and management improvement. However, detailed analyses of growth parameters that affecting growth performance hasnot been documented in the Fantale area. Therefore, the current study was performed to assess the effect of non-genetic factors on reproductive traits such as litter size, birth weight to yearling weight under village management conditions to make sound recommendations for improvement of productivity of sheep.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Fantale districts of the Oromia region from 2015 to 2016. Fantale Districts is located 200 km east of Addis Ababa. It lies at an altitude between 943- 1135 m above sea level. The minimum temperature is 28 ^{0}C and the maximum temperature is 40 ^{0}C. The annual rainfall averages about 520 mm.

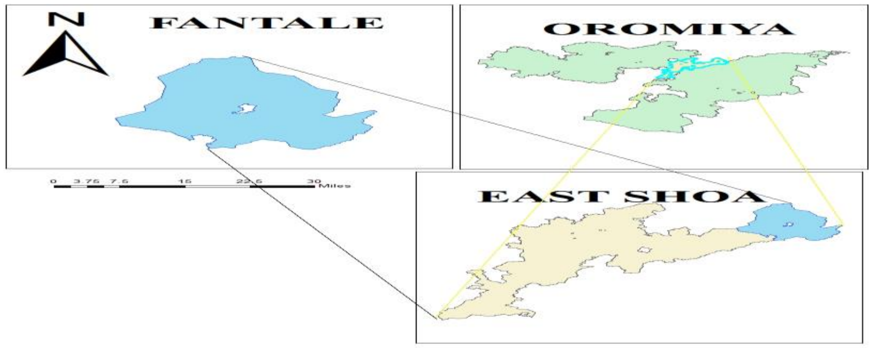

Figure.1 Map of the study area

Study sites Selection:

A total of two study sites were purposively selected depending on their flock size and accessibility tenhouseholds from each site with average flock size of twenty sheep were purposively selected and used for monitoring. Two hundredthirteen Ewe and one hundredthirteenLambs were monitored for this study

Data to be collected:

Animals under the study were identified by permanent plastic ear tags applied at the beginning, birth or at purchase of the animals to facilitate recording. Performance data were collected from 2015 to 2016 using trained enumerator. The enumerator was supervised and data crosschecking was done by researchers from AdamiTullu Agricultural Research Center.

The following growth performance data were collected.

- ✓ Birth, Weaning, Six month
- ✓ Birth weight,
- ✓ Weaning weight,
- ✓ Six month weight,
- ✓ Yearling weight
- ✓ Prolificacy (type of birth)

On- farm flock management

The ewes were kept under village management condition. The management of sheep was in such a way that in both the wet and cropping season they were kept on the grazing land. While in the dry season most of the pastoralists in the area were move their flock from place to place in searching of feeds. Breeding rams run with the group flock to mate with any ewes in heat during wet and dry season. The sheep breed in the study area wasnaturally selected for seasonal breeder. Animals were provided fenced/Karlashelter during the night. The sheep were tagged and data collectors who resided in villages monitored and followed birthsdate of birth of the ewe, the type of birth of the ewe, birth to yearling weight record, deaths, sale and exits of sheep in the households of the villages. The growth traits were recorded for animals that gave birth during the monitoring period. Since the start of data collection, internal and external parasite control has been carried out. Ivermectin was used for de-worming and sick sheep were treated.

Data management and statistical analysis

All the data collected were entered and managed using Microsoft Excel computer program. The data were analyzed using General linear model (GLM) procedures of SAS (SAS 2003). Tukey Kramer test was performed to separate means of effect with two or more levels which were significant in the least squares analysis of variance. The traits studied were: Birth weight, Weaning weight, six month weight, yearling weight, ADWG. The fixed effects fitted in the model for BW, WW, SMW and YW were Year (2015 and 2016); season (Autumn, winter, Spring, and Summer); type of birth at lambing (single, twin) and Sex (Male, Female).

For the analysis of the growth performance of the breed, the following statistical model was used:

$$\mathbf{Y_{ijklm} = \mu + G_k + S_j + Y_l + + L_m + e_{ijklm},}$$

Where: $Y_{ijklm=}$Observation on birth weight and weight at different ages;

μ = overall mean;

$G_{k=}$Fixed effect lamb sex (k= male, Female)

S_j= Fixed effect of lamb birth season (j=Autumn, Winter, Spring, and Summer);

$Y_{l=}$Fixed effect of lamb birth years (l=2015,2016);

$L_{m=}$Fixed effect of lamb birth (m=Single, twin)

e_{ijklm}= is the random error attributed to the n^{th}lamb.

Average daily weight gain (ADG):Average daily weight gain were calculated as follows

ADG (ADG1, ADG2 & ADG3) = $\frac{\textbf{Weight at the end of period} - \textbf{weight at the beginning of the period}}{\textit{length of the periods}}$

Where:- ADG1 = Average daily weight gain from birth to three month of age;

ADG2 = Average daily weight gain from three month to six month of age;

ADG3 = Average daily weight gain from six month to yearling age.

RESULTS AND DISCUSSION

Pre-Weaning weight and growth performance of sheep in the study areas

Growth is the most important trait in small ruminant production affecting the contribution of the sector to the farm household through live animal sale and meat production (Kosgey, 2004). Growth performances of lambs' in the study areas werestudied at different ages (three, six, nine months and yearling) by considering sex of lambs, year, season and type of births as fixed independent non genetic factors. The analysis of variance showed that the fixed factors considered (year of birth, season of lambing and sex of lamb) were not affect statistically ($P>0.05$) birth weight of the sheep in the study area.This may relate to the breeding season and lambing concede with the rainy season which is naturally selected.

The current results disagree with the report of Getahun, (2009) that reported significant effects of sex and season of birth on birth weight.Only typeof birth had effect on birth weight of sheep breed at monitoring site at $p<0.05$ significant levels (Table 1). Single born lambs were heavier than twin contemporaries (2.87±0.03Vs1.25±0.05). This result agreed with the result reported by Gemeda et al (2002) Gardner et al (2007). This may be due to the finite capacity of the maternal uterine space to gestate offspring (Gardner et al.,2007) and As litter size increase the individual birth weight will decline (Robinson, 1977).

The overall least square mean birth weight of sheep breed at the study site had higher value than the report (2.45±0.40 kg) of Berhanu and Aynalem (2009) forsheep around Jima Zone south-west Oromia, 2.30±0.03 kg for Alaba sheep were reported Gemiyu (2009). The birth weight is a trait which has a lot of economic importance and therefore kids with higher birth weight are usually has higher growth performance through lifetime (Kosgey, 2004).The observed overall least square mean birth weight (2.84±0.04 kg) of sheep breed at Fantale district was more or less comparable for many of the reports made on different Ethiopian indigenous sheep breeds birth weight.

The findings pertaining to the weaning weight performances of the ewes are presented in Table 1. The findings show that the weaning for the lambs did not vary across birth type and Sex of the kids. This might be ascribed to similar management of the lambs and ewes in the studied districts. The findings also show that weaning of the kids varied ($P<0.05$) across year of birth. The lowest weaning weight was recorded in 2015 and the highest in both 2014 and 2016. The highest weaning weight was observed in lambs born in autumn season which may related with the availability of feed resource in that season (Table 2).

Table 1: Least Squares Mean of birth and weaning weight of sheep in Fantale districts

Factors	**N**	**Birth weight**	**N**	**Weaning weight**

Overmeans	113	2.84± 0.04	106	7.95±0.04
Year of birth	-	-	-	
2015	83	2.86±0.05	76	7.69±0.22
2016	30	2.79±0.06	30	8.62±0.43
Seasone of Birth				
Autoum(Sep-Nov)	52	2.87±0.05	52	8.51±0.32
Winter(Dec - Feb)	21	2.93±0.05	19	7.12±0.28
Spring(Mar– May)	12	2.84±0.10	11	7.72±0.74
Summer(Ju – Aug)	28	2.72±0.10	24	7.53±0.35
Type of birth				
Single	111	2.87±0.03[a]	104	7.99±0.21
Twin	2	1.25±0.05[b]	2	6.10±0.10
Sex				
Male	57	2.89±0.06	51	8.03±0.26
Female	56	2.79±0.05	55	7.89±0.31

The weaning weight as obtained in this study is in close accordance with the findings of Tsedeke (2007) for Arsi Bale sheep. Similar results have also been reported by Solomon *et al* (2007) in Gumuz breed of sheep reared at Benushangul gumuz in Ethiopia. However, the weaning weight as observed in this study was higher than those reported by Fsahatsion (2013) for Gamogofa native sheep and Dhaba (2013) for Illu Abba Bora native sheep.

The differences as observed may be ascribed to the management of the sheep besides the genotypes being reared in the studied areas. While the weaning weight of the sheep in the studied districts is lower than those reported by DeribeG. (2009), 10.35±0.19 for Alaba sheep.

Post- Weaning weightand growth performance of sheep in the study areas

The result ascribed the six month and yearling body weight is presented in Table 2. The findings show that the six month weight for the kids did not vary across year of birth, birth type and sex of the lambs. This might be ascribed to similar management of the lambs and ewes in the studied districts. Whereas the six month weight significantly(<0.05) vary on the season of birth with highest value observed autumn season which may be due to the availability of feed resource in this season.

The results related to the six month as recorded in this study too indicate similarity from the results obtained by Zewdu (2008) for Horro sheep. The current result of six month weight was lower than those reported by Birhanu & Ayinalem (2009) for sheep around Jima native sheep.

Table 2: LS Mean of six month and Yearling weight of sheep in Fantale districts

Factors	N	Six month weight	N	Yearling weight
Overmeans	102	11.81±0.21	98	15.82± 0.13
Year of birth				-
2015	74	11.42±0.23^{b}	70	15.72±0.16
2016	28	12.80±0.40^{a}	28	16.20±0.21
Seasone of Birth				
Autoum(Sep-Nov)	49	12.15±0.31^{a}	48	15.90±0.20^{ab}
Winter(Dec - Feb)	18	10.60±0.40^{b}	18	15.35±0.27^{b}
Spring(Mar– May)	11	11.82±0.58^{ab}	10	16.45±0.31^{a}
Summer(Ju – Aug)	24	12.46±0.42^{a}	22	16.03±0.26^{ab}
Type of birth				
Single	100	11.86±0.21^{a}	96	15.80.137±
Twin	2	9.25±0.25^{b}	2	15.00±1.00
Sex				
Male	47	11.67±0.28	43	16.00±0.20
Female	55	11.92±0.31	55	15.74±0.17

The results as presented in Table 2 indicate that yearling weight of lambs in the study area, the findings show that season of lamb birth and sex of lamb do not have any effect on yearling weight of the lambs.Both the year of birth and type of birth have significant effect ($P<0.05$) on yearling weight of lambs. The yearling weight of the sheep were in close accordance with the findings of Duguma et al. (2017) for Afar sheep (16.10) of the same breed sheep.

The yearling weight of the Fantale sheep as observed in the present study are in close accordance with the findings of Sisay, (2002) among central highland breed of sheep. The yearling weight of the lambs is in close accordance with those of Sisay (2002), the similarity as observed may be related to the management besides the genotype of the sheep. The present values were however lower than those reported by Markos and Ginber (2004) for Bonga ram reared in Keffa, Sheka and Bench communities and Solomon *et al* (2007) for Gumuz ram reared Gumz and Amhara communities and Duguma et al (2017) for Horro (28.20) ram Bonga ram (34.60). Contrary to the same, lower values of the trait have been reported by (Sisay, 2002) for rift valley sheep type.

Pre and Post weaning Growth rate

The result pertain the average daily weight gain at different age categories were presented in Table 3. From the result the pre-weaning growth rate was 56.78 ± 2.17gm and it is very lower (123.18 ± 15.20) than washera sheep in its home areas (Mengistie*et al.*, 2009). The variation may be due to the difference in breed and feed availability both in quality and quantitiy for lactating ewes and lambs as well as management difference for supplementing of lactating ewes and lambs as lambs enteirely depends on their dam for growth.

As the result showed as year of birth and season of birth have statistically significant effect(P<0,05) on the pre-weaning growth rate of the lambs. This difference of growth rate between years could partly explained by the difference in the nutritional status of dam, since up to weaning lambs mostly dependent on their dam for their growth requirement. Season was source of variation(P<0.05) for lamb growth rate in all groups of age categories; lambs born in wet season have higher average daily weight gain than those born in dry season. According the report of Tibbo (2004), lambs born in the wet season have fast growth rate than in the dry seasons which might descriebed that seasonal variation in feed availability both in quality and quantity on natural pasture for the dam during lactation to produce and supply sufficient milk for thier lambs.

Table 3. Least square means for growth rates of sheep in study areas at different ages

Factors	**Birth to 90 days**		**90 to 180 days**		**Birth to 360 days**	
	N	**LSM** ± SE	**N**	**LSM** ± SE	**N**	**LSM** ± SE
Overmeans	106	56.78±2.17	102	43.01±2.02	98	36.16±0.37
Year of birth						
2015	76	53.63^{b}±2.36	74	41.29±2.29	70	35.73 ±0.46
2016	30	64.78^{a}±4.53	28	47.54±4.10	28	37.24±0.55
Seasone of Birth						
Autoum(Sep-Nov)	52	62.67^{a}±3.39	49	40.77^{b}±2.88	48	36.20^{ab}±0.57
Winter(Dec - Feb)	24	53.15^{ab}±3.61	24	34.21^{b}±2.91	22	35.10^{b}±0.83
Spring(Mar– May)	11	54.34^{ab}±8.13	11	45.56^{b}±6.46	10	37.89^{a}±0.81
Summer(Ju – Aug)	19	46.67^{b}±3.05	18	59.26^{a}±4.55	18	36.42^{ab}±0.69
Type of birth						
Single	104	56.84±2.21	100	43.17±2.06	96	36.12±0.37
Twin	2	53.89±0.56	2	35.00±1.67	2	38.19±2.64
Sex						
Male	51	57.08±2.77	47	40.95±3.03	43	36.45±0.60
Female	55	56.51±3.32	55	44.77±2.71	55	35.93±0.47

Result of daily weight gain from 90 to 180 days of age was 43.01 ± 2.02 gm. The result of post-weaning gaind in current study is comparable with Washera sheep breed (Mengistie *et al*., 2009) but higher than Farta sheep breed (Agraw *et al*, 2014) under on farm condition. Season of birth was source of variation (P<0.05) for lamb growth rate in post-weaning of age categories; lambs born in wet season have higher average daily weight gain than those born in dry season.

The overall least square mean of overall (birth to yearling) growth rate is comparable with Farta sheep breed (Agraw *et al*., 2014) under on farm condition. But lower than Washera sheep breed (Mengistie *et al*.,2009). The variation may be due to the difference in breed and feed availability both in quality and quantitiy for lactating ewes and lambs as well as management difference.

Season have siginificant effec on overall growth rate. Lambs born during wet season have faster growth in pre-weaning, pos-weaning and overall growth rate than dry season born lambs. There should be having all birth during the wet season when there is better feed availability in terms of quality and quantity for lactating ewes and lambs.

Conclusions and recommendation

In general, sheep breed Fantale district monitoring site significantly ($p<0.05$) outsmarted in all the parameters (in birth weight, three, six, nine months and yearling weight) compared with other sheep breed in Ethiopia.The study has demonstrated that the non-genetic factors exerted a significant effect on growth performances of lambs.

From these it can be recommended that:-

- ✓ Strong extension service is required to convince the farmers not sale rams at younger age
- ✓ Strengthen veterinary services including training should be given to farmers
- ✓ Feed conservation, introduction of adapted improved forages and strategic supplementation schemes should be implemented to increase the growth performance of sheep
- ✓ Appropriate community breeding schemes should be designed and implemented

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Evaluation of different feeding options for yearling Arsi-Bale sheep to attain export market body weight

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Abstract

*The study was conducted at Adami Tulu agricultural research center on yearling Arsi-Bale rams. Twenty one rams of Arsi-Bale sheep were purchased from the surrounding area and assigned to three feeding treatment (T1 = grazing + 50 % wheat bran + 50 % noug seed cake, T2 = grazing + 45% what bran + 20% maize grain + 35% noug seed cake and T3 = grazing + 65% wheat bran + 35% cotton seed cake) with aims of evaluating the three feeding options to come up with the economical one(s) which could enable the rams to attain export market weight. The rams were supplemented based on their individual body weight requirements and kept on feeding for 75 days. Final body weights, total weight gain and average daily weight gain of the rams were not significant among the treatments. The yearling rams which were fed the three dietary rations attained export market weight in 75 days of feeding. Average daily weight gains of the rams over the feeding period were 133.3, 109.3 and 104.7 grams for those rams in treatment one, two and three, respectively. Partial budget analysis indicated that feeding option number two (T2) is more economical as compared to rams feeding on T1 and T3. Therefore, fatteners can use T2 preferably. However, as there was no significant difference among the treatments, they can also use any of the feeding options depending on availability of the ingredients in their area***.**

Keywords: y*earling Arsi-Bale Rams, export market weight, sheep fattening*

INTRODUCTION

Ethiopia has above 30 million heads of sheep (CSA, 2017). Beside large population, sheep production is very low. Carcass yield of local small ruminants remained at about 8 kg per head between the year 1999 and 2008 (Getahun, 2008), which was below the East African (11 kg) and the world (12 kg) average carcass yield during the same years. In Ethiopia, the current per capita consumption of meat is 13.9 kg/year, being lower than the African and the world per capita averages, which are 27 and 100 kg/year, respectively (Tsigereda *et al*., 2016).

The small ruminant meat demand of the foreign countries particularly Arab countries increased and forced them to import from Africa. Ethiopia has relative opportunities for live animals and meat expert since found in the entrance of Asia countries. Currently, the country has more than nine standard livestock slaughtering abattoirs. However, the earning from export of live animals and processed meat is very small as compared to the potential of the country. Moreover, the red meat currently produced from livestock production in the country could not satisfy the high demand for animal protein (Shapiro *et al*., 2015).

The standard export market live weight for yearling small ruminants is 25 – 30 kg per individual. However, yearling live weight for our sheep is estimated at 15 to 17 kg per individual. To improve this scenario various livestock research and development activities have been undertaken by different research institutions. Improving the growth performance of fattening animals is one of the most important traits to obtain the required export market weight gains. Different feed options played a significant role to bring experimental animals to attain export market weight demand at different length of the fattening period. In addition to the effect of dietary feeds, various fixed effects have their own role on growth performance and carcass characteristics of experimental animals kept under a given environmental conditions (Abebe *et al.,* 2013).

A study by Endashaw *et al., (*2012), indicated that yearling Afar goats fed on different diets reached the required export market body weight. Information on feeding rations that enable yearling Arsi-Bale sheep to reach export market weight is scanty. Therefore, this study was designed to evaluate different feeding options and identify the most economical feeding option(s) for Arsi Bale rams to attain export market body weight.

MATERIALS AND METHODS

Description of the Study site

The experimental was conducted at Adami Tulu Agricultural Research Center, which is located in mid rift valley at 167 km from Addis Ababa, at altitude of 1650 m above sea level. The agro ecological zone of the area is semi-arid and sub humid with acacia woodland vegetation type. The mean annual rain fall is 760 mm and mean minimum and maximum temperatures are 12.6 and 27^0c, respectably.

Experimental animals and dietary feeds

One year old Arsi-Bale rams were purchased from Bulbula and Batu markets. The purchased rams were treated for internal and external body parasites. Each animal was assigned randomly to treatments. All experimental animals were individual fed their corresponding rations for 14 days for adaption and 75 days for fattening period. The feeding treatments offered for the rams during the fattening period were: ration one (grazing + 50% wheat bran + 50% noug seed cake), ration two (grazing + 45% what bran + 20% maize grain + 35% noug seed cake) and ration three **(**grazing + 65% wheat bran + 35% cotton seed cake).

Feeding of experimental animals

After 14 days of adaptation period, concentrate feeds were given to the animals at a rate of 2.5% of their body weights. Feed amounts given to the animals were adjusted per two weeks over the feeding period. Each dietary treatment was offered twice daily (half in the morning and half in the afternoon after eight hours grazing) for the respective groups of animals. Feed refusals from each treatment group were collected and weighed every day in the morning before the daily feed allowance was provided for rams.

Growth performance measurement

$$ADG = \frac{(FBW - IBW)}{D}$$

$$TWG = FBW - IBW$$

ADG-=Average daily weight gain, TWG=Total weight gain, FBW= Final body weight, IBW=Initial body weight, D= total of fattening days

Economic return on rams fattening

Costs incurred for feeding the rams were recorded. Total variable costs such as animal purchase, transportation, feeds, labor and veterinary costs were included in partial budget analysis. At the end of the fattening period, the gross output/revenues were obtained from prices of the rams as estimated by the help of people who have enough knowledge on the prices of fattened animals. Fixed costs incurred for feeding the animals were not included in cost benefit analysis.

Statistical analysis

Data of all live weights and carcass parameters were analyzed using general linear model (GLM) of Statistical Analysis System (ver. 8). The estimated least squares means were separated using the Duncan's Multiple Range Test at $P < 0.05$.

RESULT AND DISCUSSION

Growth performance of rams

Experimental rams were fed different feed options to attain export market body weight. The weight changes during fattening period were properly recorded. The average initial weights were 16.85, 16.85 and 17 kg for animals in treatment one, treatment two and treatment three, respectively. Final body weights, average daily weight gains, total weight gains of rams in 45 and 75 days are indicated in Table 1. No statistical difference observed among the three dietary treatment groups in final weight gain, average weight gain and total weight gain during both 45 and 75 days. The yearling Arsi-Bale rams attained export market body weight in the 75 days of fattening. Study conducted at Werer Agricultural Research Center indicated that yearling Afar sheep that have 18.5 kg initial weight and fed on different wheat bran and leucaena leaves mixture reached 30 kg in 98 fattening days (Abebe *et al.*, 2013). The rams fed on T1 (grazing + 49% wheat bran + 50% noug seed cake) had relatively higher weight gain than those fed on T2 (grazing + 20% maize grain + 35% noug seed cake) and T3 (grazing + 65% wheat bran + 35% cotton seed cake). This shows that the feed conversion of animals in treatment one is higher than that of the rest. Total weight gain of animals fed with each feeding treatment was calculated at different fattening period. The weight changes of yearling rams from an initial body weight of 17.5 kg to final body weight after 75 days were 8.5, 8.2 and 7.85 kg per treatment one, two and three, respectively.

Table 1: The growth performance of Arsi-Bale sheep rams at different feeding days

Fattening period	Weight	T1	T2	T3
First day	IBW (kg)	18.85	16.85	17.0
45 days	FBW (kg)	22.3±1.9	22.2±2	22.3±1.8
	TWG (kg)	5.4±1	5.4±1	5.3±1.7
	ADG (g)	120.6±28.3	119±29.6	117.5±40
75 days	FBW (kg)	25.3±1.5	25.1±1.2	24.8±1.1
	TWG (kg)	8.5±1.2	8.2±1.91	7.85±1.4
	ADG (g)	113.3±15.86	109.5±25.5	104.7±18.3

ADG-=Average daily weight gain, TWG=Total weight gain, FBW= Final body weight, IBW=Initial body weight, Treatments not significance at p<0.05

Average daily weight gain of yearling Arsi-Bale was lower than that reported for Afar sheep (116.3, 120 and 116.1g/day) which fed different wheat bran and leucaena mixture level for 98 days (Abebe *et al.,* 2013). Study conducted at Debre Zeit Agricultural Research Center (Getahun, 2014) indicated that Black Head Ogaden sheep which fed teff straw *ad libtum* and 450 gm concentrate per day registered lower average daily weight gain of 65.2 g/day. The average daily weight gains of yearling Arsi-Bale rams in this study were relatively similar to that reported by Tadesse *et al., (*2014) for the Southern Ethiopian on Arsi-Bale sheep (111.9 g/day) which fed concentrate blocks.

Rams daily weight gain trend

The trend of daily weight gain of experimental rams fed different dietary rations for 75 days were illustrated in Figure 1. Rams average daily weight gains were higher at the initial stage of the fattening period. These results may be associated to the animals' compensatory growth (Girma *et al*., 2015). Later, average daily weight gains of rams had decreasing trend which is in agreement with the findings of Abebe *et al.,* (2013) in which animals' daily weight gains decreased steadily as their body weight progressively increased.

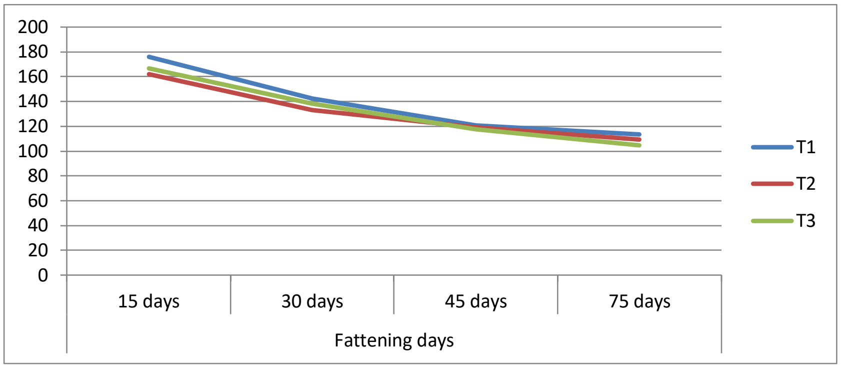

Figure 1: Rams daily weight gain trend through fattening period

Economic return of sheep fattening

The partial budget analysis of yearling Arsi-Bale rams fattening was summarized in the Table 2. Feeding treatment three diet incurred more variable cost than other treatments. The partial budget analysis indicated Arsi-Bale rams allocated to all treatments have positive gross margins. Feeding maize grain is more profitable than feeding the other two treatments (treatment 1 and 3). This may be related to the price of maize grain which was lower than that of the noug seed cake and cotton seed cake. Therefore fattener or exporters can choose treatment two to fetch more profit. However, based on accessibility and availability of the feed ingredients, they can use the other two treatments as well as there was no significant difference among the treatments.

Table 2: Partial budget analysis of feeding Arsi-Bale rams on three dietary rations for 75 days

List of items	T1	T2	T3
Feeds costs per sheep	230	200	217
Purchasing price	900	900	900
labor cost per sheep	125	125	125
Vet cost per sheep	28.6	28.6	28.6
Total variable cost	**1283.5**	**1253.5**	**1270.5**
Total gross output per sheep	1650	1650	1650
Gross margin per sheep	366.5	396.5	379.5
Total gross margin	**2565.5**	**2775.5**	**2656.5**

CONCLUSION AND RECOMMENDATION

This trial showed that no significance difference among treatments in final body weight, total weight gain and average daily weight gains in 75 fattening days. This implies dietary treatments have similar effect on body weight of yearling Arsi-Bale sheep to attain export market weight. The yearling Arsi-Bale rams also attained export market body weight in 75 fattening days. This shows that yearling Arsi-Bale rams have good growth performance. The fact that positive gross margins are observed from the partial budget analysis indicates that fatteners can use one of the three feeding options depending on the availability of and accessibility for the feeds.

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Prevalence of gastrointestinal parasites in cattle kept under pastoral management system in selected districts of Borana zone, Ethiopia

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Abstract:

Prevalence of gastrointestinal of gastrointestinal (GI) parasites in cattle kept under pastoral management system in three selected districts (Arero, Moyale and Yabello) of Borana zone, Ethiopia, was conducted during the period of October 2016 to June 2017 to determine the prevalence, identify the species of parasite involved and access the risk factors of GIT parasites. For this study a total of 383 faecal samples were collected directly from the rectum and examined using standard parasitological procedures. The study revealed that an overall prevalence of GI parasite was 218 (56.92%). The prevalence is higher in Moyale (71.65%), followed by 52.76%and 46.51% in Yabello and Arero respectively. The occurrence of GI parasites in districts was found statistically significant (P <0.05). Highest prevalence was determined for strongyles type species (29.6%), Eimeria Oocyst (23.28%) and lower levels in trematodes and cestodes. Age, body condition of the animal and history anthelmintic use were also shown to have association with the prevalence of GI Parasites (P<0.05). Sex was insignificantly (P>0.05) associated with the occurrence of GIT Parasites. The study indicates that GI parasites are one of the major problems that affect health and productivity of cattle in the study area. Awareness creation to the pastoralists in the study area about the effect of GIT and designing appropriate control methods has a paramount importance to improve the health and productivity of cattle production in the area.

Key words: *Cattle, GIT Parasite, Prevalence, Borana, Ethiopia.*

INTRODUCTION

In Ethiopia livestock population has reached to 52 million cattle, 33 million sheep, 30 million goats and 2.5 million camels and it is the largest in Africa (Diriba and Tulu 2018).Despite the large cattle population, productivity in Ethiopia is low due to poor nutrition, reproduction inefficiency, management constraints and animal diseases (Habtemichael et al. 2018). The costs with frequent usage of anti-parasitic drugs, the poor feed conversation rates, the reduction of reproductive and/or productive performances, together with the possibility of drug resistance due to indiscriminate treatments with anti-parasitic drugs, represent some of the factors contributing to the reduced efficacy in cattle production (Hamid et al. 2016).

The gastrointestinal tract (GIT) of animals harbor a variety of parasites particularly helminthes, which causes clinical and sub clinical parasitism. These parasites adversely affect the health status of animals and cause enormous economic losses to the livestock industry (Turi et al. 2011).These losses are reduced weight gain, digestive disturbance, lowered production, impaired reproductive performance, condemnation of affected organs, and mortality in infected animals (Marskole et al. 2016) and working capacity of the animal mainly in developing countries (Telila et al. 2014)

The prevalence of gastrointestinal parasites, the genera of helminth parasites involved, species, and the severity of infection also vary considerably depending on local environmental conditions, such as humidity, temperature, rainfall, vegetation, and management practices (Regasa et al. 2006). In Ethiopia several studies have been conducted to determine prevalence of GIT helminthes in different agro ecology of the country (Ahmed et al. 2015) and most of them are tended to central, northern highlands and semi-arid regions of eastern Ethiopia (Awraris et al. 2012). Therefore, taking into account the significance of the parasite as one of the most important causes of economic losses and the scarcity of information in the area the present study was designed to determine the prevalence and major risk factors related to GIT parasite in study area.

MATERIAL AND METHODS

Study Area

The study was conducted from October 2016 to June 2017 in four districts (Arero, Moyale and Yabello) of Borana zone, Oromia national regional state, which is located about 565 km to South East of Addis Ababa. Resource use in the Borana rangeland is largely communal though with crop cultivation and private enclosures that appear to be increasing in recent decades. The area receives bimodal pattern of rainfall, with the long rains falling between March and May and the short rains between September and November. Spatial and temporal variability in both the quantity and distribution of rainfall renders the area semi-arid, with an average annual rainfall ranging from 400mm in the South to 600mm in the North. The average temperature varies from 13.1^0Cto 25.2^0C per annual (Coppock, 1994).

Study animals and management

In this study a total of 383 cattle of different age groups and both sexes were included. The animals were maintained under traditional extensive management system, where they foraged in communal pastures. In these areas, veterinary care was low and cattle had contact with other animal species such as goat and sheep in the communal grazing areas.

Study design and sample size determination

Multistage random sampling was applied to select the study animals. The sampling frame comprised a list of all districts in the zone and three zones (Arero, Moyale and Yabello) were selected for the study. The total sample size was determined based on internationally set standard formula (Thrusfield, 2005). There was no previously published documented prevalence in the study area. Therefore, sample size was calculated using 95% confidence level at 5% absolute precision and expected prevalence of 50% by substituting the value, the minimum sample sizes of 384 was obtained however for this study 383 cattle were considered.

Study Methods

i) Faecal sample collection and examination

The faecal samples were collected directly from the rectum of selected cattle by using latex examination glove and placed in screw cupped universal bottle. The bottles were labeled with a code containing the district name, season and animal identity. The fecal samples were transported with an icebox to parasitology laboratory of Yabello pastoral and dry land agriculture research center. Samples were properly stored at 4°C till examination. The faecal samples were examined by direct, sedimentation and floatation methods for presence of eggs. Floatation technique was employed for qualitative examination of faecal samples. Saturated NaCl solution was used to concentrate nematode eggs, cestode eggs and coccidian oocysts. Sedimentation technique was also conducted to detect trematode infection in faecal samples Identification of eggs was done by examining under a compound microscope as described in Soulsby, (1982).

ii) Data Management and Statistical Analysis

Data collected from the field and laboratory assays were entered and stored in Microsoft Excel spread sheet, screened for proper coding and errors and analysis was done. The results were summarizes by descriptive statistical tools such as frequency tables percentage, graphs. STATA version 13 software was used for statistical analysis of the data (Stata Corp LP, College Station, Texas USA). Chi-square test was used to measure association between potential risk factors and sero-prevalence. Variables with p-value of less than 0.05 were included in multivariable analysis and multivariable model was fitted. Finally, odd ratios and 95% confidence interval were calculated and disease associated risk factors with a p-value less than 0.05 considered significant.

Results and discussion

Prevalence of Cattle gastrointestinal parasite by risk factors

Cross-sectional study on CCPP was conducted in selected districts of Borana zone, Southern Oromia, Ethiopia from October 2016 to June 2017 and the results are summarized in Table 1. In the present study, out of 383 cattle screened, 218 (56.92) were harbored one and/or more gastrointestinal parasites. This is in similar with findings with (Derib et al. 2005, Regasa et al.

2006,Telila et al. 2014) who reported 50.2%, 50.8%, 50.08%, prevalence respectively. Elsewhere in the world similar prevalence 55.59% by (Turi et al. 2011). This result is also similar with that of Ntonifor et al. (2013) who reported the prevalence of 56.7% GI parasites of cattle in western Cameroon. In contrast to this finding lower prevalence where reported by (Bacha and Haftu, 2014, Diriba et al. 2018) and higher prevalence of GI parasites of 82.8% in Holleta were reported by (Etsehiwot, 2004).The difference might be due to variation in the type of management, geographical location and the number of samples and as well as sampling design used in the study and also The probable reason for low prevalence could be due to regular use of anthelmintics. The highest prevalence (71.65%) was observed in Moyale, followed by 52.76% and 46.51% in Yabello and Arero respectively and the difference was statistically significant ($P < 0.05$). Based on history of deworming 38 (41.3%) cattle were positive from cattle treated with anthelmintic and 180 (61.86%) were positive from cattle not treated and significant variation ($p>0.05$) was observed. This result is similar with Telila et al. (2014). The effect of sex on the disease prevalence was assessed however, the difference in prevalence was not significant ($p>0.05$). There was a significant difference in the occurrence of GI parasite between different age groups ($P< 0.05$) where young (66.85%) were more likely to test positive than Adult cattle (47.74%).This finding is in consistent with the work of Pfukenyi et al. (2005) in communal grazing areas of Zimbabwe, Kemal and Terefe (2013) in Gedebario Gutazer Wolane district and (Tulu and Lelisa 2016) in Tulo District. However the present finding contradicts with the report of Regassa et al. (2006). Difference in age groups in the present study is most probably due to susceptibility and resistance of different age groups. Out of 218 cattle found positive for fecal egg detections, 80(47.62%) had good body condition score, 80(57.14%) medium and 58(771.33%) poor body conditions and significant variation was observed. This study finding is in line with reports of, Awraris et al. (2012), Telila et al. (2014),(Diriba and Tulu 2018), who reported that significant association between prevalence of gastrointestinal parasite and body condition. However, this finding disagrees with the findings of Manaye (2002) and Regassa et al. (2006) who reported absence of significant difference on the prevalence of helminths in animals with body condition.

Table 2: Prevalence of Cattle gastrointestinal parasite by risk factors

Risk factors		**No examined**	**No positive**	**Prevalence (%)**	**X^2**	**P-value**
District	Arero	129	60	46.51	17.84	<0.001
	Moyale	127	91	71.65		
	Yabello	127	67	52.76		
History of deworming	Yes	92	38	41.30	12.04	<0.001
	No	291	180	61.86		
Sex	Female	278	152	54.68	2.08	0.149
	Male	105	66	62.86		
Age	Adult	199	95	47.74	14.24	<0.001
	Young	184	123	66.85		

Body Condition	Good	168	80	47.62	18.67	<0.001
	Medium	140	80	57.14		
	Poor	75	58	77.33		
	Total	**383**	**218**	**56.92**		

Results of multivariate logistic regression analysis to fit the model revealed that among the risk factors considered in the analysis district, body condition, history of deworming and age of animals had statistically significant effect on sero-positivity ($p<0.05$). However, sex of the animal had not statistically significant effect on sero-positivity. The individual animal level sero prevalence was significantly by 2.7 times higher in Moyale district than in Arero district and prevalence in Yabello district shows about 1 times higher chance of getting infection to GI parasite than cattle those reared in Arero district. Animals with no history of deworming was found epidemiologically very important for harboring parasite in the area and increase the sero-positivity of GI parasite infection by 0.5 times than animals dewormed. Sero-prevalence was significantly increased by 1.8 times in young age than adult animals. The odd of sero-positivity for GI parasite in poor and medium body condition were about 2.3 and 1.14 times higher than that of good body condition animals (Table 2).

Table 2. Results of multivariate logistic regression analysis of prevalence GIT parasites in cattle

Risk factor	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf. Interval]
District					
Moyale	2.683	0.754	3.514	<0.001	(1.547 - 4.654)
Yabello	1.033	0.276	0.123	0.902	(0.612 - 1.746)
Animals not dewormed	0.491	0.132	-2.641	0.008	(0.290 - 0.832)
Young age	1.796	0.43	2.447	0.014	(1.124 - 2.872)
Body condition					
Medium	1.137	0.288	0.509	0.611	(0.693 - 1.867)
Poor	2.293	0.78	2.439	0.015	(1.177 - 4.468)
constant	0.718	0.176	-1.349	0.177	(0.444 - 1.162)

The prevalence of various GI parasites were; *strongyle spp, Eimeria Oocyst, Ascaris, strongyloides, Fasciola spp, Monezia spp, Trichuris spp and paraphistomum,* was 29.60, 23.28, 11.78, 9.48, 4.31, 1.44 and 0.86 percent respectively. The mixed infection rate was 14.37percent (Figure 1). These findings are similar with the finding of Telila et al. (2014).

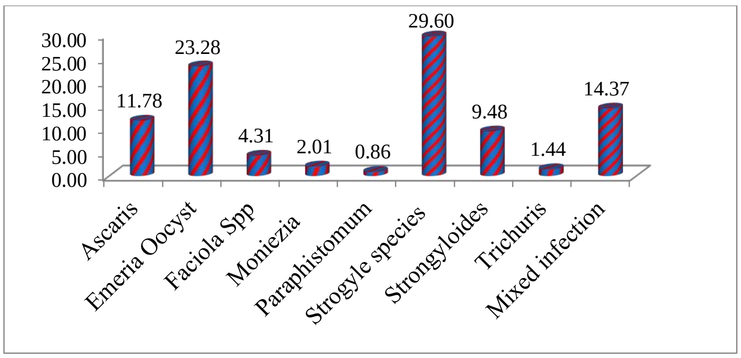

Figure 1: Prevalence of gastrointestinal parasites in Cattle

Conclusion and recommendations

This study revealed that the occurrence of high prevalence of GI parasitic infestation which cause serious problems in livestock production in the study area. Therefore, there should be implementation of strategic control measure that integrate better nutrition with anthelmintic treatment in order to increase the productivity of cattle in the area are suggested. Future studies on seasonal transmission pattern of the parasite in order to design control program and studies to evaluate the economic impact GI parasite in the study area are required.

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Evaluation of Growth and Survival Performance of Different Blood Levels of Crosses between Dorper and Black Head Sheep

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Abstract

Growth and survival performance of Black head and Dorper crossbred lambs were studied at Yabello Pastoral and Dry land Agriculture Research Center across periods from birth to weaning and weaning to 365 days of age. Performance data sets created via measurements and observations made, and each data set was analysed using generalized linear procedure and logistic regressions. Explanatory variables included in the models were breed group, sex, and lambing season. Growth performance estimated for Birth (BWT), Weaning (WWT), Six (6MWT), Nine (9MWT), and Yearling Weight (YWT) respectively ranged from 2.43kg to 2.75 kg, 7.79kg to 14.89 kg, 14.55kg to 19.86 kg, 17.30kg to 24.79kg, and 18.31kg to 29.55 kg for all cross-bred groups. Blood group of crossbred lambs had a significant effect ($p \leq 0.05$) on lamb growth performance for all growth traits. Pre-weaning (Pre-WADG) and Post-weaning (Po-WADG) average daily gain of all breed groups ranged from 83.99g to 163.98g and 71.32g to 95.23g respectively, with a significant ($p<0.05$) breed group effects. The overall mean of cumulative lamb mortality rate was 16.55% from birth to weaning and 18.14 % from weaning to one years of age. Pre and post weaning mortality rate of lambs' significantly varied ($p<0.05$) based on breed group. Generally, the difference in growth performance between Black head sheep and other breed groups were found to be higher with the likelihood of low survival rate of the higher Dorper blood level crossbred lambs. Therefore, proper fostering will have the potential to increase overall lamb survival and establishing proper management for crossbred lambs with higher blood level of Dorper which is essential to improve productivity of sheep in Borana zone.

Key Words: Black Head Sheep; Crossbred; Dorper; Evaluation; Growth; Survival.

Introduction

Country reports on farm animal genetic resources (FAO, 2007) indicated that importance of small ruminant is very diverse, particularly for the poor under low input production system in the developing countries. They are integral part of livestock keeping in Ethiopia and are kept mainly for immediate cash sources, milk, meat, wool, and manure and saving or risk distribution (Tibbo, 2006). Small ruminants also have various social and cultural functions that vary among different cultures, socio-economies, agro-ecologies, and locations in tropical and sub-tropical Africa.

Ethiopia's sheep population was estimated at 30.70 million heads (CSA, 2017). They are widely distributed across the diverse agro-ecological zones and geographical regions of the country.

The annual mutton and goat meat production of the country was estimated at 78 and 69 thousand metric tons, respectively (FAO, 2004). Live animals are also exported to Middle East countries and sources for foreign currency; for example, between 1995-1996 an estimated amount of 4.6 million US$ was derived from the export of small ruminant (EARO, 2000). In Ethiopia, sheep and goats provide 25% of the domestic meat consumption with production surplus, which mainly exported as live animals. The two species also provide about 40% of fresh skins and hides production and 92% of the value of semi-processed skins and hides export trade (Kebede, 1995).

Despite genetically diverse sheep population and an emerging opportunity for sheep mutton in either domestic or foreign markets, most of the indigenous breeds are characterized by slow growth rate (18-20 kg) and their average yearling weight is by far below the required standards by most of the export abattoirs and off take rate is very low at 33% (EPA, 2002). The low productivity attributed to low genetic potential, poor husbandry practices and diseases prevalence.

With the objective to improve marketable weight, currently, exotic mutton sheep breed (Dorper) imported and has been severing as sire line for upgrading growth performance of local sheep breeds. Crossing of Black head sheep with Dorper and dissemination of F1 genotype has been in progress in different parts of the country with the initiative started by Ethiopian Sheep and Goat Productivity Improvement Project (ESGPIP). Accordingly, disseminating F1 genotypes have been on progress to the sheep producers to upgrade the performance of local breed through terminal crossing. Preliminary results indicated that the performance of F1 genotypes under station management level found significantly higher than pure dam line (Zewdu*et al.,* 2011). However, performances of crossbred sheep with various exotic blood levels have not been yet thoroughly evaluated both at on-station and on-farm levels. Generally, little information is available on growth, reproduction, and survival performances of crossbred genotypes with different exotic breed blood proportion in the country.

Systematic evaluation of different blood level is a prerequisite prior to deciding wider scale dissemination of exotic bloods because different exotic blood levels vary in their performance. Thus, it is logical and procedural to evaluate the performance of different exotic bloods levels with its full packages at station level prior to engage in dissemination of crossbred animals for the commercial producers. At the same time, evaluating adaptability and performance of different blood levels of crossbred genotypes at on farm levels is mandatory. Among the arrays of reasons for the failure of past crossbreeding projects, lack of systematic crossbreeding strategy is one of the frequently reportedfactors of all type.

Objective

- To evaluate growth and survival performance of Dorper × BHS crosses and under station management system.

Materials and methods

Experimental site

The study was carried out at Yabello Pastoral and Dry land Agriculture Research Center (YPDARC). The center is located at 570 km south of Addis in the semi-arid agro-ecologies at an altitude of 1621 meters above sea level (masl). The area is characterized by bimodal rain fall which is unreliable and erratic measured as average annual rainfall of 585mm. Fifty –nine percent (59%) of annual precipitation occurs from March to May and 27% from September to November (Coppock, 1994).

Management of parent stock

Pure Blackhead Somali sheep kept at the BED site or purchased from the locality were used as dam line and best F1 males having good growth rate were used as sire line for the production of 25% Dorper&75% BHS. For 75% Dorper and 25% BHS production, best 50% D x 50% BHS females were mated to pure Dorper rams. Pure Dorper rams were obtained from other nucleus sites of Werer, Haramaya and Fafen.

Breeding scheme and management

A two-way cross between two sheep breeds (Dorper and BHS) performed. The crossed animals mated with either pure BHS or Dorper sheep depending on the desired blood level of the progeny (25%, 50%, or 75% of the exotic blood). From F1 females progenies produced, randomly selected for production of progenies with 75% exotic blood level. Similar procedures followed to select F1 breeding rams to produce progenies with 25% exotic blood level from local ewe. Both males and females that failed to meet the breeding criteria regularly culled. Rams released for night mating during the peak-mating season (October to May) to synchronizekidding with optimum forage production. The mating periods were on average for two months.

Animal management

Animals raised under extensive conditions with supplementation made only inside extreme dry period. Animals were released on pasture during the day and kept indoors during the night. The routine activity of taking sheep flock forgrazing and supplementation lucks regularity and considered as one of the major factors for under performance of sheep flocks in the study. Moreover, access for local minerals (Soda) and water problem was observed most regularly. Ewes with new born lambs kept in separate pens up to weaning age. Within 24 hours of birth, lambs sexed, weighed, and identified. Kid ID, Dam ID, Sire ID, date of birth, sex and birth status of lambs recorded regularly. Following birth, lambs are weighed fortnightly using spring balance. Lambs were suckling their dams twice a day (morning and evening) and weaned at approximately three months of age. The flocks were annually vaccinated for Contagious Caprin Pleuro Pneumonia_(CCPP), PPR, Ovine pasteurellosis anthrax, and blackleg and goat pox. All flocks were dewormed with *albendazole* quarterly and sprayed against internal parasite for external parasites with *acaricids (1cc/1lt water).* Treatments were given based on observed clinical signs.

Collected Data

Production data such as Birth, weaning, six-months, nine months, and yearling weights were regularly collected. Moreover, fortnight body weightswere collected up to six month of age and monthly until the animal exist from the breeding flock.

Health data: Data on daily clinical activity, Periodic sampling along with laboratory analysiswere performed side by side to growth data collection.

Data management and Statistical Analysis

Relevant productive data recorded on routine basis on record sheet and then the collected data entered and coded. GLMprocedures of SAS (2009) employed to analyse quantitative variables. Traits fitted in model included, birth weight (BWT), weaning weight (WWT), six-month weight (6MWT), nine-month weight (9MWT), yearling weight (YWT), Pre-weaning (PreADG), and post-weaning (PoADG) average daily gain.Fixed effects included, sex (male, female) type of birth (single, twin), lambing season (long dry, cool dry and rainy/wet), parity of dam (from first to fifth)and breed group (Local, 25% Dorper, 50% Dorper, 62.5 Dorper and 75% Dorper). Effects of class variables were expressed as Least Square Means (LSM) ± SE. Average daily pre weaning gain values from birth to weaning (approximately 105 days of age) and average pre-weaning gain from birth to weaning calculated as differences between the live weights at birth and weaning weight of the lamb divided by days-of-age. Similarly, post weaning average gain from weaning to yearling calculated as differences between weight at weaning and yearling weight of the lamb divided by days of age. The extended model fitted for growth traits:

$$\mathbf{Y_{ijklmn} = \mu + S_i + P_j + LS_k + BG_l + BT_m + e_{ijklmn}}$$

Where: Y_{ijklmn}= an observation of a trait on the i^{th} sex, j^{th} parity of dam, k^{th} lambing season, l^{th} breed group, and m^{th} birth type

μ = Overall mean

S_i = fixed effects of the i^{th} sex (i= male and female)

P_j= fixed effect of j^{th} parity of dam (j = 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th})

LS_k = fixed effect of k^{th} lambing season (k = long dry, cool dry and wet/rainy)

BG_l= fixed effects of the l^{th}breed group (l = Local, 25% Dorper, 50% Dorper, 62.5% Dorper and 75% Dorper)

BT_m= fixed effects of the j^{th} birth type (m = Single and Twin)

e_{ijklmn} = residual error variance

Pre and post weaning mortality of kids was analysed using binary logistic procedure of STATA version 13 (2013) for windows. The Pearson chi-square for two-way tables performed to analyse the differences between the observed and expected frequencies, the expected frequencies computed under the null hypothesis of independence. The Pearson chi-square statistic computed as:

$$Q\rho = \sum_i \sum_j \frac{(n_{ij} - e_{ij})^2}{e_{ij}}$$

Where: n_{ij} is the observed frequency in table cell (i, j)

e_{ij} is the expected frequency for table cell (i, j).

The expected frequency computed under the null hypothesis that the row and column variables are independent, and computed as

$$e_{ij} = \frac{n_i * n_j}{n}$$

Results and Discussion

Pre-Weaning Growth: The average birth weights (BWT), pre-weaning growth (PWADG) and weaning weights (WWT) are shown in Table 1. Black Head × Dorper (50 % Dorper) lambs showed the highest BWT, WWT and PWADG; Black Head (Borana black-headed mutton sheep) showed lowest weight performances with significant difference ($p<0.05$). Besides the genotype factors such as birth type (single and twin), Parity (1st, 2nd, 3rd, 4th and 5th) and birth season (cool dry, long dry and rainy) had significant influence on BWT, WWT and PWADG significantly ($p<0.05$). However, sex of lambs did not have significant influence ($p>0.05$) WWT and PWADG except BWT ($p<0.05$).

Table 1. Least Square Means (means ± SE) for Pre-weaning Growth Performance of Black Head Sheep and their Crosses with Dorper

Items	Effects	BWT kg^{-1}	PreWADG gm^{-1}	WWT kg^{-1}
Overall ± STD		3.03 ± 0.69	149.66 ± 46.13	13.55 ± 4.19
CV (%)		19.59	18.36	18.53
Sex	Female	2.36±0.13^{b}	123.22±8.09^{a}	11.45±0.74^{a}
	Male	2.66±0.14^{a}	129.72±8.26^{a}	11.94±0.76^{a}
Birth Type	Single	3.01±0.08^{a}	142.24±4.03^{a}	13.04±0.37^{a}
	Twin	2.00±0.23^{b}	110.21±14.56^{b}	10.34±1.33^{b}
Blood Level	Local	2.43±0.15^{bc}	83.99±9.560^{d}	7.79±0.87^{d}
	25 % Dorper	2.62±0.12^{a}	110.35±9.40^{c}	10.23±0.86^{c}
	50 % Dorper	2.68±0.24^{a}	163.98±7.22^{a}	14.89±0.66^{a}
	62.5 % Dorper	2.06±0.24^{c}	131.63±12.21^{b}	12.46±1.12^{b}

	75 % Dorper	2.75±0.15^{a}	141.18±8.79^{b}	13.08±0.80^{b}
Parity	First	2.24±0.13^{b}	111.30±7.80^{b}	10.12±0.71^{bc}
	Second	2.73±0.15^{a}	98.95±8.41^{c}	9.23±0.77^{c}
	Third	2.48±0.16^{ab}	147.19±9.47^{a}	13.45±0.86^{a}
	Fourth	2.80±0.22^{a}	161.24±11.66^{a}	15.06±0.07^{a}
	Fifth	2.30±0.15^{b}	112.46±9.29^{bc}	10.60±0.85^{b}
Birth Season	Cool Dry	2.36±0.16^{b}	116.70±9.65^{b}	10.70±0.88^{b}
	Long Dry	2.55±0.14^{ab}	128.36±8.19^{ab}	12.01±0.75^{a}
	Wet (Rainy)	2.60±0.13^{a}	133.63±7.92^{a}	12.36±0.72^{a}

^{abcd}With in a column under the same factor identifier, values with different superscript letters (a–d) differ significantly at P < 0.05.

Post-Weaning Growth: list square means with standard error (Means ± SE) from GLM analysis presented in Table 2.Average six month weight (6MWT), nine month weight (9MWT), post weaning daily growth (PoWADG) and yearling weight (YWT) of Black Head Sheep and their Dorper crosses respectively, ranged from 14.33±0.93kg to 19.86±0.53kg, 20.91±1.39kg to 24.79±0.77kg, 71.32±4.87g per day to 95.23±2.86g per day and 18.31±1.59kg to 29.55±2.23kg. Post weaning growth for Black Head Sheep × Dorper (50% Dorper) were consistently higher (*p<0.05*) than the other particularly Black Head Sheep (Local). In association to birth season, considerable difference (*p<0.05*) existed among means of 6MWT and YWT. Accordingly, lambs that were born long dry season for 6MWT and cool dry for YWT had heavier weight than those that born in side the other season of birth for respective growth traits. However, there is no significant differences (*p>0.05*) observed in related to the sex of lambs borne.

Table 2.Least Square Means (means ± SE) of Post-weaning Growth performance for Black Head Sheep and their Crosses with Dorper.

Item	Effects	**6MWT kg^{-1}**	**9MWT kg^{-1}**	**PoWADG gm^{-1}**	**YWT kg^{-1}**
Overall ± STD		18.49±4.93	21.77±5.49	82.72±20.44	23.99±6.35
	CV (%)	19.73	21.57	20.99	21.3
Sex	Female	16.99±0.58^{a}	20.86±0.78^{a}	78.83±2.90^{a}	23.74±1.13^{a}
	Male	17.56±0.56^{a}	21.67±0.77^{a}	82.88±2.87^{a}	24.47±1.16^{a}
Blood Level	Local	14.55±0.76^{c}	17.30±1.32^{c}	71.32±4.87^{b}	18.31±1.59^{d}
	25 % Dorper	14.50±0.71^{c}	19.47±1.00^{bc}	72.19±3.571^{c}	20.44±1.16^{cd}
	50 % Dorper	19.86±0.53^{a}	24.79±0.77^{a}	95.23±2.86^{a}	27.99±1.02^{ab}
	62.5 % Dorper	17.91±1.48^{a}	20.92±1.88^{bc}	77.29±6.98^{b}	24.24±2.12^{bc}
	75 % Dorper	19.55±1.35^{a}	23.84±1.82^{ab}	88.26±6.98^{ab}	29.55±2.23^{a}
Birth Season	Cool Dry	14.33±0.93^{b}	20.91±1.39^{a}	80.57±5.16^{a}	26.04±1.81^{a}
	Long Dry	19.57±0.65^{a}	20.94±0.91^{a}	79.45±3.41^{a}	19.92±1.33^{b}
	Wet (Rainy)	17.92±0.61^{a}	21.95±0.86^{a}	82.55±3.25^{a}	23.45±1.79^{ab}

^{abcd}With in a column under the same factor identifier, values with different superscript letters (a–d) differ significantly at *P < 0.05*.

Pre-weaning survival: total of lambs, lambs died to weaning, and percent of loss that occurred from birth to 90 days presented in Table 3. Of all lambs with different blood levels born, 11heads of 62.5% Dorper cross lambs born alive and eight (8) of them survived to weaning. Hence, 27.27% were born alive but died before weaning which is the highest rate of pre-weaning mortality observed among Black Head Sheep and their Crosses. However, there is no significant differences (*χ^2 >0.05)* observed in related to this particular risk factor. In the contrary, 131 heads of female and 153 heads of male lambs were born alive, respectively; whereas, 21.37% and 12.42% diedbefore weaning, in respective order. The rate of lambs that born alive, but, died before weaning was not similar ***(χ^2 <0.05)*** in both sex. Similarly, the number of lambs died before weaning was found similar ***(χ^2 <0.05)***in associated with lambing season.

Table 3. Mortality Rate of Pre and Post weaning Growth Traits for Black Head Sheep and their Crosses with Dorper

Growth Stage	Risk Factors	Levels (N)	Lambs Died	Mortality (%)	χ2	P<0.05
Birth to Weaning	Sex	Female (131)	28	21.37		
		Male (153)	19	12.42	4.09	0.0429
	Breed Group	Local (53)	3	5.66		
		25 % Dorper (50)	6	12.00		
		50 % Dorper (152)	25	20.39		
		62.5 % Dorper (11)	3	27.27		
		75 % Dorper (18)	4	22.22	8.26	0.0824
	Lambing Season	Cool Dry (134)	15	11.19		
		Long Dry (128)	29	22.66		
		Wet (Rainy) (22)	3	13.64	6.37	0.0413
Weaning to 1 Year	Sex	Female (103)	15	14.56		
		Male (134)	29	20.90	1.57	0.2099
	Breed Group	Local (50)	2	4.00		
		25 % Dorper (44)	9	20.45		
		50 % Dorper (121)	26	21.49		
		62.5 % Dorper (8)	2	25.00		
		75 % Dorper (14)	4	28.57	9.08	0.0591
	Lambing Season	Cool Dry (119)	19	15.97		
		Long Dry (99)	22	21.10		
		Wet (Rainy) (19)	2	10.53	2.23	0.3277

Post-weaning Survival: Number of lambs born alive and survived to yearling and percent of loss that occurred from 90 days to yearling presented in Table 3. Of all 75%Dorper cross lambs born, 14 alive and 73.33% of them survived to yearling. Hence, 26.67% were born alive but died before yearling, which is the highest post weaning mortality rate, observed among Black Head Sheep and their Crosses. In the contrary, Black Head lambs (locals) exhibited the lowest (MR=4%) post weaning lamb loss with the majority (96%) survived to Yearling. However, there is no significant differences ($\chi^2 > 0.05$) observed in the remaining risk factors (sex and lambing season). Similarly, mortality rate of female lambs that were born alive, but died in production period from 90 days to yearling was lower (14.56%), not significantly different ($\chi^2 > 0.05$) when compared their male counterpart. On the other hand, the number of lambs died before weaning was found similar ($\chi^2 > 0.05$)in associated with lambing season.

Discussion

The overall least-squares means for lambs' weights at the different growth periods observed for the current study were within the range of values observed by Tibbo (2006), Awgichew *et al*. (2000), Abegaz (2002), Tibbo *et al*. (2004), Gizaw *et al.* (2012) and Abebe *et al.* (2015). In most of the cases breed group, birth season, parity, type of birth and sex of the lamb had significant effects on body weights at different ages. These factors were also proven to be important in previous studies on growth performance for lambs of different breeds (Teklebrhan *et al*., 2014; Deribe, 2009; Gardner *et al.,* 2007; Yilmaz *et al.,* 2007, Hassen *et al.*, 2004; Hassen *et al*., 2002). The significant differences in body weight among lambs born in different periods attributed to differences in management (availability of feed and water) and environmental conditions such as the ambient temperature, humidity, rainfall, etc. Similarly, pre and post weaning average daily gain of crossbred lambs were significantly ($p<0.05$) higher than their local counterpart and affected by the non-genetic factors such as sex, birth type and season of lambing. The current result found in agreement with several research results disclosed by Mestafe *et al.* (2015); Momoh *et al.* (2013); Taye *et al.,* (2010) and Tibbo (2006) for different type of sheep breed.

Pre and Post weaning mortality observed under this study was relatively higher particularly, for lambs with 62.5% and 75% dorper blood. The current result was found far from the two extreme lower and upper MR results (3% MR) reported by Gavojdian *et al.* (2013), (50.50 % MR) Tibbo (2006) and (34.6 % MR) Tsedeke (2007) for various type of sheep breeds. Nevertheless, more or less the result (16.8% MR) reported for Dorper crosses by Marufa *et al.* (2017) found within the range of current study. The reason why the current MR is observed unusually very high is attributed to the management level given to the sheep flock at the station can be considered purely extensive and sometimes get worse.

Conclusions and Recommendations

Black Head Sheep producers in the Borana Pastoral Range lands should be able to produce lambs through crossing with Dorper. Lambs with 50% and 75% Dorper blood rate were exhibited heavier weight at weaning (90 days), six month (180 days), nine months (270 days) and yearling (365.5 days) with higher rate of average pre and post weaning daily gain. There were no significant differences in death loss due to blood level of Dorper and season of birth in this study, indicating that producers would not suffer higher losses for lambs with 50% Dorper. However, 75% Dorper lambs displayed higher rate of mortality. This may indicate a need to look at fostering one of the higher Dorper blood (≥ 50% Dorper) lambs to improve overall pre and post weaning survival rate. More research needed to determine the meat quality, feed conversion ratio and economic differences between Black Head and their crossbred lambs. Additionally, studying recombinant effect of cross breed lambs will provide additional information in order to set future cross breeding plan.

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Evaluation of Growth and Survival Performances of Pure Borana Goats and their Crosses with Boer Goats

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Abstract

Evaluation on growth and survival performances of Borana goats and their crosses with Boer was performed at Yabello Research Center. General Linear Model (GLM) and Chi-Square procedure of Statistical Analysis System (SAS) was used to analyse the effect of breed group, sex, parity, birth type and kidding season on traits such as BWT, PADG, WWT, 6MWT, 9MWT, YWT, PoADG and Mortality Rate. Growth performances and mortality rate of crossbred goats were significantly affected ($p<0.05$) by most of the factors including as breed group, sex, parity, birth type and birth season. Average pre and post weaning growth performances of crossbred goats were 3.26±0.78kg (BWT), 138.34±41.87 g (ADG)and 11.79±2.88 kg (WWT). Post-weaning growth performances were, 16.63±3.51 kg, 19.55±4.62 kg, 21.61±5.47 kg and 84.68±29.1 g, respectively for 6MWT, 9MWT, YWT and PoADG were varied ($p<0.05$) based on Boer to Borana goat blood ratios of kids. Mortality rate were 9.38%, 16.95%, 25%, and 20.91%, in respective order, for 25% Boer, 50% Boer, 75% crosses of Boer and Local Borana Goat; the mortality rate did not significantly influenced by the level of bloods($\chi^2>0.05$). Generally, crossbred goats outperformed the indigenous goat breed. As a result, systematic crossing of Boer with indigenous Borana goat breed is recommended as it improves the growth performance without a major loss of kids due to the blood ratio of Boer up to 75% cross level. Further research work is needed to understand responses of breed groups in relation to various management systems in order to reduce mortality rates.

Key words: Crossbred; Evaluation; Goats; Growth; Pre and Post weaning; Survival Performance

Introduction

Country reports on farm animal genetic resources (FAO, 2007) indicated that importance of small ruminant is very diverse, particularly for the poor under low input production system in the developing countries. They are integral part of livestock keeping in Ethiopia that are mainly kept for immediate cash sources, milk, meat, wool, manure and saving or risk distribution (Tibbo, 2006).

The annual mutton and goat meat production of the country is estimated at 78 and 69 thousand metric tons, respectively (FAO, 2004). Live animals were being also exported to Middle East countries and were sources for foreign currency; for example, between 1995-1996 an estimated amount of 4.6 million US$ was derived from the export of small ruminant (EARO, 2000). In Ethiopia, sheep and goats provide 25% of the domestic meat consumption with production surplus, which is exported mainly as live animals. The two species also provide about 40% of fresh skins and hides production and 92% of the value of semi-processed skins and hides for export trade (Kebede, 1995).

With the objectives to improve marketable weight, currently, exotic meat goat breed (Boer) and sheep breed (Dorper) have been imported and being severing as sire line for up-grading of local meat sheep and goat breeds. Crossing of pure Borana goat with Boer and dissemination of first filial generation(F1) genotype has been in progress in different parts of the country with the initiative of Ethiopian Sheep and Goat Productivity Improvement Project (ESGPP). In this program, F1 genotypes have been disseminating to the goat producers to upgrade the performances of local breed through terminal crossing. Preliminary results indicated that the performance of F1 genotypes under station management level is significantly higher than pure dam line (Zewdu*et al.,* 2011). However, performances of crossbred goat with various exotic blood levels have not been yet thoroughly evaluated both at on-station and on-farm levels. Generally, little information was available on growth, reproduction and survival performances of crossbred genotypes in the country.

Systematic evaluation of different blood level is a pre-requisite prior to deciding wider scale dissemination of exotic bloods as different exotic blood levels vary in their performances. Thus, it is logical and procedural to evaluate the performances of different exotic blood levels with its full packages at station level prior to engage in dissemination of crossbred animals for the producers. At the same time, adaptability and performance of different blood levels of crossbred genotypes should be evaluated at the farm levels. Among the arrays of reasons for the failure of past crossbreeding projects lack of systematic crossbreeding strategy could be one of the factors.

Objective

- To evaluate the growth and survival performances of crosses of Boer and Pure Borana goats (75% and 25%) under station management system

Materials and methods

Experimental site

The study was carried out in the Yabello Pastoral and Dry land Agriculture Research Center (YPDARC). The center is located at 570 km south of Addis in the semi-arid ago-ecologies at an altitude of 1621m.a.s.l. The area is characterized by bimodal rain fall which is unreliable and erratic measured as average annual rainfall of 585mm. Fifty –nine percent (59%) of annual precipitation occurs from March to May and 27% from September to November (Coppock, 1994).

Management of parent stock

Pure Borana goat kept at the breeding evaluation and distribution (BED) site or purchased from where pure Borana goats found (Moyale and Dirre) was used as dam line and best F1 males having good growth rate was serve as sire line for the production of F2 (25% Boer & 75% PBG). For 75% Boer and 25% PBG production, best 50% Boer x 50% Borana goat females mated to pure Boer Bucks. Pure Boer bucks were purchased from nucleus sites of Werer, Haramaya and Fafen.

Breeding scheme and management

Cross breeding scheme followed is indicated in Figure 1. Two way crosses, a cross between two breeds (Boer x PBG). The crossed animals were mated with either pure Borana Goat or Boer goat depending on the desired blood level of the progeny (75% or 25% of the exotic blood). Similar procedures wasfollowed for selection of F1 breeding bucks to produce progenies with 25% exotic blood level from local doe. Both males and females that failed to meet the breeding criteria were culled. Bucks were released for night mating during the peak-mating season (October to May) to synchronize kidding with optimum forage production.

Animal management

Animals were raised under semi-intensive conditions with some supplementation depending upon status and age category. Animals were allowed to graze on pasture during the day and kept indoors during the night. Animals had access for local minerals (Soda). Doe with newborn kids were kept in separate pens up to weaning age. Within 24 hours of birth, kids were sexed, weighed and identified with permanent ear tag. Then after, kid ID, dam ID, sire ID, date of birth, sex and birth status of the kids recorded. Following birth, kids were weighed fortnightly using spring balance. Kids were allowed to suckle their dams twice a day (morning and evening) and weaned at approximately at three months of age.

The goat flockswere vaccinated annually for Contagious Caprine Pleuro pneumonia(CCPP), PPR, Ovine pasteurellosis, anthrax, and blackleg and goat pox. All the flocks were dewormed with *albendazole* quarterly against internal parasite and sprayed for external parasites twice per month with acaricides (1cc/1lt water). Treatments were given whenever clinical signs of illness wasobserved.

Collected Data

Production performance data including, birth weight, weaning weight, six-month weight and yearling weight were evaluated. Moreover, fortnight body weight recordingwas made up to six month of age and continued monthly until the animal existed from the breeding flock.

Data on daily health activity, periodic sampling along with laboratory analysis, number of kids born alive, number of kids born died, date and season of death and sex of the kids died were recorded.

Data management and Statistical Analysis

Relevant production, health, and socio-economic were data recorded routinely on recording sheet, entered to computer and then coded. All quantitative data collected were analysed using GLM procedure of SAS (2009) version 9.2. The model for birth weight, weaning weight, six month weight, yearling weight, ADG1 and ADG2 included fixed effects of sex (male, female), type of birth (single, twin and triplet), season of kidding (long dry, cool dry and wet/rainy season) and exotic blood level (100% local, 25% Boer, 50% Boer and 75% Boer). The effects of class variables expressed as Least Square Means (LSM) ± Standard Error (SE). Average pre-weaning gain values from birth to weaning (approximately 90 days of age) and average post-weaning gain from weaning to one year was calculated as live weight at weaning divided by age of the kid's in days. Similarly, post weaning average daily gain from weaning to yearling was calculated as differences between weaning and yearling weight of the kids divided by age the kids in days. The following model was fitted for the aforementioned growth traits:

$$Y_{ijkl} = \mu + S_i + P_j + Bt_k + Ks_l + Bg_m + e_{ijkl}$$

Where: $Y_{ijk\,l}$= an observation of a trait on the i^{th} sex, j^{th} parity, k^{th} type of birth, l^{th} kidding season and m^{th}breed Group

μ = Overall mean,

S_i = fixed effects of the i^{th} sex (i= 1, 2)

P_j = fixed effects of the j^{th} parity (j = 1, 2, 3,4,5)

Bt_k=fixed effect of bt^{th} birth type (k=1, 2, 3)

Ks_k=fixed effect of l^{th} kidding season (l=1, 2, 3)

Bg_k=fixed effect of m^{th} blood level (m=1, 2, 3, 4)

e_{ijk} = residual error variance

Pre and post weaning mortality of kids was analysed using binary logistic regression of STATA version 13 (2013). The Pearson chi-square for two-way tables performed to analyse the differences between the observed and expected frequencies; the expected frequencies computed under the null hypothesis of independence. The Pearson chi-square statistic computed as:

$$Q\rho = \sum_i \sum_j \frac{(n_{ij} - e_{ij})^2}{e_{ij}}$$

Where: Qp is specified frequencies or specified proportions,

n_{ij} is the observed frequency in table cell (i, j)

e_{ij} is the expected frequency for table cell (i, j).

The expected frequency computed under the null hypothesis that the row and column variables are independent, and computed as

$$e_{ij} = \frac{n_i * n_j}{n}$$

Results and Discussion

Pre-weaning Growth: The pre-weaning growth performance of Borana goat and their crosses of different blood level of Boer goatis given in Table 1. Under on-station condition, average birth weight (BWT), weaning weight (WWT) and pre-weaning average daily gain (PWADG) of Borana goat and their crossbred kids' ranged from 2.13 ± 0.12 kg 3.31 ± 0.07kg, 9.77 ± 0.53kg to 13.19 ± 0.28kg and 122.46 ± 6.74g to 164.07 ± 3.59g, respectively, for BWT, WWT and PWADG. Generally, pre-weaning growth traits of the kids was significantly influenced (*$p<0.05$*) by birth type, blood level of Boer goat, birth season and parity of dam. However, sex of kids significantly affected only (*$p<0.05$*) BWT where male kids were heavier at birth than their female counterpart.

Table 1. Least Square Means (means ± SE) of Pre-weaning Growth Traits for Borana Goats and their Crosses with Boer

Factors	BWT kg^{-1}	PWADG gm^{-1}	WWT kg^{-1}
Overall ± STD	3.27 ± 0.78	138.34 ± 41.87	11.79 ± 2.88
CV (%)	17.87	19.83	18.20
Sex			
Female	$2.96{\pm}0.071^{b}$	$134.46{\pm}4.30^{a}$	$10.92{\pm}0.34^{a}$
Male	$3.17{\pm}0.073^{a}$	$137.72{\pm}4.29^{a}$	$11.08{\pm}0.33^{a}$
Birth Type			
Single	$3.56{\pm}0.07^{a}$	$148.18{\pm}3.48^{a}$	$12.01{\pm}0.27^{a}$
Twin	$2.82{\pm}0.06^{b}$	$130.64{\pm}8.59^{b}$	$10.57{\pm}0.29^{b}$
Triple	$2.68{\pm}0.14^{c}$	$129.46{\pm}3.77^{b}$	$10.42{\pm}0.67^{b}$
Blood Level			
Local	$2.13{\pm}0.12^{c}$	$126.75{\pm}5.11^{b}$	$10.28{\pm}0.40^{b}$
25 % Boer	$3.10{\pm}0.12^{b}$	$122.46{\pm}6.74^{b}$	$9.77{\pm}0.53^{b}$
50 % Boer	$3.31{\pm}0.07^{a}$	$164.07{\pm}3.59^{a}$	$13.19{\pm}0.28^{a}$
75 % Boer	$3.30{\pm}0.12^{a}$	$131.08{\pm}7.40^{b}$	$10.75{\pm}0.58^{b}$
Parity of dam			
First	$2.77{\pm}0.08^{b}$	$123.19{\pm}4.65^{b}$	$10.38{\pm}0.36^{b}$
Second	$3.04{\pm}0.07^{a}$	$119.62{\pm}4.58^{b}$	$9.94{\pm}0.36^{b}$
Third	$3.18{\pm}0.11^{a}$	$152.62{\pm}5.48^{a}$	$11.84{\pm}0.43^{a}$
Fourth	$3.12{\pm}0.15^{a}$	$131.06{\pm}6.44^{b}$	$11.49{\pm}0.50^{a}$
Fifth	$2.99{\pm}0.11^{ab}$	$153.96{\pm}5.46^{a}$	$11.34{\pm}0.43^{a}$

Season of Kidding			
Cool Dry	3.10±0.07^{a}	130.45±4.68^{b}	11.02±0.37^{ab}
Long Dry	2.83±0.07^{b}	118.49±3.66^{c}	10.42±0.29^{b}
Wet (Rainy)	3.14±0.10^{a}	159.34±7.31^{a}	11.56±0.57^{a}

^{abc}With in a column under the same factor identifier, values with different superscript letters (a–c) differ significantly at P < 0.05.

Post-weaning Growth: Average post weaning growth performance of Borana goat and their cross with Boer is presented in Table 2. The result indicated that except nine month (9MWT) and yearling (YWT) which were not significantly affected *(p>0.05)* by sex of the kids, all traits of interest were significantly influenced *(p<0.05)* by sex of the kids, season of birth and blood level of the kids. Post weaning growth performances of 50% and 75% Boer kids did not differ significantly (p>0.05). However, results in Table 2 revealed that there is no difference *(p<0.05)* between pure Borana and 25% Boer kids for all the post weaning traits investigated. On the other hand, kids born during the long dry season were significantly *(p<0.05)* lighter than that born during cool dry and rainy season.

Table 2. Least Square Means (means ± SE) of Post-weaning Growth Traits for Borana Goats and their Crosses with Boer

Factors	6MWT kg^{-1}	9MWT kg^{-1}	PoWADG gm^{-1}	YWT kg^{-1}
Overall Mean ± STD	16.64±3.52	19.55±4.63	84.68±29.19	21.62±5.47
CV (%)	19.73	15.88	18.58	27.99
Sex				
Female	15.68±0.31^{a}	18.26±0.47^{a}	78.39±2.58^{b}	22.89±1.03^{a}
Male	16.53±0.32^{b}	18.83±0.44^{a}	86.84±2.54^{a}	23.38±0.01^{a}
Blood Level				
Local	14.12±0.45^{b}	16.11±0.92^{b}	68.47±3.47^{b}	21.86±1.96^{bc}
25 % Boer	13.43±0.66^{b}	15.95±0.85^{b}	70.38±5.53^{b}	19.57±1.04^{c}
50 % Boer	18.83±0.32^{a}	21.95±0.44^{a}	100.38±2.61^{a}	25.77±1.03^{a}
75 % Boer	18.03±0.69^{a}	20.80±0.86^{a}	91.60±5.74^{a}	25.36±2.95^{ab}
Birth Season				
Cool Dry	15.34±0.45^{b}	19.23±0.51^{a}	92.08±3.53^{a}	26.04±1.81^{a}
Long Dry	14.98±0.43^{b}	15.76±0.56^{b}	68.77±3.55^{b}	19.92±1.33^{b}
Wet (Rainy)	17.99±0.45^{a}	20.64±0.90^{a}	86.99±4.64^{ab}	23.45±1.79^{ab}

^{abc}With in a column under the same factor identifier, values with different superscript letters (a–c) differ significantly at P < 0.05.

Pre-weaning mortality:number of kids born alive, number of kids survived from birth to weaning and percentage of loss that occurred from birth to 90 days is presented in Table 3. Of all kids born, survival rate were not significantly influenced *(p>0.05)* by blood levels of Boer. However, noticeably varied mortality rates of 15 % for Borana goat kids, 12.20% for 25% Boer crossed kids,and 22.78% for 50% Boer crossed kids, and 25% for 75% Boer crossed kids were observed. Likewise, sex of kids and season of birth did not significantly influenced *($p>0.05$)*mortality rates to weaning of kids. On the contrary, type of birth influenced survival rate of kids; where triple born kids were less likely to survive to weaning than single or twinborn kids.

Post-weaning mortality: The effect of birth type, blood proportion of Boer goat, season of kidding and sex on survival rate from weaning to yearling showed in (Table 3). The results of current study revealed that there was no significant difference *($p>0.05$)* on survival rate of kids based on their sex differences and season of birth which a particular kid born inside. On the contrary, blood level of Boer goat and birth type of kids intend to significantly influence *($p<0.05$)* post weaning survival of the kids. Accordingly, 25% Boer crossed kids showed a maximum (35.29%) mortality loss of kids from weaning to yearling followed by 75% Boer crossed kids. Similarly, triplet born kids were less likely to survive further in periods between weaning to yearling than single or twinborn kids.

Table 3. Mortality Rate of Pre and Post weaning Growth Traits for Borana Goats and their Crosses with Boer

Growth Stage	Risk Factors	Level (N)	Kids Died	Mortality (%)	$\chi 2$	$P<0.05$
Birth to Weaning	Sex	Female (190)	35	18.42	0.21	0.6466
		Male (258)	52	20.16		
	Birth Type	Single (154)	36	23.38	16.56	0.0003
		Twin (237)	31	13.08		
		Triple (57)	20	35.09		
	Breed Group	Local (123)	15	15.00	7.66	0.0637
		25 % Boer(40)	6	12.20		
		50 % Boer (237)	54	22.78		
		75 % Boer (48)	12	25.00		
	Kidding Season	Cool Dry (44)	8	18.18	5.09	0.0783
		Long Dry (315)	69	21.90		
		Wet (Rainy) (89)	10	11.24		
Weaning to 1 Year	Sex	Female (155)	40	25.81	1.22	0.2703
		Male (206)	43	20.87		
	Birth Type	Single (118)	31	26.27	7.73	0.0210
		Twin (206)	38	18.45		
		Triplet (37)	14	37.35		
	Breed Group	Local (108)	14	12.96	10.68	0.0136
		25 % Boer (34)	12	35.29		
		50 % Boer (183)	46	25.14		
		75 % Boer (36)	11	30.26		
	Kidding Season	Cool Dry (246)	12	33.33	2.57	0.2773
		Long Dry (36)	55	22.36		

	Wet (Rainy) (79)	16	20.25

Discussions

Pre-weaning Growth: In general, birth (BWT) and weaning (WWT) weights of Boer crossbred kids were heavier than Borana goats particularly, 50% and 75% Boer crossbred kids. Breed levels, birth type, sex, parity and year of birth had a significant effect ($p<0.05$) on pre and post weaning weights. The observed mean birth weight for crossbred kids in the present study was higher than previous research results 2.32kg (Tesfaye *et al.*, 2006), 2.01±0.03kg (Deribe and Taye, 2013a) for Central Highland kids, 2.34kg for Borana Somali and 1.5kg for Mid Rift Valley kids (Tucho et al., 2000). Similarly, weaning weight of cross-bred kids in this study found heavier than the values of 6.32kg for Mid Rift Valley kids (Tucho *et al.*, 2000); 6.8kg for Abergelle kids (Deribe and Taye, 2013a); 8.4 kg for Arsi Bale (Woldu *et al.*, 2005). In addition, the estimates 7.2 kg (Tucho et al., 2000) and 9.02 kg (Deribe and Taye, 2013a) for Borana Somali kids; and 6.72kg (Tesfaye *et al.*, 2006) for Central Highland kids lighter than estimates for crosses in this study. However, the average pre-weaning weights of Borana goats were in-line with most of the mentioned values. Average birth to weaning growth of kid's gm day^{-1} is found influenced by type of birth, season of kidding and breed group. Similar situation reported by previous studies made by Deribe and Taye (2013b) and Zeleke (2007). While the variation observed associating with birth type and breed group related with the amount of milk provided by kid's dam, whereas season difference directly related with availability of feed resource for both to the dam and kids.

Post-weaning Growth:similar to pre-weaning growth performances, cross-bred kids showed their superiority on post-weaning growth performances of six months (6MWT), nine months (9MWT) and yearling (YWT) weights. The least square mean weights of Borana goats14.12kg for six months and 21.86kg for yearling in the present study were comparable with respective values of 13.82kg and 20.69 kg for central highland goats (Deribe and Taye, 2013b) and 13.61kg and 20.15kg reported for the same breed (Tesfaye *et al.*, 2006). On the other hand, for six months and one year old goats, respective values of 7.87kg and 12.85kg for Mid Rift Valley and 9.3kg and 13 kg for Borana goats (Tucho *et al.*, 2000), 9.1 kg and 14.2kg for Abergelle goats (Deribe and Taye, 2013b) and 11 kg and 16 kg for Afar goats (Awgichew *et al.*, 1989) were reported at different locations. The overall least square means of six month weight (13.54kg) and yearling weight (19.53 kg) for Boer cross with central high land goat were (Deribe *et al.*, 2015), respectively lower than the values obtained under the current study for Boer cross Borana goats. Factors such as sex, birth type and breed group had effects on post-weaning growth rate. Single born kids, 50% Boer and 75% Boer crossbred kids and kids born during wet/rainy and long dry season significantly *($p<0.05$)* resulted in higher daily average post-weaning growth than their corresponding factor levels.

Pre-weaning mortality: birth to weaning mortality rate (MR) was high in crossbred goats particularly for higher grade cross kids 50% Boer (MR = 22.78%) and 75% Boer kids (MR = 25%). Considering the inconsistent and seasonal management given to the crossbred kids, the identified estimates were somehow better. The current result is in line with the reasons that mortality increases in response to increased exotic blood level, which expected to have difficulty in resisting environmental stress compared to local breeds (Barbind and Dandewar, 2004). However, lower mortality rates than the present estimates were reported by Petros *et al.*, 2 014 (MR = 46.8%) and Debele *et al.*, 2011 (MR=34.2%) for different breeds in Ethiopia. The result obtained for sex effect in the present study was in contrast with previous estimates where male kids were more likely to die from birth to weaning than female (Aganga *et al.* 2005; Hailu *et al.*, 2006; Bushara *et al.*, 2013; Debele *et al.*, 2011).

Post-weaning mortality:weaning to one year mortalities appear to be variant due to birth type and breed group. The frequently associated reasoning feed shortage appeared to be the cofactor that contributed the mortality of post weaning in this study. The current result is in agreement with previous studies that confirmed poor management was the most limiting factor for goats post weaning survival and productivity (Markos, 2000; Tsedeke, 2007). Over all, the current mortality values obtained with considering every factor ranged from 12.96% to 37.35% was in agreement with several research findings for various types of goat breeds 13.3% (Endeshaw, 2007), 14.2% (Belete, 2009) and 25.4% to 50% (Grum, 2010). Similarly, the mortality rate (MR = 45%) reported for Borena goat under traditional management system (Hailu *et al*., 2006) higher than the current values and in line with 26.7% Post weaning MR for Arsi Bale Goat reported by Girma *et al*. (2011). Moreover, post weaning MR figures of current study are closer to those reported for other African goats (Mtenga *et al.*, 1994; Ikwuegbu *et al.*, 1995; Manjeli *et al.*, 1996).

Conclusions and Recommendations

Overall, cross breeding with Boer goats increased pre and post weaning growth traits including birth weight, average pre weaning growth rate, weaning weight, six months, nine months and yearling weight in Borana goats. Generally, kids with higher blood levels (50% and 75%) Boer outperformed the local and 25% Boer crossbred kids. From the result, terminal cross breeding system recommended as it can improve the productivity of Borana Goat until improvement of the local breed achieved in the end. However, in terms of survival, the local breed appeared to be better the cross breeds. Given the versatility of Boer crossbred kids and high survive ability of local (Borana goats), the following points need to be considered to maximize the merits of the two breeds. The first consideration should be avoiding utilization of Boer for other breeding system except for terminal crossing. The second attention is employing the buck that has low or no genetic potential of giving twin or multiple births. The next point is considering prevention of higher blood level production under extensive system. Moreover, further research work required to understand response of breed groups in related to various management systems and a solution to reduce mortality.

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Poultry Research Results

Systematic substitution of Soybean meal with fish meal in the diet of Fayoumi chickens

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Abstract

Four experimental rations were formulated with the aim of knowing the amount of fish meal that can substitute soybean meal in fayoumi layer chickens and to know the financially feasibility of such substitution. for fayoumi layer chickens. Ninety six fayoumi chickens of 24 weeks of age were subjected to four formulated rations. Each of the four treatments were replicated three times with 8 birds (1 male: 7 females) per replicate. Each replicate feed was fed in group in feeding pens. Feed intake and egg production data were collected daily for each replicate. Dry matter feed intake was not significantly different (P >0.05) between treatments 1 and 3, and between treatments 2 and 4. Significantly higher (P<0.05) egg production and egg weight were observed in treatment 2 with no significant difference (P>0.05) among the other three treatments , . Egg shell weight (g), shell thickness (mm) and Yolk color did not differ (P>0.05) significantly among the treatments. In the current study net profit of 47.4, 39.4, 26.48 and 11.36 Ethiopian Birr were obtained per bird on treatments 234and 1 respectively within six months of feeding. Egg production and net return were highly influenced by the level of fishmeal and toasted soybean in the ration. In fayoumi layer chickens the ration containing 3.5% fish meal was found to be financially feasible and recommendable in areas with similar climatic conditions to Adami Tulu area and in area where fish meal is available.

Key wards: *formulated rations, financially feasible, layers ration, net return, ingredients.*

Introduction

Fayoumi chickens are one of the egg producing breeds introduced to Ethiopia. It is originated from Egypt, hardy and very precious in being early maturing (Evans, 2010). They mature at very young age of 4-5 months, lay good number of white cream eggs, have excellent resistance to viral and bacterial diseases, can cope with hot conditions and are excellent foragers (Anna, 2017).

Considering their production traits, the breed was brought to mid rift valley of Ethiopia to distribute for farmers. However, chickens rearing in mid rift valley of Ethiopia is characterized with inadequate feeding system which resulted in low growth rate and low egg production performance (Hunduma *et al*, 2010). In mid rift valley of Ethiopia, surplus of protein source grains are not generally available to feed chickens in order to satisfy nutrients needed. It is, therefore, not advisable to develop a wholly grain-based feeding system because of socio-economic reasons.

In poultry production feed represents the major cost of production. Identifying locally available feed resources to formulate diets are the recommended policy for chickens feeding (Branckaert. *et al.,* 2000). Soybean is one of the good protein sources for chickens feed. It contains 40 to 48 percent crude protein depending on the amount of hulls removed and the oil extraction procedures (ESGPP, 2008). However, in mid rift valley area it is not possible to use soyabean for layers ration as it is not extensively cultivated.

It is possible to use fishmeal instead of soybean meal in mid rift valley area as layers ration as it is highly available in the area. Nutritionally it has been widely used as a supplemental protein source for many years primarily for mono-gastric animals. Fish meal is the most important animal protein supplement used in poultry ration that contributed protein especially essential amino acid, vitamin (B12) and minerals (Gopalakrishnan and Mohanlal, 2004; Richard and Church, 1998). It produced from clean dried ground tissue of un-decomposed fish residues remaining after processing for human food or industrial purposes. Considering its availability and nutritional value, it is worthwhile to observe if it could be used instead of soybean in ration of layer fayoumi chickens. Therefore the proposal was proposed with the following objectives.

- To know the amount of fish meal used as a substitute of soyabean meal in layers ration.
- To know the economic benefit of using fish meal in layers diet

Material and methods

The experiment was conducted at Adami Tulu Agricultural Research Center, located in the mid rift valley of Ethiopia at latitude of 7°9`N and 38°7`E. The altitude of the area is 1650 meter above sea level.. The average annual rain fall of the area was 949 mm with an average minimum and maximum temperatures of 14^{o}c and 29.6^{o}c, respectively and the relative humidity of the area was 57.42 (ATARC, 2016 metrological data, personal observation).

Feed management

Fish meal was processed to separate the solids (fat-free dry matter), oil and water. It was made by cooking in barrel, then pressing and drying on sun and finally by grinding the dried fish meal. Cooking coagulates the proteins and is a critical process responsible for sterilizing the product and preparing it for liquor (a mixture of oil, water and protein) removal. Once cooked, the liquor is removed by pressing. The solid residue that remains after pressing is called "press-cake."Cooking not only coagulates protein but also removes most of the oil and water and also facilitates sun drying and grinding processes. Pressing helps to remove water. Fresh offal releases a small amount of water. The purpose of the drying process is to convert the wet and unstable mixture of press-cake, decanter sludge and concentration into a dry and stable fishmeal. In practice, this means drying to a moisture content below 12%, which may generally be considered low enough to check microbial activity (Windsor, 2001; Asrat, 2007). Fish meal processed according to the described procedure above was brought to Adami tulu agricultural research center from Batu aquatic and fishery resource research center and further dried and ground to be used as poultry feed.

Locally available feed resources (maize, wheat bran and noug cake) were used as other ingredients to formulate experimental diets. Maize is a highly produced cereal grain in mid rift valley of Oromia, Ethiopia and it is rich in carbohydrate and fat, contains 8% CP and 14.5 KJ/g metabolizable energy (Smith,2001). Wheat bran is the outer fibrous layers separated from wheat grain with protein content of 14-18%, 12MJ/kg metabolizable energy. It is quite palatable and is a well known by-product (Adugna *et al*., 2007). The protein content of noug seed cake varies from 28 to 38% with most values lying between 30 and 35%, and its energy value is 2.37 Mcal ME/kg DM (Adugna *et al*., 2007). Wheat bran, maize, noug cake, Limestone, layers premix, and salt were purchased and added in to the rations.

Four poultry rations were formulated as is given in Table 1. In the rations (treatments) fishmeal substitute 0%, 25%, 50%, and 75% of the recommended soybean meal in treatments one, two, three and four, respectively. The recommended soybean meal to be used as layers ration is 15 gram in layers ration.

Table 1. Rations formulated for fayoumi layers chickens

Feed ingredients	**T1**	**T2**	**T3**	**T4**
limestone	0.5	0.5	0.5	0.5
salt	0.5	0.5	0.5	0.5
premixes	1	1	1	1
Wheat bran	46	28	41	40
Fish meal	0	3.5	7.5	11.25
soybean	15	11.5	7.5	3.75
maize	24	32	28	26
Noug cake	13	23	14	17
Total	100	100	100	100

From each of the formulated diet 120 g was daily provided for each chicken. Left over feeds of the treatment diets were collected every next day in the morning before providing feed for the day. Water was provided *ad libitum*. Eight chickens (7females and 1 male) were randomly allotted to four dietary treatments each of which were replicated three times.

Animal management

A total of 96 Fayoumi chickens of 24 weeks of age were selected from chickens reared in Adami Tulu research center. Litter housing system that was partitioned in to 12 equal sized pens (4 m^2) was used. Before placing the experimental chickens in to the experimental pens the whole units were cleaned and disinfected with Dizinon disinfectant and littered with properly dried tef (*Ergrostis tef*) straw. The experimental house was electrically heated during night.

Data collected and performance parameters considered

Feeds offered to the chickens and refusals were measured every morning. The differences between offered and refusals were calculated as intake. Egg production were collected and recorded daily. Data on egg quality parameters were taken at the end of the experiment. Eggs were weighed using an electronic digital balance. Egg shell thickness was measured using electronic digital caliper and yolk color was determined by adjusting the score of yolk color on color fan from Roche.

Statistical analysis

Analysis of variance of feed intake, egg production and egg quality parameters were done according to the general linear model (GLM) procedure of the Statistical Analysis System (SAS, 2001) software. Mean comparisons were made using Duncan Multiple Range Test procedure of the SAS package

Economic analysis

Variable costs collected from the prices of dry matter feed intake per bird, vaccine, medicine and disinfectant used. Net return was obtained from egg produced and sold during six months experimental period. The economic benefit was estimated by considering partial budget analysis, according to the formula developed by CIMMT (1988); Ehui and Rey (1992).

$$\mathbf{NI = TR - TVC}$$

Where, NI = Net income, TR = Total return, TVC = Total variable cost.

Results

Chemical composition of the rations

The chemical compositions of the experimental rations used were analyzed at National veterinary Institute. The dry matter (DM %), mineral matter (MM %), crude fiber (CF %), crude fat (%), calcium (Ca %), Phosphorus (P %) and crude protein (CP %) composition of the formulated treatment rations were analyzed using the method of AOAC (1990) proximate principle and given in (Table 2).

Table2: Nutritional composition of experimental diet used for layer fayoumi chickens

TR	DM (%)	MM (%)	CF (%)	Fat (%)	Ca (%)	P (%)	CP (%)	ME(Kcal/DM)

1	89.6	7.2	4.6	4.4	0.84	0.84	16.36	2870
2	86.4	8.6	5.1	3.2	0.92	0.96	16.50	2870
3	90.8	8.2	5.8	4.2	0.98	0.88	16.78	2870
4	86.9	8.0	5.4	2.8	0.85	0.82	16.24	2870

TR =treatment, DM% = dry matter percentage, MM% = mineral mater percentage, CF% = crude fiber percentage, Ca = calcium percentage, P = phosphorus percentage, ME= metabolizable energy

Feed intake, egg production performance and egg quality parameters of fayoumi chickens fed the rations formulated using fish meal is given in Table 3.

Table3 Feed intake, egg production and egg quality parameters of fayoumi chickens (Mean±SD)

TR	Feed intake/ day (g)	Egg production within six months	Egg weight (g)	Shell weight(g)	Shell thickness (mm)	Yolk color	HDP (%)	HHP (%)
1	86.4±8.2b	$52±4.6^{b}$	$39.8±2.3^{b}$	4.4±0.54	0.32±0.03	2.4±0.69	$29±3.2^{b}$	$45±3.6^{b}$
2	94.6±10.4a	$64±5.6^{a}$	$42.6±3.1^{a}$	4.6±0.51	0.34±0.04	2.6±0.78	$36±3.8^{a}$	$55±4.2^{a}$
3	82.2±6.5b	$56±4.8^{b}$	$39.2±2.4^{b}$	4.3±0.53	0.36±0.05	2.5±0.73	$31±3.2^{b}$	$48±4.2^{b}$
4	89.4±4.2a	$54.4±2.8^{b}$	$38.4±4.2^{b}$	4.2±0.50	0.37±0.02	2.6±0.76	$30±2.8^{b}$	$47±3.6^{b}$

SD = standard deviation, TR= treatment, g = gram, mm =millimeter, HDP= Hen day production, HHP= hen housed production,

^{a,b} =superscripts in the same column with different letters are significantly different($P<0.05$).

Production cost and return of fayoumi chickens reared using formulated feed

Variable costs were collected from the prices of dry matter feed intake per bird, from vaccine, medicine and disinfectant used per bird based up on price of data set collected for respective treatments. Money obtained from sale of total egg laid during experimental period was the source of income. Fixed costs (feeders and waters) were taken from the previously purchased and used for flock and returned as soon as the trial finished and feeding pen were constructed previously by the farm and its cost were not included in calculation. Poultry litters that can be used as fertilizer and as a source of animal feeding also not included in calculation because poultry litters selling is not common in the study area. The financial analysis of the experiment was computed and described for each treatment in table 4.

Table 4 Partial budget analysis for fayoumi chickens

Partial budget cost	**Treatments (TR)**			
	1	2	3	4
Total feed consumed in six months, kg/chick	16	17	15	16.1
Feed cost /kg(ETB)	7.54	7.8	7.24	7.15
Total feed cost(ETB)	120.64	132.6	108.6	115.12

Cost of Vaccine, Medicine and Disinfectant(ETB)	21.00	21.00	21.00	21.00
Cost of pen construction (Mish wire, poles and Bedding Material/teff straw/) (ETB)	42.00	42.00	42.00	42.00
Labour cost (ETB)	13	13	13	13
Total variable cost(TVC) (ETB)	196.64	208.6	184.6	191.12
Price of total eggs laid(GR)(ETB)	208.00	256.00	224.00	217.60
NR (GR-TVC)	11.36	47.4	39.4	26.48

TR = treatment, ETB = Ethiopian Birr, TVC= Total variable cost, NR = Net return, GR= Gross return

Discussions

There is no significant difference in feed intake between treatment one and treatment three, and between treatment two and treatment four most probably due to the similar fat content of the corresponding treatment diets. Significantly ($P<0.05$) higher feed dry mater intake was observed in treatments two and treatment four compared to treatment one and three. This could be due to the lower fat content of treatment two and four diets. Dry mater feed intake in the current study is generally lower than the study done by Tesfa *et al., (2013*), by khan *et al., (*2006).

Significantly higher ($P<0.05$) egg production and egg weight were observed in treatment two compared to the rest treatments most probably due to the higher dry matter feed intake.

Egg production performance of fayoumi chickens in the current study is higher than the study done on the same breed using locally formulated diet by Tesfa *et al.*, (2015), but lower than the study done using commercial layer diet (Tesfa *et al.*, 2013). Egg production performance of fayoumi chicken in the current study also lower than their egg production performance in middle Egypt as reported by Ann (2017) and by khan *et al.,(*2006). This is due to the lower dry matter feed intake compared to the findings of others.

Egg weight in the current experiment was also similar with the egg weight obtain from using locally formulated ratio by Tesfa *et al.*,(2015) but lower than the egg weight observed from using commercial layer diet (Tesfa. *et al.*,2013) and than the report of Khan *et al.*,(2006). This is most probably due to the quality of protein in the diet.

Shell weight and shell thickness did not differ ($P>0.05$) significantly among treatments. This could be due to similar calcium and phosphors contents of the formulated rations as egg shell is the function of minerals in the diet. Yolk color of the eggs also did not differ ($P>0.05$) significantly among treatments because chicken were not subjected to green feeding that influence yolk color.

In the current study, 47.4, 39.4, 26.48 and 11.36 net Ethiopian Birr from the sale of eggs was obtained per bird from T2, T3, T4 and T1 respectively. Compared to the other rations higher net return was obtained when a ration with 3.5% of fish meal was used, that is in which 25% of soybean was replaced by fish meal (T2). Compared to the previous work done using commercial diet by Tesf *et al.,* (2013) higher net return was obtained in the current study.

Conclusion

Egg production and net return were highly influenced by the level of fishmeal and toasted soybean in the ration. Egg production and net return decreased as the level of fishmeal increased beyond 7.5% and soybean decreased from the ration.

Recommendation

In fayoumi chicken layers ration including 3.5% fish meal is found to be financially feasible and recommendable in areas with similar climatic conditions to Adami Tulu area and in area where fish meal is available.

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Apiculture Research Results

Effects of using two honeybee queens (Apis mellifera L.) on different colony parameters in the central high land areas of Ethiopia

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Abstract

We investigated the effect of using two queen honeybees (Apis mellifera L.) in one colony on different colony parameters. The study was conducted at Gedo Research Station of Holeta Bee Research Center in Oromia National Regional State, Ethiopia from September 2015 to August 2017 for two consecutive years., A total of 13 honeybee colonies were obtained by splinting queen rearing method from two sister mothers and were maintained in nuclei boxes until they achieved standard hive colony size. The colonies were then transferred to Langstroth moveable frame hives and managed under the same conditions until they achieved uniform strength. Out of the total colonies, 10 were selected and 5 of them allocated to single-queen system colony management and the remaining 5 allocated to double-queen system colony management. Data on brood rearing, nectar gathering, bee population and honey yield conditions were collected and analyzed. The result revealed that there is highly significant ($p<0.001$) differences in parameters considered. Colonies with two queens produced 86.4 % more honey than colonies with single-queen. Two-queen colonies had 50 % more number of bees, and were reared 95 % more brood combs and gathered 64 % more nectar during the nectar flow season compared to single queen system colonies. Significant correlations were also found between colony population and honey yield ($r = 0.83$), colony population and brood rearing ($r = 0.87$) and colony population and nectar gathering ($r = 0.89$) ($P<0.001$). The production cost per kg of honey was also estimated to US\$ 0.96 and US\$ 1.31 for double queen and single queen colonies, respectively. The lower production cost in the two-queen colonies was due to savings resulted from labor, beeswax and feeding. It is concluded from this study that using two queen system, is technically less demanding, yields much better honey production and financially profitable, compared to single queen conventional approach. It is also recommend that two queen should be tried in other more potential beekeeping areas by involving more representative numbers of colonies for validating the system further.

INTRODUCTION

The amount of stored food (pollen and nectar) and brood in the colony reflects colony strength and can be used to predict the amount of honey yield that can be produced at the end of a season. Several investigators have proved positive correlation between stored pollen, brood production and honey yield (Szabo and Lefkovitch, 1989; Kolmes and Sam, 1990; Mladenovic *et al*., 1999;

Jevtic *et al*., 2009). But Pollen collection, brood production and honey yield are affected by many other factors such as honeybee flora, time of the year, feed supply and colony strength (Marceau *et al*., 1990; Al-Humyarie *et al*., 1999; Georgijev *et al*., 2003; Castagnino *et al*., 2004; De Grandii-Hoffman *et al*., 2008; Taha *et al*., 2009). According to Taha and Al-Kahtani (2013), the dominant factor affecting the amount of stored pollen, brood rearing and honey yield at the end of the season is strength of honeybee colonies. The idea behind testing double (two) -queen system of colony management in one colony is, therefore, based on the principle that two queens can build strong population during period of nectar flow to exploit the available resources efficiently and effectively. In other words, higher worker population will result in higher production and productivity from more intensive foraging activity by worker bees.

However, from local honeybees' perspective, there is no relevant information weather use of two queen system is in line with the experience from elsewhere. Therefore, in this study attempts were made to investigate the effects of double queens on brood rearing, food collection and storing, population growth rate and honey yield.

MATERIALS AND METHODS

Description of the study site

The study was carried out in Gedo Research Station of Holeta Bee Research Center, Oromia National Regional State, Ethiopia from September 2015 to August 2017 for two consecutive years. Two apiaries separated by a distance of one kilo meter were arranged for facilitating queen rearing. The study area has two active blooming seasons in which there is available pollen and nectar for the bees. The first Nectar flow season runs from September to November after a heavy rainy season. The second honey flow coincides with beginning of minor rainy season in March and lasts until to May. Honey harvesting is conducted in the months of December and June and no available resources during the dearth periods (January to February and July to August). The experimental colonies were maintained by providing them with sugar syrup during resource scarce period.

Experimental colony set up

Two sister *Apis mellifera* L. colonies were obtained from a single mother colony by splitting method and used as startups for the experiment. Then from these two sister colonies, a total of 13 honeybee colonies were obtained by rearing queens during the active season of 2014 (September) and all obtained queen were open-mated from drones derived from local source colonies. For starting a new colony, nuclei box with two combs of capped brood and three fully occupied combs with pollen and neater and/or honey were provided. The established new colonies were then maintained in nuclei boxes until they achieved standard hive colony size. By April 2015, all the colonies achieved the required colony size (10,000 workers) and transferred to the Langstroth moveable frame hives and managed under the same conditions and brought to the uniform strength. Then out of the total colonies, 10 were selected and 5 of them allocated to single-queen system colony management and the remaining 5 were allocated for two queen colonies randomly. These 10 colonies were then maintained for the whole study period. Similar treatment procedures were adopted during each main honey flow season.

For single queen colonies, provisions of additional supers were done as needed for swarm control and space for storing surplus available resources until the beginning of nectar flow.

For the two-queen system, two months prior to the beginning of each active nectar flow season, each colony was split in two parts (creating one half queenless and one half with queen) with equal resources (young larvae, pollen and nectar) and each half was moved to a second apiary, which located one kilo meter away from their original site on the same day splitting conducted. Each queenless half acquired its own queen within 10 to 12 days. All the five colonies were then followed for the new queens mated and started laying eggs. After all the new queens started egg-laying (between 20-22 days after splitting), each colony with new queen was superimposed on their own mother half at dusk by placing modified inner cover to prevent the mix-up of mother and daughter colonies. Then all the five two queen colonies transported one kilo meter to their original mother apiaries the same day and maintained with the single queen colony systems. The inner cover separator was used to separate the two combined colonies but work together side by side. For this purpose, the inner cover consists of double wire grid (mesh size 3 x 3 mm) of dimensions similar to the outer hive chambers stretched by wooden rims on the four external sides. The double screen wire grid separator was designed to serve temporarily to prevent bees' passage, thus preventing bees in the lower section from fitting against those in the upper section. To construct the inner separator, four wooden pieces of dimensions 10 mm high and 20 mm wide for the bottom rims and four wooden pieces of dimensions 20 mm high and 20 mm wide for the upper rims were used. The wooden pieces for bottom and upper wooden rims were aligned to form two separate rectangles and the wire grid screen stretched and sandwiched between the two rectangles by cigar box nails (16 mm shoe nail). Then the front side of upper wooden rim of the inner lid was cut 15mm wide and 150 mm long for the entrance pass for the worker bees in the upper section. This arrangement allowed the two units to mix by exchange of odors between workers to accept each other again as members of one colony. Five days after superimposing, the screened wire grid separator was removed and replaced by queen excluder for the mother and daughter colonies to combine in one colony with two queens. During this management procedure, egg production by the two queens was verified and supers were provided as described for the single queen system. At approximately 45 days to honey harvest, the separating queen excluder removed for the two queens to fight and one dies converting the colony back into a single queen colony since eggs laid after this period could not become forager on top of the fact that they consume much food for development.

Data collations

The areas of stored pollen, nectar, honey and sealed brood were estimated at an interval of 30 days using empty standard frame divided into square centimeters 10 x 10 wire grid. The gross number of one parameter was calculated by adding all the square grids on the two sides of all frames. For example, the gross brooded area (cm^2) = Σ (brood areas from one side of all frames + second side of all frames). Then, the obtained result was converted to number of frames occupied for the given parameter under consideration per colony. Based on this procedure, brood, pollen, and nectar combs measuring table was developed and used for the later result analysis. Similarly, numbers of combs covered with bees/colony were recorded monthly to determine the colony population size. The bee population per colony was counted as one comb well covered with bees in the two sides equals 2000 bees (Taha, 2007). By the end of each honey flow season, honey yield was calculated from the difference between weight of honey combs before and after extraction. All measurements were performed after dusk so that no bees would be missed outside for foraging. Counts were performed throughout the year under both systems every month except for honey yield data, which conducted only during harvesting date at each harvesting season.

Statistical analysis

Data of honey production were compared by using Student's test between single and double queen management systems. Colony population and other colony parameters were subjected to ANOVA over period data were collected, the latter being the independent variable, while colony parameter data were dependent variables. Cost benefit analysis was performed on the bases of investment cost on value of amount of honey produced under each system.

RESULTS

Two-queen colonies produced 98.4 % more honey than single-queen colonies ($p<0.001$), with a mean of 61.3±1.3 and 30.9±1.1 kg/year for double queen and single queen colonies, respectively (Table 1). However, the production level was significantly different between the two nectar flow seasons for both queen systems owing to the differences in the amount of nectar available during the two seasons. The average annual colony population was also significantly ($P<0.001$) higher for double queen system compared to single queen system. Double queen system had 12450 more worker bees than single colonies per year. The population difference was further increased to 27815 during the nectar flow seasons (November and May) on average for double queen system compared to single queen system (Table 1 and Figure 1). However, during the dearth periods, there was no significant ($P=0.63$) difference between the two systems with regards to the number of bees. The average numbers of worker bees during the months of February and August were 26400 and 24600 for double queen systems and 25000 and 23200 for single queen system, respectively (Figure 1).

Double queen system colonies produced significantly ($P<0.001$) higher number of brood combs during the active brooding seasons (October to November and April to May) (Figure 2). The number of brood combs in double queen colonies was larger than that of single queen headed colonies during all blooming seasons. For example, the average number of brood combs 9.5 (range 6 to 12) in November in two queen colonies compared to an average of 5.4 (range 3.8 to 7) for single colonies during the same period. This indicates, two queen colonies reared about 76 % more brood than single queen colonies. However, there was no significant (P>0.05) differences between the two systems during the beginning of blooming seasons and throughout the dearth periods in this regard as well (Figure 2). The number of stored pollen was also significantly (P<0.001) higher for double queen colonies compared to the single queen during the active season as shown in Table 1.

Table 3. Means ± SE (n= 10 recordings per system) of different variables in double and single queen systems during active seasons (September to December and March to June) at Gedo. Means followed by different small letters within column and different capital letters within rows are significantly different.

Variables	**Months**	**Management system**	
		Double queen	**Single queen**
No. of combs occupied by brood/colony	October	8.7 ± 1.4^{a}	4.4 ± 0.6^{a}
	April	8.1 ± 0.9^{b}	4.1 ± 0.9^{b}
	Av. of the months	8.4 ± 0.3^{A}	4.3 ± 0.1^{B}
No. of combs occupied by nectar/colony	November	17.4 ± 3.5^{a}	10.4 ± 1.5^{a}
	May	12.3 ± 1.5^{b}	7.8 ± 1.0^{b}
	Av. of the months	14.9 ± 2.5^{A}	9.1 ± 1.4^{B}
No. of combs occupied by pollen/colony	October	3.3 ± 0.9^{a}	2.1 ± 0.6^{a}
	April	1.9 ± 0.7^{b}	1.2 ± 0.4^{b}
	Av. of the months	2.6 ± 0.7^{A}	1.6 ± 0.5^{B}
No of worker bee population/colony	November	77400 ± 1374^{a}	48570 ± 1603^{a}
	May	70467 ± 1690^{b}	43667 ± 1462^{b}
	Av.	73934 ± 1893^{A}	46119 ± 1092^{B}
Honey yield (kg)/colony	December	36.6 ± 0.8^{a}	18.1 ± 0.7^{a}
	June	24.7 ± 0.7^{b}	12.8 ± 0.5^{b}
	Annual Av.	61.3 ± 1.3^{A}	30.9 ± 1.1^{B}

Table 1 also shows high significant differences between two queen and single queen colonies in terms of number of combs occupied by nectar and pollen. The numbers of nectar and pollen combs in double queen colonies were larger than that of single queen colonies during the blooming seasons. Number of occupied combs with nectar and pollen in double queen colonies were higher with about 64 % and 63 %, respectively compared to the respective data for single queen colonies.

Table 4. Pearson correlation coefficients for colony population, brood comb, nectar combs and honey yield for pulled data from the two colony systems.

Correlated Variables	bee population	brood combs
Brood comb	0.87**	
Pollen combs	0.74**	0.76**
Nectar comb	0.89**	0.71**
Honey yield	0.83**	0.67**

***P<0.001; n= 60 for bee population-honey yield, and n= 120 for other variables.*

Honey making or production potential per individual bee was greater for double queen system colonies compared to the single queen colonies. Unit honey productivity/bee was 0.83 g/year from double queen system while this potential was only 0.67 g/year for the single queen colonies.

The average production cost per kilogram of honey was US$ 0.35 lower for the two queen colonies compared to single colonies (Table 2). This production cost difference indicates that there was about 36 % higher production costs for managing single queen colonies compared to two queen colonies. In real terms, this figure represents a possibility of saving cost of US$ 18.2 for managing two queen colonies compared to that of single queen colonies (Table 1 and 2).

The lower cost of production was resulted from the reduced cost from labor, beeswax and feeding. For managing two queen colonies, a total of 76 hours were devoted for each colony, while this was only 60 hours for each single queen colony throughout the year. When we consider only feeding, two queen colonies required 66.7 % more sugar than single colonies as this was used managing colonies for splitting to obtain the second queen during early active seasons.

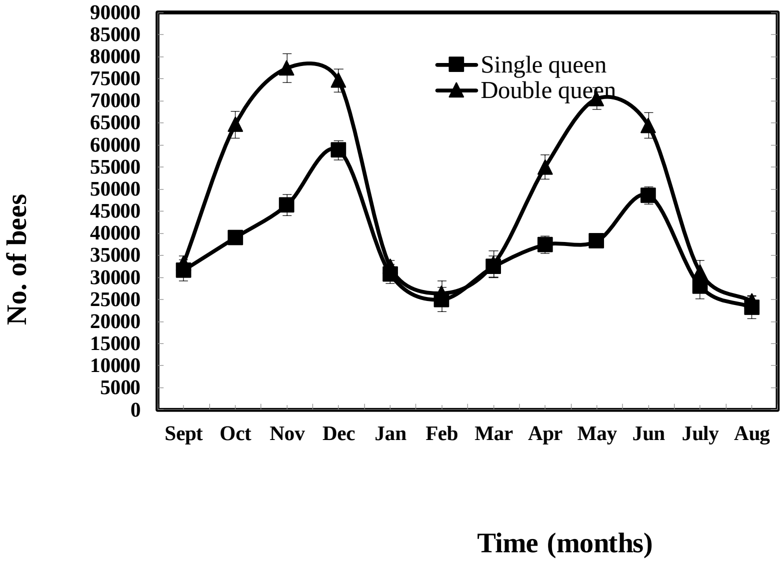

Figure 3: Effect of using two different queen systems on colony population during the different months of a year. Vertical bars on each column represent ± SE (n=10 per category).

The largest brood and stored pollen combs were recorded during the earlier nectar flow seasons for both queen management systems (Figure 3). The result indicates that peak brood rearing activity coincides with higher pollen stores, which latter on converted to maximum number of worker bees during the active honey harvesting seasons.

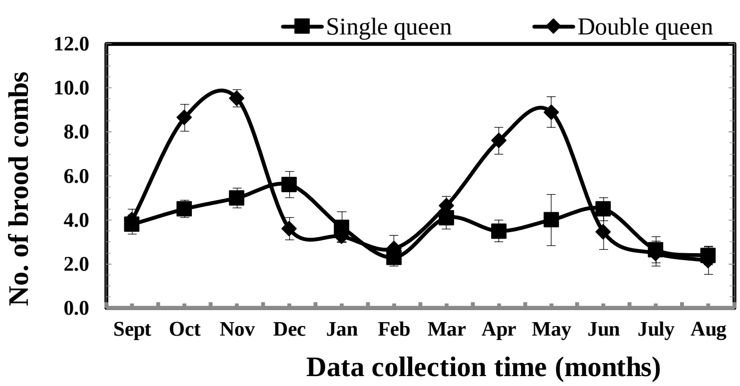

Figure 4. Effects of using two different queen systems on brood rearing conditions of bee colonies during the different months of a year. Vertical bars on each column represent ± SE (n=10 per category)

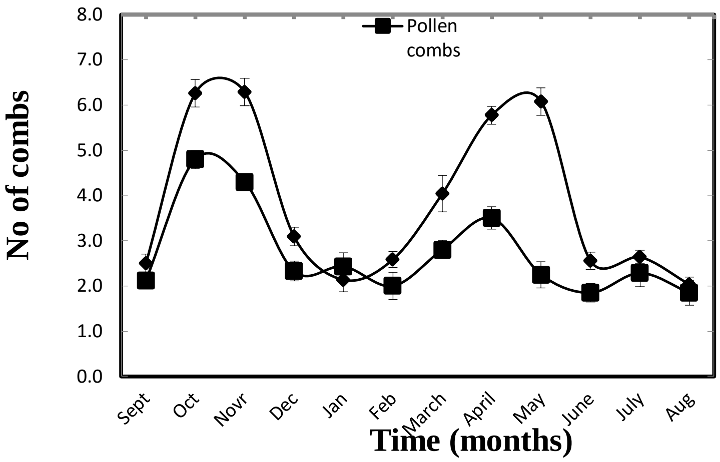

Figure 5. Trends of stored pollen and brood rearing conditions of bee colonies during the different months of a year. Data from both queen systems (double and single) were pulled and analyzed. Vertical bars on each column represent ± SE (n=20 for each month)

Table 5. Production costs per colony and per kilogram of honey, with double- and single-queen production systems (US$)

Required Items	Colony management system	
	Double queen	**Single queen**
Beehive and inputs	92.86	64.29
Hive stand construction	7.86	6.00
Labor	13.57	10.71
Feed	14.29	8.57
Bee colony	28.57	28.57
Beeswax	36.96	24.64
subtotal	194.11	142.79
Contingency (10%)	**19.41**	**14.28**
Partial cost per colony	**213.52**	**157.06**
Price of honey produced	222.86	120.00

cost per kg	0.96	1.31
Cost difference	**-0.35**	

DISCUSSIONS

Though there is established fact about high positive correlation between bee colony population and honey yield, there is no relevant information related to how double queen system affects different variables of beekeeping under Ethiopian conditions. Our current investigation identified significant difference between two systems for all the colony parameters during the nectar flow seasons (Table 1). Accordingly, two-queen colonies produced more than 98 % of additional honey yield than single queen colonies. Similar study by Horr (1998) showed that two queen colonies produced 75-100 % more honey than single queen colonies. Another study by Gris *et al*. (2004) in the Mexican high plateau found that two queen colonies yielded 101.2 % more honey than colonies with single queen. This increased productivity can be attributed to the highest numbers of nectar foragers resulted from the high bee population in double queen colonies as compared to single queen colonies. In our current study, two queen colonies had at least 27815 more worker bees during nectar flow seasons (See Figure 1 and Table 1). In the study by Gris *et al*. (2004) in Mexico, two queen colonies had more than 32000 more bees than single queen colonies on average during blooming season. In connection to the importance of colony population size for honey production, Fathy (1998), Shawer *et al*. (2003) and Jevtic *et al*. (2009) underpinned that large colonies surpassed the small colonies in honey production.

From honey production potential analysis, we found that a worker bee in double queen colony has 24 % (compare 0.83 and 0.67 g/year) more productivity than a worker bee in single queen colonies. This can be attributed to a higher proportion of bees searching for nectar, since by the end of the blooming seasons, majority of the workers attain forager age, thus released from the task of nursing activities. On top of this, the intake of feed could be decreased due to reduced amount of brood because of the disappearance of one dam. This productivity potential difference per individual bee can underline the importance of having high rate of worker brood rearing at early blooming season, which later on can result in high forager population at the right time for collecting the available nectar sources before the seasons gone. Furthermore, the reduction in honey yield in single queen colonies was probably due to the consumption of major part of the collected nectar for building colony population still during the late part of flow season instead of making honey as can be witnessed from Figure 1 (population growth) and Figure 2 (brood rearing). In connection to colony population importance for honey production, Graham (1993) found that a colony with 60000 bees made more than 2-times honey as that produced by two colonies with each having 30000 bees. These results showed not only the importance of having more populous colonies to yield larger honey product, but also implicated the boosting of potential of individual worker for collecting nectar and storing surplus honey than the relatively weaker colonies or less populous colonies. However, there was significant honey yield difference between honey yield harvested during December and June for similar treatments. This can be explained by the fact that there was a difference between the two seasons in availability of nectar sources with higher accumulation of forage flora during September to December than during the second season (Data were not presented). And also the colony population size was greater during the December compared to June for both queen systems (Figure 1).

Data in Table 3 showed significant ($p<0.001$) positive correlations between colony population, stored pollen, brood, nectar combs and honey yield. The largest stored pollen combs and brood combs were recorded during the nectar flow seasons for both queen management systems in the colonies. The result indicated that the major peak of brood rearing activity coincides with high stored pollen, which latter on converted to maximum number of worker bees during the active honey harvesting seasons. In our current study, the highest numbers of bee population were recorded in December (during first honey flow season) and in June (during second honey flow season). These highest population numbers proceeded by highest rates of stored pollen and sealed worker brood started during October and April, respectively. The results of these findings were also in line with previous reports (Fathy, 1998; Mladenovic *et al*., 1999; Jevtic *et al*., 2009) who proved that there is a positive correlation between the colony population, brood area and honey yield.

However, in this study, fast and drastic decline in colony population density was recorded in a month after honey harvest in both queen systems (Figure 1). The decrease in population size of colony resulted from low rate of brood rearing (Figure 2) due to sharp decrease in pollen collecting activity as a result of death of most pollen flora during January-February and July-August months in the study localities (Figure 3). This result is in agreement with the previous findings (Shoreirt *et al*., 2002; Shawer *et al*., 2003) which showed that the amount of brood rearing is dependent on the availability of forage resources.

From financial analysis point of view, our study result showed that use of two queen colonies is more profitable than managing single queen colonies. The lower production cost was mainly resulted from savings from labor, beeswax and feeding. Moeller (1976 quoted in Gris *et al*., 2004) reported that 50 % more labor time required for two queen colonies than for single queen colonies, indicating two queen colonies needed less total labor per kg of honey produced. In their study in the Mexican high plateau, Gris *et al*. (2004) also reported that only 24 % more labor cost was required than what needed in the single queen colonies. In our current study, additional cost required for managing two queen colonies was about 36 % more than the one for managing single queen colonies. In terms of feeding cost, two queen colonies use feed more efficiently, because with only about 67 % additional feed, honey production was increased by 98 % compared to single queen colonies. This indicates, the benefit of managing two queen systems depends on two pillars, increased unit honey productivity/bee and reduced cost of management.

The proportional worker bee population reduction was higher in two queen colonies, since they had only 35 % of their population at honey harvesting during nectar dearth periods as compared to 57 % in single queen colonies (Figure 1). It is important to mention that the final populations were recorded nearly three months after separating queen excluder removed from the two queen colonies. The removal of queen excluder allows strong fight between the two rival queens and this might be the main reason for decreased population in the two queen colonies in addition to reduced egg laying by 50 % when one queen disappeared. For this reason, two queen colonies should lose proportionally more population than the stable single queen system. However, the increase of population during the blooming seasons goes in similar fashion as that of the decrease during the dearth periods.

CONCLUSIONS

The productivity of honeybee colonies was significantly influenced by the population size. Two queen colonies can be used to attain possible maximum colony population size to produce nearly twice amount of honey yield compared to conventional single queen colonies at least in the central highland areas. In addition, it is more profitable due to about 36 % decrease in production cost per kilogram of honey. Thus, it is concluded that the use of two queen system, which is technically less demanding and also yields more honey production and financially profitable, compared to single queen conventional approach. But the two-queen management method should be complemented with good management practices, starting well before the blooming season, for colonies to have peak population of foragers during the maximum nectar flow seasons. It is also recommend that two queen should be tried in other more potential beekeeping areas by involving more representative numbers of colonies for validating the system further.

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Assessing the response of honeybees (Apis mellifera L.) to Karl Jenter and Doolittle grafting queen rearing methods

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Abstract

A study was conducted in view of analyzing the responses of central highland honeybees (Apis mellifera bandasii) to Karl Jenter and Doolittle grafting queen rearing methods at Holeta for two consecutive active seasons from September 2016 to May 2018. The result of the study revealed that there was significant difference ($p<0.001$) between the techniques in percent acceptance of larvae and sealed queen cells. The acceptance rates for Karl Jenter and Doolittle grafting queen rearing methods were 78.19 and 50.81 % respectively while the rates were 42.75 and 25.56 % for sealing, respectively. However, the result of the study showed that the rate of hatching (out of the total given larvae) into virgin queen stage in Karl Jenter and Doolittle grafting systems were about 23 and 23.8 %, indicating no significant difference between the two techniques. From technical point of view, Karl Jenter kit is better than Doolittle grafting to overcome the problem of indentifying appropriate larvae for grafting under field conditions. The quality of queens raised by these two techniques is not assessed in this study. Thus, further study is recommended to evaluate the performance of queens reared using the two techniques.

Key words: *Apis mellifera* L., Jenter, Doolittle grafting, queen rearing

Introduction

A honeybee queen has significant effect on the colony performances and is one of the most important factors in a bee colony's production and productivity (Ahmet and Hasan, 2005). Several production and productivity traits such as disease resistance, prolificacy, and early population build up, surplus honey storing tendency and many other behavioral characters are attributed to the nature of a queen (Morse, 1993; Crane, 1990, Laidlaw and Page, 1997). Therefore, in order to improve performances of a honeybee colony, better performing queen is one of the indispensable parts of beekeeping. In this regards, artificial queen rearing techniques, is one of the important approaches to help producing of queens with desirable characters in beekeeping to regularly re-queen colonies, to minimize swarming tendency, to enhance brood and honey production, and increase colony stock number. Other desirable traits of a colony like calmness and disease resistance are governed by the genetic makeup of the queen, which generally indicates the importance of queen rearing (Serrano, 1997; Cobey, 2007; Büchler et al., 2013; Adgaba et al., 2018). Towards this, researchers have tried to produce queens from appropriate larval stages by involving different queen rearing techniques (Morse, 1993; Laidlaw & Page, 1997; Crailsheima et al., 2013; Cobey, 2013; Buescu et al., 2015) however, no convenient and economical method has been developed as recipe to fit all races of bees, and all beekeepers and conditions (Ahmad and Dar, 2013)(Karl Crailsheim, Robert Brodschneider, Pierrick Aupinel, Dieter Behrens, Elke Genersch, 2013).

Some studies on responses of local honeybees to queen rearing techniques (Nuru Adgaba and Dereje Woltedji, 1999; Nuru Adgaba, 2012; Zewudu Ararso *et al*., 2013) indicated that different queen rearing methods can be employed to produce queens. However, the responses of colonies towards different queen rearing techniques were greatly varying from technique to technique and seasons to seasons. Similarly, variation of responses to different queen rearing techniques by honeybees were well documented elsewhere (Morse, 1993; Büchler et al., 2013; Crailsheima et al., 2013 ; Nuru et al., 2018). On top of the variation in responses to the techniques, environmental conditions like temperature, relative humidity and pollen source plants were also indicated as important determining factors in level of acceptance and quality of reared queens artificially (Büchler et al., 2013; Nuru et al., 2018). Moreover, variations in diameter of artificial queen cell cups also affects acceptance rate of grafted larvae (Ahmad and Dar, 2013; Nuru et al., 2018). Generally, different techniques affect responses and rates of acceptance and quality of the reared queens. Besides the types of techniques used, the number of young worker bees, the status of brood and food resources were reported to influence the response and quality of the reared queens (Laidlaw and Page, 1997; Büchler et al., 2013). Consequently, the aim of the present work was to investigate the responses of local honeybees (Apis mellifera L.) to Jenter queen rearing method and compare the acceptance, sealed and emerged queens with Doolittle grafting technique under central highland part of Ethiopia.

Materials and methods

Study site, experimental colonies and treatments

The study was conducted in Central Highland areas of Oromia National Regional State, Ethiopia at Holeta apiary site from September 2016 to May 2018 for two years during breeding seasons, September-October and April-May. *A. mellifera bandasii* colonies within the movable Langstroth type frame hives were used for the study. Detailed descriptions of the biological characteristics and variations of the race is given elsewhere (Amssalu et al., 2003). All the colonies were fed with one-liter sugar syrup (2:1 sugar and water) twice for the colonies to attain the required strength at the onset of each breeding season during the study period.

To assess the responses of colonies to Jenter queen rearing system and to compare their responses with that of Doolittle grafting, a total of 24 colonies in hives of 10 frames with single super were used. The test was done by involving four different batches of colonies throughout the study. For both treatments, each colony received 24 to 36 hours old larvae and data on number of accepted larvae, sealed queen cells (pupae) and queen hatched were collected to see the responses of colonies to Jenter queen rearing method and compared with the data collected from Doolittle grafting.

Experimental setup

Standard plastic Karl Jenter method (Model Karl-Heinz Jenter Company Steinbeisstraße 5, 72636 Frickenhausen, Germany) and Doolittle grafting method with plastic cell cups were used to assess the responses of local honeybees to the methods and to avail information for the potential users under local conditions.

For Karl Jenter method, a total of 12 well fed local honeybee colonies (two breeders, five queenless starters and five queenless builders) with uniform strength in Langstroth hive with the population size of first super were used. The Karl Jenter queen kit system was inserted into the two breeder colonies to get young larvae that subsequently transferred to the five queenless cell starter colonies. For the production of young larvae, section of brood combs obtained from breeder colonies were cutout equal to the size of the Karl Jenter kits and each kit fitted into the cutout section two days prior to confinement of the queen for egg laying so that the bees can polish and clean up the kits. Then after two days, two preselected selected breeder queens confined into the kit to let them fully lay eggs on tops of removable cell plugs (Figure 1). After 24 hours, the queens released and the kits maintained in the same colonies for further 72 hours (3 days) for allowing the eggs to hatch into 24-36 hours old larvae. The starter colonies were made queenless one day in advance before transferring the cell plugs of hatched larvae. 24 hours after the five colonies made queenless, the Karl Jenter queen rearing kit with hatched larvae were transported to laboratory, a total 200 starter cups extracted along with cell plugs from the back of Karl Jenter Jenter kits, inserted into standard queen cell cup holders and attached on 10 wooden cell bars. Then 2 cell bars with the attached cell cups were fixed into a standard frame on the same day and each placed in the five colonies made queenless one day in advance for acceptance of the larvae and starting queen cells. 24 hours after placed in starter colonies for acceptance, inspection of the colonies was done and number of accepted larvae for each starter colonies recorded. On the same day, cell builder colonies were made queenless to receive the accepted larvae by the starter colonies. After 24 hours further in starter colonies, accepted cell cups were transferred to the builder colonies. Then, after a week in cell builder colonies, the number of matured queen cells (pupae) recorded and each matured queen cell placed in queen cage for hatching in the same colonies. For each test colony, 40 cell plugs on standard queen cell cup were used and the testing was repeated two times each active season and accordingly eight batches of queen rearing conducted during the whole study period.

For Doolittle grafting method, a total of 12 well fed local honeybee colonies (two breeders larval suppliers, five queenless starters and five queenless builders) with uniform strength in Langstroth hive with the population size of first super were used. In this case, combs with larvae of age 24-36 hours old from the two supplier colonies were chosen and taken to laboratory for grafting. 40 larvae were grafted in to 200 standard plastic queen cell cups lubricated (primed) with a drop of dilute fresh royal jelly of 1:1 (distilled water to royal jelly) ratio and 40 of them placed arranged on two wooden cell bars and fixed into a frame (Figure 2). After five nursery frames prepared in the same way, all framed cell bars were taken and placed in the five colonies made queenless one day in advance for acceptance and starting queen cells. 24 hours after placed in starter colonies for acceptance, inspection of the colonies was done and number of accepted larvae for each starter colonies recorded and similar activities performed for Jenter queen rearing system was adopted for grafting as well for the whole study period. The testing was conducted for 8 batches per colony for the whole study period. Data on number of accepted larvae, sealed queen cells and hatched queens converted to percentage based on the number of given larvae and were analyzed using ANOVA and Student's test.

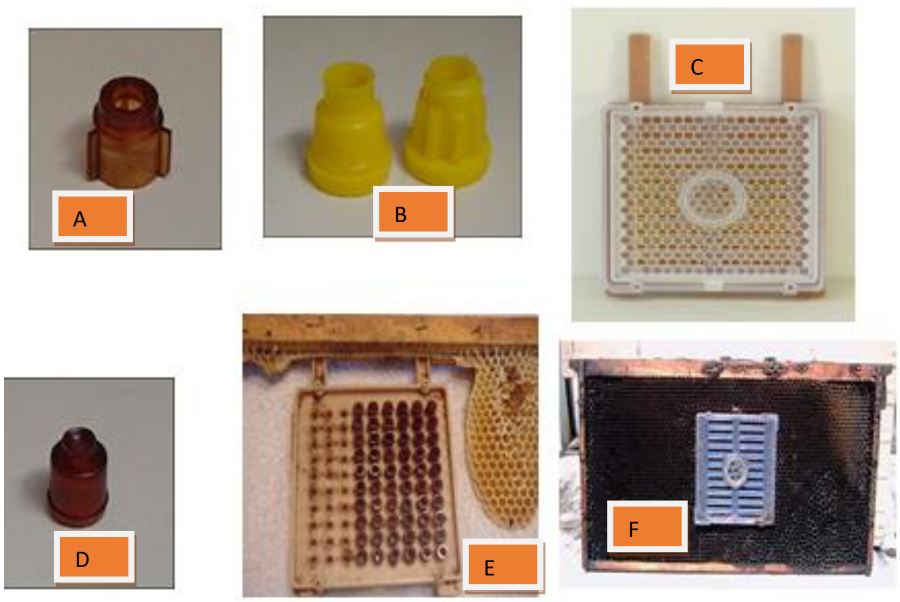

Figure 6. Jenter queen rearing kit showing: Queen cell starter plug-housing (A), Yellow plug holders (B), Plastic comb box with queen excluder (front) and Cover plate (rear) (C), Cell Plug (D), inserted cell plugs into the pre-drilled holes (E) and a plastic Jenter comb box fitted to honey comb in a frame with confined queen (F) for obtaining appropriate larvae.

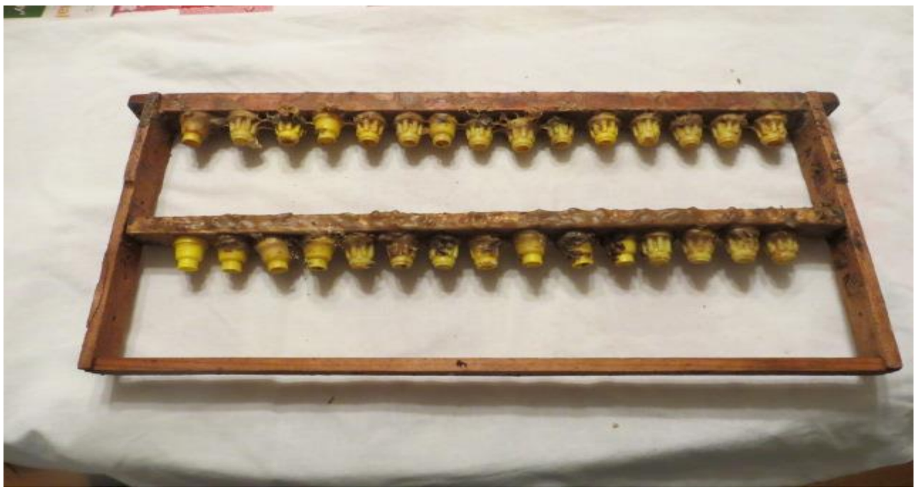

Figure 7. Arrangements of yellow plug holders for the bees to construct queen cells and arranged on wooden bars in a frame.

Results and discussion

Effects of treatments on larval acceptance

The result of the study revealed that there was significant difference ($p<0.001$) between the two techniques in the larval acceptance rate (Table 1). In Karl Jenter queen rearing technique, the average acceptance was 78.19% while in Doolittle grafting method the rate was only 50.81 %. This is in agreement with the findings of Dhaliwal et al. (2017), who indicated that mean acceptance of queen cell cups in Cup kit apparatus, Karl Jenter apparatus, plastic cell cups and wax cell cups were different with acceptance values of 66.00, 50.00, 58.66 and 56.00 %, respectively.. However, the acceptance rate for Jenter queen rearing system in this study (78.19 %) is higher than the acceptance rate in Karl Jenter apparatus reported by (Dhaliwal et al., 2017) which was 50 %. The observed significantly higher acceptance rate for Karl Jenter over Doolittle grafting system in this study could be attributed to various factors. But the most important factor could be due to lack of identifying appropriate age and injury to the grafted larvae (personal error) is more in Doolittle grafting technique compared to Karl Jenter system. In line with this, Dhaliwal et al. (2017) indicated that graftless method has better acceptance as it avoids any injury to larva and larva is fed royal jelly from first day onwards. Similarly, Büchler et al. (2013) described that acceptance of larvae depends on different factors, among which the most important include: quality, strength and developmental stage of the nurse colonies, age of the workers, age of the grafted larvae, presence of open brood in the cell-starting colonies, rearing sequence and method of rearing. Several investigators (Morse, 1993; Nuru and Dereje, 1999; Crailsheim et al., 2013; Adgaba et al., 2018) also indicated that the responses of colonies towards different queen rearing techniques are greatly affected by agro ecological conditions, race of honeybees and pollen source plants. On top of these, low acceptance level in Doolittle grafting compared to Karl Jenter in this study could also be due to failure to work rapidly while grafting the larvae from the worker comb to the queen cells and maintaining suitable environmental conditions.

Table 6. Comparative responses of Apis mellifera bandasii colonies to Jenter and Grafting queen rearing techniques to acceptance of larvae and sealed queen cells on the bases of given 40 larvae per colony. Values are mean ± standard deviations (SD) (n=1600) larvae per rearing technique.

Rearing technique	Rearing Seasons	Accepted larvae (%)	Sealed queen cells (%) on the bases of:	
			Given larvae	Accepted larvae
Jenter method	Sept - Oct	84.13±4.39[a]	50.13±5.53[a]	56.11±10.08[a]
	April - May	72.25±5.86[b]	35.37±7.00[b]	52.37±9.35[a]
	Overall	78.19±7.94	42.75±9.82	54.24±9.78
Grafting method	Sept - Oct	58.00±7.05[a]	28.50±5.98[a]	55.52±10.21[a]
	April - May	43.62±5.76[b]	22.63±3.58[b]	52.33±8.70a
	Overall	50.81±9.66	25.56±5.70	53.93±9.47
L.S.D (P=0.05)		27.31	17.06	N.S.

Values followed with different letter in a column shows significant difference between seasons for each technique (P<0.05).

Effects of treatments on sealing of queen cells (pupae)

The variation of queen cells sealing was significantly different ($P < 0.0001$) between the two methods on the bases of given larvae. Analysis of the data (Table 1) indicated that sealing of cell cups from Karl Jenter was 42.75±9.82 % while it was only 25.56±5.70 % from grafted cell cups in Doolittle grafting out of the total 1600 larvae provided for each system. However, there was no significant differences between the two techniques with regards to sealing of the queen cell cups on the basis of accepted larvae (compare 54.24±9.78 % and 53.93±9.47 % for Karl Jenter and Doolittle grafting, respectively). The similarity in sealing level of queen cell cups from Karl Jenter and Doolittle grafting on the basis of accepted larvae can be explained by several factors of which the amount of royal jelly produced by nurse bees to feed the larvae, number of available worker bees for nursing, nutritional quality of pollen and race of the bees may contribute and these required to be investigated.

In this study, sealing rate of the queen cells both on the bases of given and accepted larvae was generally lower compared to previous reports. For example, Dhaliwal et al. (2017) reported that sealing of cell cups ranged from 50.67 % to 60.67 % on the basis of total cell cups given while it was ranged from 88.57 to 97.50 % on the basis of cell cups accepted for different queen rearing techniques. Similarly, Nuru et al. (2018) reported that 71.84 % of sealed larvae (from the total grafts) into pupae stage in wet grafting for *A. mellifera jemenitica* in Saudi Arabia. Generally, in different queen rearing techniques the rate of sealing queen cells reported to be varied. But besides the types of techniques used, the population size of the colonies, amount food resources available for the bees during the breeding seasons, races of the bees were indicated as some of the factors to influence different parameters in queen rearing (Nuru and Dereje, 1999; Dodologlu et al., 2004; Dhaliwal et al., 2017). Therefore, the relatively low rate of sealed queen cells for both queen rearing techniques in this study could be one of or the combination of these factors and this suggests the importance of further investigations to determine the important factors that affect raising and sealing of queen cells in different queen rearing techniques under local conditions for different honeybee races.

Effects of treatments on hatching of virgin honeybee queens

The rate of hatching (out of the total given larvae) into virgin queen stage in Karl Jenter and Doolittle grafting systems were about 23 and 23.8 %, indicating no significant difference between the two techniques (Table 2). However, the variations in queen emergence rates based on accepted larvae and sealed queen cells were found to be very significant ($P<0.001$). Accordingly, the emergence of queen bees on the basis of accepted larvae and sealed queen cells were 29.22 and 55.71 %, respectively for Karl Jenter while the corresponding rate of emergence for Doolittle grafting were 46.47 and 86.68 %, respectively indicating significant difference between the two methods. The result of this study agrees with the findings of Dhaliwal et al. (2017) who reported that the rate of emerged queens on the basis of accepted cells for different rearing techniques were significantly different. According to the report by Dhaliwal et al. (2017), the emergence of queen bees in the Cupkit apparatus and plastic cell cups were 83.28 and 83.34 % , respectively, while the respective rates for Karl Jenter apparatus and wax cell cups were 52.20 and 54.73 % in that order. In another report by Cengiz et al. (2009), 100.00 % rate of queen bee emergence were recorded in queenright and queenless colonies for the grafted larvae raised with Doolittle method. Similarly, ÖNK et al. (2016) reported 100.00% queen bee emergence rate of accepted larvae for Caucasian race of A. mellifera honeybees. In this study sealing of queen cells and emergence rate of queen bees on the basis of accepted larvae was significantly ($P<0.001$) higher for Doolittle grafting compared to Karl Jenter system. But the larval acceptance rate was significantly ($p<0.001$) higher for Karl Jenter system compared to Doolittle grafting method (Table 1). On the other hand, the queen emergence rate for the two techniques based on the basis of given larvae was similar, indicating that accepted larvae less successfully sealed and converted into virgin queen stage in Karl Jenter than Doolittle grafting. On the base of the current result, both techniques can be practiced for rearing queen bees as the number of queen bees obtained is similar. Though the bees responded to the two methods similarly, the percent emergence was low for both methods. This could be due to environmental factors such as: humidity and temperature which may negatively affect the rearing colony and/or the feed supply of the nurse colony. So, this should be the subject of future investigation to identify important factors that affect different queen rearing parameters, which result in low rate of queen emergence. If percent emergence of queen bees on the basis of given larvae improved, at least Karl Jenter system can be used to yield higher number of queens. If so, the method can be an excellent option for those who face difficulties in identifying appropriate larval age and lack skill in grafting can opt for commercial queen bee rearing. However, there might be a difference in quality of the queens obtained from these two methods. Therefore, further study should be conducted to evaluate the performance of queens reared using the two techniques.

Table 7. Mean ± SD of percent queen cells emerged (hatched) into virgin queens using based on given and accepted larvae and sealed queen cells under Jenter and grafting rearing techniques.

Rearing technique	Queen rearing Seasons	Emergence (%) of queens on the bases of:		
		given larvae	accepted larvae	sealed queen cells
Jenter method	Sept and Oct	25.25±4.28[a]	30.21±4.30[a]	56.36±12.41[a]
	April and May	20.50±3.20[a]	28.23±4.44[a]	55.07±15.57[a]
	Overall	23.08±4.44	29.22±4.43	55.71±13.90
Grafting method	Sept and Oct	22.88±4.36 [a]	46.78±10.66[a]	90.83±14.50[a]
	April and May	22.75±2.84 [a]	46.16±1254[a]	82.54±17.32[a]
	Overall	23.82±3.63	46.47±11.50	86.68±16.31
L.S.D (P=0.05)		N.S.	17.25	30.97

Values followed by similar letters show no significant difference between seasons for each technique (P<0.05).

Effects of seasons on different queen rearing parameters

Table 1 and 2 illustrates rates of different queen rearing parameters of *Apis mellifera bandasii* colonies to Jenter and Grafting queen rearing techniques under two seasons. The difference between seasons in terms of larva acceptance and sealed queen cell rates were statistically significant (P<0.01). Larva acceptance and sealed queen cell rates were found to be higher in September and October than April and May. Similarly, Gene et al., (2005) showed that rearing seasons were found to be significant in affecting acceptance of larvae. This difference in performance level in different seasons may be arise from the fact that different floral resources may be preferred by honeybees to focus more breeding offspring in one season and to focus on honey storage another season. Another explanation for lower acceptance in April and May could also be lower swarming tendency of the bees during this season under local conditions. However, the other queen rearing parameters were not influenced by the seasons. This result is in line with a previous study report by Nuru Adgaba and Dereje Woltedji (1999) on the responses of local honeybees to different queen rearing method.

Conclusion

The present study found that both Karl Jenter and Doolittle grafting queen rearing technique are similar in percentage of hatched queen bees. But Karl Jenter queen rearing is better technique for those who face technical difficulties while practicing grafting and lack skill in identifying the appropriate larvae, as age of larvae obtained from Karl Jenter is known and grafting of larvae is not required. Season has no influence on the queen emergence rate in both queen rearing techniques. However, the rate of emergence of virgin queens was very low compared to the given and accepted larvae and this need further investigations to determine the important factors that affect the final success of queen in different queen rearing techniques under local conditions for different honeybee races.

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International Partnership on Innovation in Smart Apiculture Management Services

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ABSTRACT

Smart Apiculture Management Services **(***SAMS) project aims to develop an open source information communication and technology (ICT) that allows active monitoring and managing of bee colonies to ensure bee health and bee productivity. It also gives answers to the requirements of beekeeping in different countries and settings, for sustainable agriculture worldwide. Risks of depleting honey production threatens livelihoods of beekeepers and degradation of pollination power of suffering bee colonies threatens overall agricultural production and affects the entire population. That is the reason why SAMS targeted monitoring of bee colonies through an open source technology, compare the collected data, evaluate the gained information and convert them into specific requirements and recommendations concerning the management of bee colonies. Thus, SAMS is important to overcome country-specific challenges of beekeeping and simplify the management. At the end of project, there will be the possibility to understand the behaviour of bees and the environmental aspect better to ensure food production and bee farming activities. In addition, the production of bee products increase, jobs are created (particularly youths/ women), investments are triggered and knowledge exchange networks are established. Towards the fact SAMS is addressing, user needs and results will be of major interest for stakeholders along the whole value chain of honey production. As a final outcome of the project: a) A physical low-cost beehive model, that is locally produced and adapted to local conditions, including integrated open source sensor and information transition technology, as well as energy-supply solution; b) A decision support system that combines the sensor-based data-outputs with other information sources and predictive models to measure, analyse and describe different states of the bee colony such as health, vitality, production, etc.; c) An automatic advisory support tool, which will alert the beekeeper in an easily understandable way if any aberrations from normal states are metered and will provide advice on appropriate countermeasures and d) A bee management business concept for the local production and up-scaled implementation of the developed beehives with integrated beehive monitoring system are targeted.*

INTRODUCTION

SAMS is an international project with the focus on Smart Apiculture Management Services initiated and started in January 2018 and is under implementation by GIZ in collaboration with two partners from Ethiopia and Indonesia and one each from Austria, Germany and Latvia. In the context of the SAMS consortium, there is a strong belief that bees have high potentials to foster sustainable development in different sectors but they are often used inefficient. The project has received funding from the European Union´s Horizon 2020 research and innovation programme under the Grant Agreement N° 780755. SAMS enhances international cooperation of ICT and sustainable agriculture between EU and developing countries in pursuit of the EU commitment to the UN Sustainable Development Goal (SDG N°2) “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”.

Pollination is basic to agricultural and natural productivity and this important step depends, to a large extent, on the symbiosis between species of the pollinated and the pollinator(Abrol, 2012) and reduction and/or loss of either will affect the survival of both (Panday, 2015). Pollinators contribute to the maintenance of biodiversity, and ensure survival of plant species including plants that provide food security to the global population. Honey bees are major group of insects that play important role in pollination of crops. Among different species of honeybees, *Apis cerana* and *Apis mellifera* are the most important ones because they can be managed for pollination and moved to fields/orchards where and when necessary for pollination. Dias et al. (1999, cited in Abrol, 2012) indicated that no other group of insects are of more benefit to humans than honeybees as more 35 % of the world's diet comes from crops that these golden insects give the service of pollination. World diet of fats, oils ,fruits, vegetables and other plants in natural ecosystems that include oil palm, olives, peanuts, rape, soybeans, sunflower, apple, citrus, tomato, melon, strawberry, apricot, peach, cherry, mango, grape, carrot, potato, onion, pumpkin, bean, cucumber, various nuts, a range of herbs, trees, cotton, alfalfa and lavender are dependent upon or benefited by honey bees pollination (Fichtl & Adi, 1994;Adi et al., 2014). McGregor (1976) and Free (1993) cited in Partap (2003) indicated that many cash crops are self-sterile and require cross-pollination to produce seeds and fruit. But it is not only self-sterile varieties that benefit from cross-pollination, self-fertile varieties also produce more and better quality seeds and fruits if they are cross-pollinated (Abrol, 2012). Inadequate pollination can result not only in reduced yields but also in delayed yield and a high percentage of culls or inferior fruits (Partap, 2003). In the current scenario, due to the massive scale and homogeneity of modern agriculture, the majority of crops requiring pollination are dependent on managed honeybees (Abrol, 2012; Zetterman, 2018). So, honey bees play a key role in the preservation of our ecosystem and greatly contribute to the global fight against hunger ensuring our existence.

Honeybees are responsible not only for their invaluable pollination services but also produce different products. The most common reason for exploiting the honeybee would be for honey, a source of sweetener for prehistoric people and beeswax an equally important material for various technological, ritual, cosmetic and medicinal applications (Fessenden, 2015; Roffet-Salque et al., 2015). Royal jelly, pollen, propolis and bee venom are also other high potential value products to foster sustainable development in world economy but they are often used inefficient ways. In addition, an important aspect of beekeeping is the production of bees, queens, package bees, etc. In order to get the required potential out of the beekeeping, beekeepers should strictly adopt regular hive managment, a crucial factor for honey bee colony health and productivity.

Current colony population monitoring reports showed that there is different levels of colony losses in many regions and countries all over the world (Brodschneider et al., 2016; Zacepins et al., 2016; Switanek et al., 2017). Because of this declining trend and their roles in world economy, managment and health of honeybees become a growing concern amongst scientists, ecologists, farmers and policy makers (EFSA, 2013). Monitoring for pests, parasites and diseases, as well as colony strength, is a vital element of successful beekeeping (Delaplane et al., 2013). To assess honeybee colony health, production and productivity, beekeepers must open the hive and visually inspect for the presence of diseases and colony development and strength (bee and brood quantity). However, monitoring beehives manually to obtain the information is a time-consuming process for beekeepers as most of the hives are generally located away from homesteads, so every inspection also incurs a transportation cost to beekeepers (Meikle and Holst, 2015; Zetterman, 2018). Furthermore, manual hive inspection is a source of stress to the colony and often disrupt the life cycles of the bees. Frequent hive inspections may destroy the inner order and homeostasis of the honey bee nest, for example by breaking wax bridges between combs. There is also scarce information on how long opening of hives and pulling combs affects the behavior of bees or nest structure/architecture and homeostasis. On top of this, some honeybee races are very aggressive, causing serious problem during hive operation.

Recently, several authors (Bencsik et al., 2011; Murphy et al., 2015; Zacepins et al., 2016; Gustavo et al., 2017) underlined the necessity of adopting Information Technologies (IT) into the beekeeping field. Several multi-dimensional monitoring Information Systems have been developed and applied in Precision Beekeeping (Kviesis et al., 2015; Zacepins et al., 2016; Gustavo et al., 2017). Even though Precision Beekeeping is developed and applied, it is worth mentioning that data analysis phase and development of decision support systems still to be improved (Zacepins et al., 2016). Having these in mind and recognizing several biotic and abiotic threats honeybees are currently facing, the key objective of SAMS project is to develop and refine an open source remote sensing technology and user interaction interface to support small-holder beekeepers in managing and monitoring the health and productivity in their own bee colonies, i.e., monitor colonies in beehives and collect key information about the activity/environment within beehives about productivity and health of the bees.

CONCEPT AND METHODOLOGY

The Concept

Advanced ICT and remote sensing technologies in SAMS enhance Precision Apiculture and help increase roles of bees in pollination services and production of hive products while maintaining healthy environment. Precision Apiculture is an apiary management strategy based on the monitoring of individual colonies without hive inspection to maximize the productivity of bees (Kviesis & Zacepins, 2015; Kviesis et al., 2015; Zacepins et al., 2015). SAMS is an important part of this farming industry based on the following three founding pillars: 1) development of modern modular monitoring hives adapted to the local context for monitoring and uploading data of the behavior, productivity and health status of the bee colonies, 2) development of a cloud-based decision support system (DSS) to implement a management advisory service through direct communication with the beekeepers via different channels (SMS, Email, Web services) or with local experts and 3) development of adapted bee management guidelines about seasonal changes, the presence of pronounced dry/wet seasons, available forage plants etc. and there management practices to the local settings based on an ICT concept.

User Centered Design

User-Centered Design (UCD) is a philosophy and a process that places the person at the center and focuses on cognitive factors as they come into play during peoples' interactions with things. A key aspect of successful UCD is evaluating early and throughout the whole process. It differs from project to project to decide exactly which method to use, and when and how to use (Devi, Sen, & Hemachandran, 2012). In this project, UCD is a multi-step iterative approach that requires a multidisciplinary team of designers, product (especially software) engineers, usability engineers, domain experts and furthermore experts on the value chain from the thematical use of the web-side (for the detail, see Figure 1 UCD Cycles, changed from DIN EN ISO 9241 – 210). The standard describes UCD states that in the process, the following key principles are iterates:

1- The active involvement of users and clear understanding of user and task requirements.
2- An appropriate allocation of function between user and system.
3- Iteration of design solutions.
4- Multi-disciplinary design teams.

In order to make the users an active part of each step in this process there are a number of empirical methods, such as: interviews, surveys, workshops, focus group discussion, field studies, and usability testing. In UCD process, all activities involve participating stakeholders to form the common point of interest. The process iterates until the user requirements are met. In the process, needs and limitations of the end-users are major focus in all steps of the development and forms the basis for common technological innovations that will serve the end-users. Design solutions (low-fidelity as well as high fidelity prototypes) produced after the context of use has been analyzed and user requirements are thoroughly specified. A thorough user research and context of use analysis conducted to understand the preconditions of local potentials and challenges for successful technology supported apiculture. Within the concept of Precision Apiculture using Advanced ICT and remote sensing technologies and design solutions are evaluated against requirements. As the main concept is to develop technically robust, reliable, easily maintained under the specific conditions, affordable, easy to use and provide added (economical) value to each of the target user groups and adoptable on large-scale, user groups from different parts of the value chain and context of use identified. The development of locally feasible manufacturing or assembly, distribution and maintenance and funding models for local startups or dependencies to upscale implementation locally and regionally analyzed. Incomes for the different stakeholder groups can originate from purchasing and subscription fees from the actual end-users, from selling data and expertise as consultancy services to larger agricultural players, from the selling of detailed ecological/climate/flora information as input for Precision Apiculture, or from honey exporters relying on quality and traceability indicators for their products. Technological solution continuously refined based on the actual requirements of the users and their context of use with the processes assuring the users ownership over developed tools and acquired knowledge.

Technology and readiness level

There are many commercial systems that offer hive monitoring through audio and video sensors (Gustavo et al., 2017). Among the commercially available sensor technologies for beehives, Kviesis et al. (2015) proposed a Precision Beekeeping system platform that utilized a SHT15 sensor to measure temperature and humidity. Vladimir Kulyukin developed BeePi hive monitoring system and currently used for estimating forager traffic which refers to a number of bees going in and out of the hive per unit time using the vision sensors (Edwards-Murphy et al., 2015; Zsiray, 2018). The device is powered by a USB battery system that allows for nearly two days of continuous runtime. Another is a system developed in a scientific project with the title "Application of Information Technologies, acronym ITAPIC". ITAPIC project proposes implementation of Precision Agriculture technologies and methods in beekeeping to identify different states of the bee colony and prevent colony losses by developing and introducing wireless sensor system for online monitoring. The wireless system developed within the ITAPIC project was hive sensor hardware for audio, video, microclimate and environmental climate monitoring (see http://www.itapic.eu, ITApic, 2018).

SAMS HUMAN CENTERED DESIGN PROCESS DIN EN ISO 9241 – 210

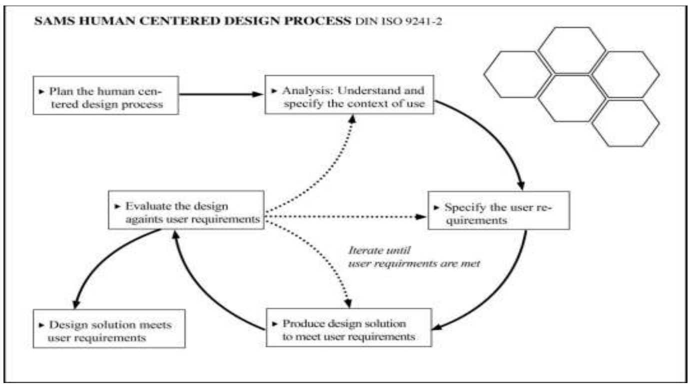

Figure 8: Iterative UCD Cycles, changed from DIN EN ISO 9241 – 210

For this project, the proposed DSS is based on the system prototypes developed by the Latvian University of Life Sciences and Technologies in ITAPIC under the EU program ICT-AGRI-12 within FP 7 (Figure 2) and the Apiary Sensor Unit (ASU) based on the system prototype developed by the University of Kassel (Figure 3). The system utilizes Wireless Sensor Network technology, including sensors, low power processing, mobile networking and energy harvesting to monitor conditions and activity within an active beehive. The main unit of the system (Figure 2) continuously receives data from the sensor (measurement node) of each beehive and when the data are received, it transfers them to the cloud database remote server. Optionally a Secure Digital (SD) card can be placed on the main unit to store data locally for backup purposes (Kviesis et al., 2015). Local data storage is useful when the Internet connection is not stable, resulting in data transfer interrupted to transfer when Internet connection resumes. Data from sensors (measurement nodes, adapted from Rasberry Pi 3 based measurement unit) using wireless communication is directly transferred to the remote server also called cloud server (computational station). In this case each measurement node (sensor in each hive) can obtain Internet Protocol (IP) address from network router and use this device for transmission of data or can use additional 3G or 4G modems to send data. The user can access data remotely by using the developed web interface as wireless system installation does not require any wire management and hence can be used in remote locations. Despite these advantages, development of hardware and software components for wireless systems is not trivial and is a complex task (Picco, 2010; Edwards-Murphy et al., 2015). But this arrangement is selected because the vast majority of beehives are kept in rural locations, where access to power lines and internet connections are extremely limited and hence GSM or Wifi router networking is an option. The idea behind the developed wireless measurement system is therefore, all colony measurements can be directly transferred to the remote server, where data analysis and decision about the colony states can be made. The monitored parameters depend on the sensors, which are placed on the measurement nodes. The honey bee colony wireless monitoring system (again see Figure 2) consists of three main components:

Measurement node

Measurement node is system's element that is responsible for sensor measurements at a specific hive, needed to measure different honey bee colony parameters and transfer the sensor data to the main unit (Kviesis & Zacepins, 2015). The node consists of several integrated blocks: a low power microcontroller, a wireless transceiver, on-board sensors and a power source (Figure 3). The developed node can use various energy sources, like 5 V batteries or solar energy. In case of solar power, the solar panel is charging lithium battery. For battery saving purposes, the measurement node enters "sleep mode" and "wakes up" on predefined time intervals (Kviesis et al., 2015).

Main unit for data transfer

This is the system's element that listens to measurement nodes and transfers the received data to cloud database server. Similarly, the main unit also consists of several integrated blocks: a low-power microcontroller, a wireless transceiver, peripheral extension connectors, an external storage device (optional) and a power source (5 V power adapter is used as energy source (Kviesis & Zacepins, 2015).

Remote database server

Data from measurement units is directly saved in cloud database for further analysis and demonstration. For access to stored data additional Hypertext Preprocessor Personal Home Page (or simply PHP) Web system was developed. This Web system can be adjusted to beekeepers need by implementing different graphical elements for data demonstration and data analysis (Kviesis & Zacepins, 2015; Kviesis et al., 2015).

This solution allows the smart beehive to send texts to the beekeepers' cell phone when the hive needs attention as soon as possible, as well as being able to upload collected images. In so doing, the system allows the beekeeper to reduce the frequency of hive visits, as the hive information can be accessed remotely.

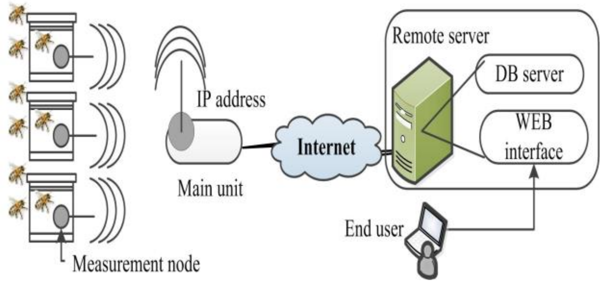

Figure 2: Architecture of Wireless measurement system used in ITAPIC project

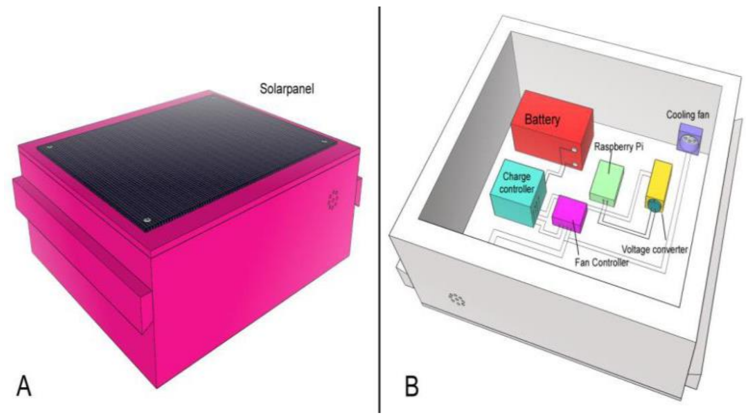

Figure 3: *University of Kassel Apiary Sensor Unit (ASU) unit with solar panel on the outside (A) and power supply, measuring and cooling components on the inside (B).*

Required data types and collection

To develop SAMS to the local context, the consortium targeted to collect data from different sources user groups (individual beekeepers, beekeeping cooperatives, private and public input supplier like beehive producers, bee keeping experts, researchers and others for UCD analysis. Accordingly, data about situation of beekeeping, problems associated with beekeeping and more others thoroughly exploited from scientific literature study, expert opinions and visit to local beekeepers' apiaries. Data and ideas were also collected from local advisory and associate board members, different stakeholders and bee technicians from different ago ecologies. Target of SAMS is to overcome country-specific challenges of beekeeping and simplify the management, understand the behaviour of bees and environmental aspect better to ensure production and beekeeping activities thereby, the production and productivity of beekeeping increased, jobs created (particularly youths/ women), different types of investments triggered and knowledge exchange networks established. As a final outcome of SAMS project: a) A physical low-cost beehive model, that is locally produced and adapted to local conditions, including integrated open source sensor and information transition technology, as well as energy-supply solution developed; b) A decision support system that combines the sensor-based data-outputs with other information sources and predictive models to measure, analyse and describe different states of the bee colony such as health, vitality, production, etc verified c) An automatic advisory support tool, which will alert the beekeeper in an easily understandable way if any aberrations from normal states are metered and provide advice on appropriate countermeasures and d) A bee management business concept for the local production and up-scaled implementation of the developed beehives with integrated beehive monitoring system were targeted.

RESULTS AND DISCUSSIONS

The overall objective of SAMS is to strengthen international cooperation by developing and refining an open source remote sensing technology and user interaction interface to support small-holder beekeepers in managing and monitoring the health and productivity in their own bee colonies. In order to help developing SAMS as open source ICT system for Precision Apiculture and help increase roles of bees in pollination services and production of hive products, data were collected from different sources. Information required for the UCD analysis were obtained through individual interview, field survey study/contextual inquiry, scientific literature study, expert opinions from the project target countries, advisory board meetings and from other similar networks. Accordingly, information on beekeeping constraints and production system and productivity were identified to develop the final outcomes of SAMS project.

Identified beekeeping constraints

Constraints faced by beekeepers broadly categorized as biological, technical, trade, technological and institutional are among the others.

Biological constraints:

These include aggressive behavior of the bees, absconding of colonies, honeybee diseases, pests, predators and problems arising from unwise uses of pesticides, unstable environmental conditions. Of these constraints, the most serious is colony loss due to absconding. From the current assessment, the average absconding rate is above 40 % annually and, in some areas, as high as 100% in dearth seasons. In essence it means that it is likely that up to 2/5th of the bees in any one place of Ethiopia can be lost due to lack of colony follow-ups. Thus, this is an important factor to take into account.

With regards to colony health problems, there are diseases, pests, predators and pesticides, which affect the health of honey bee colonies and in some areas are also major causes of economic loss. There are wide varieties of pests, pathogens and poisoning that affect honey bee health in Ethiopia. They range from protozoa, fungi and insects to mites, mammals and unwise use of Agri-chemicals. In general, the assessment showed that bees are suffering from health problems and beekeepers are also affected due to reduced production or total loss as a result of these problems. Therefore, it is necessary to work on education and dissemination to enlarge the understanding of honey bee biology, to further increase the income by developing SAMS products.

Technical constraints:

Technical constraints that beekeepers face include: lack of knowledge of appropriate methods for managing bees, lack of appropriately skilled trainers, materials and training possibilities, and lack of dissemination of new research information, especially as described above, relating to disease control. Only few beekeepers have knowledge to identify honeybee pests and predators and even knowledge to identify appropriate time for honey harvesting. Beekeeping activity is runing majorly as a side line job, causing lack of attention for the bees. No standard for beekeeping (bee management, honey harvesting etc.) as a result majority of beekeepers inspect their beehive not at all, some only during honey harvest, some only look for beehive externally for the existance of bees and have no knowledge about bee managment. There is also no standard for beehive construction and hive opration with the condition resuling in large variation in sizes and quality of Movable frame beehives. Movable frame beehive should be constructed to sock the balance between the requirements of bee colony and ease and convenience for the work of beekeepers. The interchangeability of similar parts of the beehive like frames, outer covers, bottom board, and inner covers shall be constructed based on standards. However, a survey conducted recently indicated that frame space (sidebar width) of hives constructed in different workshops and used by beekeepers indicate lack of standard construction manual and knowledge about beekeeping. In the survey, measurements of dimensions of the different parts of the box hives (including the frames) from Bako Rural Technology Research Center (BRTRC), Selam TVET (STVET), Dedessa Metal and Wood work (DMWW) and Agelegelote Sechi Wood and Metal work Cooperative (ASMWC) indicated in Table 1 below.

Table 1. Brood and honey chambers and frame dimensions bee space, space between tops and bottoms of frames in box hives constructed at four different workshops.

Measurements	BRTRC Mean+SD	STVET Mean+SD	DMWW Mean+SD	ASMWC Mean+SD	Average dimentions
Brood and honey chambers dimensions (mm)					
Length (External)	502±2	482.5±4	505±0	498±2	495±9
Length (internal)	481±1	456±3	476±3	479±2	473±10

Width (external)	430±1	400±2	432±2	422±2	421±1
Width (internal)	409±1	380±1	411±1	410±0	403±10
Height	242±1	238±1.6	233±1	230±1	236±4
Frame dimensions (mm)					
Top bar (external)	485±0. 7	460±0.9	481±1.1	483±0.5	477±6
Top bar (internal)	469±1.5	445±1	465±3	468±2	462±10
Bottom bar (external)	451±0.1	430±0.8	451±0.3	451±0.8	445±2
Bottom bar (internal)	430±2.1	415±1.5	435±4	436±2.2	430±9
Height (external)	221±0.1	210±0.2	220±0. 2	220±0.1	218±3
Height (Internal)	180±0.5	168±2.1	180±1.2	178±2.3	177±5
Side bar width top	39±1.0	37±1.0	39±0.8	40±0.9	38±0.8
Side bar width bottom	30±2.0	28±0.9	26±1.5	27±1.0	27.7±2

This lack of standard in construction of beehives cause a serious problem in expanding improved beekeeping in Ethiopia (Workneh, 2007). On the other hand, a study carried out by (Tolera, et al., 2012) on efficiency of different beehives (Langstroth, Zander, Foam, Dadant and Modified Zander) showed that Langstroth is found to be the best beehive for all practical beekeeping activities compared to the others. It was recommended from the study that using of Langstroth hive by considering the size of local honeybees will help expanding improved beekeeping and exploiting the existing potential. Therefore, based on the previous recommendation and considering the current problem in beekeeping sector, manual on hive construction and operation developed to help beekeepers and all value chain actors benefit by including this hive system as one important SAMS products.

Trade constraints:

The major constraint faced by beekeepers is lack of market for their products. Most beekeepers are found in remote areas and hence usually fail to sale their produce with reasonable price. Combined with technical constraints due to lack of technical advices, they often produce small volume of products. Traders collect this small volume of honey by deploying local agents in unorganized manner, with the approach cause problem of traceability, one major requirements for products to meet international market standards. The world market demands that honey is certified free from chemical, antibiotic and other residues. Due to these and other problems, majority of the honey produced used is for production of local beverage "*Tej*" at the moment (Gemechis, 2016; Negash & Greiling, 2017; CSA, 2017) Though Ethiopia produce more 50,000 t of honey per year (Negash & Greiling, 2017), the total exported honey to the global market is less 1 %, even though there is constant increase between the years of 2000 and 2013, with volume of 1 t in 2000, 19 t in 2004, 196 t in 2008 and 904 t in 2013 (Figure 4) (FAO, 2018).

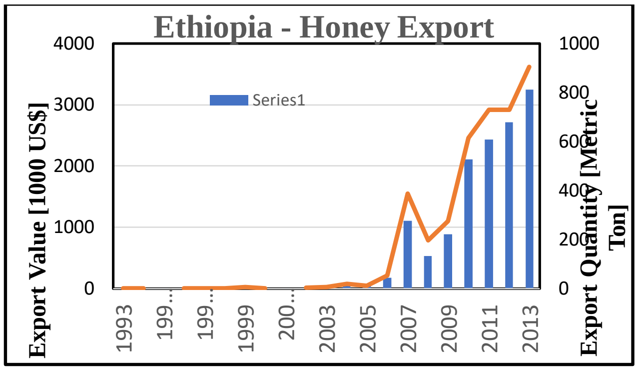

*Figure 4: Export data of honey-Ethiopia (1993-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO); **Data is not available (FAO, 2018).*

In the current scenario, there is also a rapid increase in global demand for high quality honey. In Europe, consumption and trading of honey products are increasing whereas the production is stagnating. EU is a big honey importer, providing that no genetically modified (GMO) pollen detected in the honey by the validated and harmonized (Zmijewska et al, 2013). As there are no GMO crops allowed in Ethiopia, a unique opportunity to export this highly sought-after honey to Europe potentially exists if its quality can fulfill strict European regulations and standards.

Institutional constraints: These include the weakness of producer organizations, weak extension system to support the industry, lack of certified organizations to analyze and certify products for export and only few organizations have capacity to identify diseases and parasites of bees. Infrastructure to monitor, certify and enable trade in honey and beeswax is also lacking. Beekeepers need regulatory and organizational services and support to create market links and meet trade criteria, and ultimately to maintain their bee stocks healthy.

Production system and productivity

Having favorable environmental conditions for existance of diversified natural vegetation and cultivated crops, Ethiopia is one of the best areas in the world for beekeeping. To this fact, different sources estimated that about 10 millions of honeybee colonies and 1.8 million beekeepers estimated to exist in the country (Negash & Greiling, 2017). Although, the country has potential to produce 500,000 tons of honey and 50,000 tons of beeswax per year, the current production is estimated to be about 54, 000 and 5,000 tons, respectively (CSA, 2017; Sebsib & Yibrah, 2018)

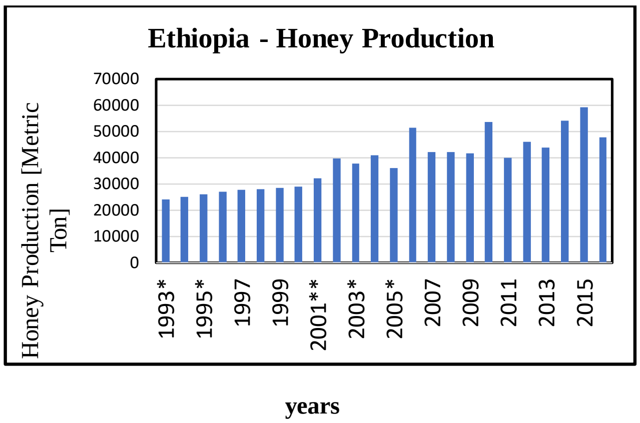

*Figure 5. Honey production in Ethiopia (1993-2016); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO); **Data is based Federal democratic republic of Ethiopia, Central statistical agency.*

However, despite favorable conditions and existing huge potentials, the country in general and the producers and all other actors in the value chain in particular are not benefiting from the sub sector. This is mainly attributed to lack of modernization of the sector through improved beekeeping technologies and product marketing both domestic and export. Owing to this, more than 90% of the beekeeping production system in the country is undertaken using traditional basket beehives which yield small quantity and low quality bee products. Average amount of honey per colony from such bee hive is so small (7kg/colony/year) and the honey harvested is crude (mixed with comb, brood, pollen etc) (CSA, 2017). However, market demands high quality honey which can be easily obtained by using improved technologies and techniques that can improve the productivities of bee colonies and hence significantly influence the honey production. This mainly requires establishing of well conditioned apiary, trained manpower and quality input that could alleviate the problems of both technology and knowledge at all levels in the value chain.

The objective of SAMS project is to develop modern sensor technology from ITAPIC to monitor honeybee colony status based on these identified constraints and challenges to support beekeepers in maintaining their apiaries. As most apiaries are found outside in rural areas where power sources are limited, the smart beekeeping uses alternative energy for powering all the devices. Most suitable power supply to this moment is usage of solar panels, which can be mounted on the hive as indicated in Figure 3. The use of modern sensor technology to monitor honeybee colony status is growing in popularity to solve lots of beekeeping related problems (Murphy et al, 2015; Gustavo et al., 2017). There are already devices, such as electronic scales for measuring hive weight changes, but the increase in hive weight can be due to increased pollen and nectar collection by foragers even in times of colony stress, including the presence of diseases (Zacepins et al., 2016). But the interest here in SAMS is to develop new simple user-friendly low-cost method that can further contribute for the development of beekeeping at least in the target regions. The new system helps to transfer the variety of interesting source of behavior data coming from the beehives. With some form of automation, the data can help the beekeeper in understanding the condition of his bee colonies. As the system is designed to be an open source remote sensing technology, further SAMS-data beneficiary like external research institutions, climate experts, and other stakeholders of apiculture can benefit from publicly available data and the general public can learn more about the key roles of bees and apiculture for environment and global economy.

CONCLUSIONS

The SAMS project aims to develop open source ICT technology that allows active monitoring and managing of bee colonies to ensures bee health and bee productivity. Continuous monitoring variables associated with honeybee colonies, including weight changes, temperature, humidity, acoustics (audio and video), activity at entrance, swarming, broodless stage, brood rearing, diseases and others is becoming feasible for most practical applications. Application of SAMS can give answers to the requirements of beekeeping in different countries and settings, for sustainable agriculture worldwide. But to develop SAMS to the local context, the consortium targeted to collect data from different sources user groups (individual beekeepers, beekeeping cooperatives, private and public input supplier like beehive producers, bee keeping experts and researchers and others for UCD analysis. Through this approach, SAMS wants to overcome country-specific challenges of beekeeping and simplify the management. At the end of project, there will be the possibility to understand the behaviour of bees and the environmental aspect better to ensure food production and bee farming activities. In addition, the production of bee products increase, jobs are created (particularly youths/ women), investments are triggered and knowledge exchange networks established. As final outcome of the project: a) A physical low-cost beehive model, that is locally produced and adapted to local conditions, including integrated open source sensor and information transition technology, as well as energy-supply solution; b) A decision support system that combines the sensor-based data-outputs with other information sources and predictive models to measure, analyse and describe different states of the bee colony such as health, vitality, production, etc. c) An automatic advisory support tool, which will alert the beekeeper in an easily understandable way if any aberrations from normal states are metered and will provide advice on appropriate countermeasures and d) A bee management business concept for the local production and up-scaled implementation of the developed beehives with integrated beehive monitoring system.

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Feed Resources and Rangeland Management Research Results

Effect of Cultivars, Row Spacing and Seeding Rates on Yield and Yield Components of Alfalfa (Medicago sativa) at Adami Tulu Condition

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Abstract

The study was undertaken at Adami Tulu Agricultural Research center (ATARC) with the objectives to evaluate the effect of cultivars, seeding rates and row spacing on yield and yield components of alfalfa. Six alfalfa cultivars (Magna-801, Hunter-river (Check), FG-10-09, Magna-788, FG-09-09 and Alfalfa-Italy), three row spacing (20 cm, 35 cm and 50 cm) and three seeding rates (10, 15 and 20 kg ha^{1-}) were arranged in split-split plot design with three replications. The results indicated that different cultivars influenced significantly the DM yield ($P<0.01$), leaf to stem ratio ($P<0.01$) and seed yield ($P<0.001$) parameters. Comparable DM yield were obtained from FG-10-09, Magna-788, FG-09-09 and Hunter river -(Check) cultivars with values of 1.22, 1.18,1.09 and 1.08 t/ha respectively. Cultivar FG-09-09 was produced the highest seed yield (21.9 kg ha^{-1}) and it performed well in all other tested parameters. Significantly the highest seed (16.9 kg ha^{-1}) followed by (15.5 kg/ha) were recorded respectively from row spacing of 50 and 35cm. Hence, by considering all agronomic and yield performances, FG-09-09 was selected as best performing cultivar in the study area. Although the highest forage DM yield was produced by the highest seeding rate (20 kg ha^{-1}), since there are no significant differences between seeding rate of 15 kg ha^{-1} and seeding rate of 20 kg ha^{-1}, it is logical to recommend the intermediate seeding rate (15 kg ha^{-1}) with row spacing of 35cm to be the optimal for alfalfa forage production. Thus, it can be concluded that alfalfa cultivar FG-09-09 with intermediate seeding rate of 15 kg ha^{-1}under row spacing of 35 cm proved to be superior with respect to dry matter yield. However, if the target is for seed production, row spacing of 35cm wide with the lowest (10 kg ha^{-1}) seeding rate should be used under Adami Tulu ecological conditions.

Key words: Alfalfa, Cultivars, Dry matter yield, Seed yield

Introduction

Ethiopian's livestock population is the largest in Africa. Despite the large livestock population (60.39 million cattle, 31.3 million sheep, 32.74 million goats, 56.06 million poultry, 2.01 million horses, 8.85 million donkeys, 0.46 million mules and 1.42 million camels), productivity remained too low to satisfy food requirement of the ever-growing human population in the country (CSA, 2017/18).

Feed scarcity is one of the major technical constraints in livestock production and thus it challenges the economic contribution of the livestock sub-sector. The critical feed nutrient, crude protein (CP), of the herbaceous plants declines during the dry season, leading to prolonged periods of under-nutrition of livestock reared under such environmental conditions (Yayneshet *et al.*, 2009). Moreover, the adoption and use of improved feed technologies remained limited (Deribe *et al.*, 2013), calling for exploring indigenous feed resources (Mekonnen *et al.*, 2009; Deribe *et al.*, 2013), giving due emphasis on indigenous knowledge on adapted feed resources in the crop-livestock farming systems. Similarly, in mid rift valley of Oromia, shortage of animal feed resource is identified as one of the major factor limiting the production and productivity of livestock. The existing livestock feed is based on natural pastures, fallow and stubble grazing and crop residues. However, natural pasture and crop residues are poor in quantity and quality (Zewdie Wondatir and Yoseph Mekasha 2014). Thus, the obtainable feed resources do not meet the nutrient requirements for growth and reproduction of animals. One of the approaches to alleviate the problem is developing forage species with their agronomic practices for the existing climatic condition.

Alfalfa (*Medicago sativa* L.) is a long-lived perennial forage legume crop and has the ability to stay in soil for 3-5 years producing economical forage yield. Alfalfa performed very well over wide range of environments with productivity determined largely by soil fertility and available water. It is highly productive forage which can be grown under both rain-fed and irrigation conditions from the lowlands to highlands. In addition, alfalfa is characterized by its ability to tolerate frequent cutting and produce forage every 20-30 days, add nitrogen to the soil by bacterial nodules in roots, ability to re-growth after cut and store energy in the crown which helps the buds in a quick re-growth (Atif*et al.,* 2012). Alfalfa improves the nitrogen content of the soil by fixation and increases the production of crops and other grasses if intercropped and decreases the cost of production and increases the income of small holder farmers by saving the cost of nitrogen fertilizer. Alfalfa is a nutrient rich forage crop that contains high crude protein (CP) which can improves the low nutritive value of crop residues and other native perennial grasses. Besides, alfalfa seed has high demand now days because of increase of dairy production in peri-urban and urban areas of the country by different NGOs and different sector investors.

Under arid and semi-arid agro ecology of mid rift valley of the country, selecting high yielder forage varieties/cultivar, in combination with different agronomic practice such as seeding rate and spacing is mandatory. The seeding rate of alfalfa varies from 2.5 kg to 30 kg ha^{-1} (Elfatih and Awad, 2012, Majid*et al.,* 2010) due to differences in environmental, edaphic and seed bed conditions and other factors that could influence germination and establishment. A seed rate of 8-15 kg is recommendable in Ethiopia for a pure stand (Dawit 2012, Kidanie 2012). Similarly, different spacing between rows (15-60cm) were used at different areas (Worku *et al.,* 2008)

Considering the importance, a new look at the effect of cultivars, seeding rates and spacing on alfalfa herbage and seed production is very crucial. Hence, the study was designed to evaluate the effect of alfalfa cultivars, seeding rates and row spacing on yield and yield components of alfalfa at Adami Tulu condition.

Materials and methods

Description of the study area

The study was undertaken at Adami Tulu Agricultural Research center (ATARC) on-station site for two consecutive years (2015-2017). The center is located in eastern Shoa zone at about 7 km from Ziway town and 167 km from the capital city of Ethiopia. The altitude of the area is about 1600 meters above sea level (m.a.s.l) and has semi-arid type of climate. The mid rift valley has erratic, unreliable and low rainfall, averaging between 500 and 900 mm per annum. The rain fall is bi-modal with the long rain from June to September (Abule *et al.,* 1999). Mean value of the temperature recorded was 21.8ºC with a range of 13 to 29ºC (ATARC meteorological station, 2010).

Experimental design and treatment

Six selected alfalfa cultivars introduced from abroad were established on finely prepared seed beds. The experiment was arranged in a split plot design with three replications. Six alfalfa cultivars (Magna-801, Hunter-river (Check), FG-10-09, Magna-788, FG-09-09 and Alfalfa-Italy) were used as main plot treatments. While three row spacing (20 cm, 35 cm and 50 cm) and three seeding rates (10 , 15 and 20 kg ha-$^{1)}$ were assigned as sub plots and sub-sub plot treatments respectively. The plot size of 3 m x 4 m with a distance between plots and replications of 0.5m and 1 m, respectively was used. Supplemental irrigation was used at dry period of the year and diammonium phosphate (DAP) fertilizer was applied at the rate of 100 kg ha^{-1} at planting. All other management practices were done as per the recommendations.

Data collection and analysis

The major important data recorded were plant vigor, plant height, numbers of tillers per plant, leaf to stem ratio, herbage and seed yield. Plant vigorsity was recorded out of 100% by visual observation from each plot. Plant height was taken from average of five plants randomly selected from each plot and measured from ground level to the tip of the plants. Number of tiller per plant was determined by direct counting of the tillers from five plants that were randomly selected and its average was taken. At full bloom stage, the fresh forage samples were harvested from two rows of each plots and weight just after mowing using field balance. The harvested biomass was manually chopped into small pieces using sickle and a subsample of 500 g was taken and dried in air draft oven at 65°C for 72 hours to determine herbage dry matter yield. A sub sample of 200 gm forage was taken and used for leaf to stem ratio determination. Accordingly the samples were taken and separated into leaf and stem components and weighed to determine leaf to stem ratio.

Seed yield was determined by collecting seeds from the two middle rows of each plot when the pods matured. The seeds were threshed and cleaned from unwanted materials and pure seed weight was recorded. All collected data including agronomic parameters, biomass and seed yield were analyzed using the general linear model procedure of SAS (SAS, 2002) version 9.1. Means were separated using least significant difference (LSD) at 5% significant level.

Results and Discussion

Plant vigor

The analysis of variance indicated that plant vigor was significantly ($P<0.05$) affected by the tested cultivars and row spacing while seeding rates and the interaction between cultivar, row spacing and seeding rates had no significant effect on plant vigor (Table 1). The highest plant vigor (74.81%) was observed for cultivar Magna-788 and it followed by FG-10-09 (69.63%) while the lowest (64.44 %) plant vigor value was recorded from Magna-801 cultivar (Table2). On the other hand, the highest plant vigor (71.48%) was recorded in wider row spacing (50cm) where as the lowest plant vigor (65.92%) had recorded from the lowest row spacing (20cm). The highest plant vigor value observed in wider row spacing might be due to more space, light and nutrients available to the plants in wider row spacing.

Numbers tillers

The data on number of tillers per plant was significantly ($P<0.05$) differ among the tested cultivars. On the other hand, row spacing, seeding rate and the interaction between cultivars, row spacing and seeding rate had no significant effect on the number of tillers per plant (Table-1). The result showed that Magna-788 cultivar produced the maximum number of tillers per plant (14.73) while the least value (11.70) was recorded from Alfalfa Italy. Numerically the highest value of tillers per plant (13.39) was recorded for the lowest seeding rate (10 kg ha^{-1}) as demonstrated in table 2. The reduced number of tillers per plant in increased seed rate might be due to inter plant competition within the rows.

Plant height

Plant height was significantly ($P<0.001$) influenced by the main effect of tested cultivars. However, the row spacing, seeding rate and their interaction effect had no significant influence on plant height (Table-1). Mean value of plant height ranges from 36.77-53.06 cm. The tallest plant height (53.06 cm) was recorded for cultivar FG-09-09 whereas the shortest plant height (36.77cm) was recorded for Magna-801 cultivar. The significant varietal differences observed for plant height in the present study was also in agreement with other findings (Sengul, 2002). The difference obtained in the plant height of the tested cultivars might be due to their genotypic variation. Ullah *et al.* (2009) and Shahzad *et al*., (2007) also stated variations in plant height to be linked to genotypic differences and environmental factors.

Leaf to stem ratio

As indicated in table 1, different alfalfa cultivars had significant ($P<0.01$) effect on leaf to stem ratio. Significantly the highest (1.16) leaf to stem ratio was obtained for the FG-10-09 while lowest (0.86) value were recorded for Hunter river (Check) and Alfalfa Italy (Table-2). This may be due to relatively high numbers of branches associated with cultivar FG-10-09 as compared to the other cultivars which were reflected in low leaf portion weight. The variation observed in leaf to stem ratio among the cultivars also verify that the differences of the tested cultivars in their growth and development performances. Leaf to stem ratio is an important trait in the selection of appropriate forage cultivar as it is strongly related to forage quality (Julier *et al*., 2000; Sheaffer *et al.,* 2000). Other studies also indicated that seeding rate had little influence on leafiness of alfalfa (McGuire, 1983).

Dry matter yield

The result indicated that the tested cultivars and seeding rates had highly significant effect ($P<0.01$) on DM yield while the row spacing and the interaction of cultivar, spacing and seeding rate had no significant differences on dry matter yield production (Table 1). The highest total DM yield (1.22 t ha^{-1}) was recorded from FG-10-09 followed by cultivar Magna-788 (1.18 t ha^{-1}) and FG-09-09 (1.09 t ha^{-1}). The least dry matter yield value (0.91t ha^{-1}) was recorded from Magna-801 and Alfalfa-Italy cultivars (Table2). The DM yield difference among the observed cultivars could be due to their inherent character which enabled them to manifest differently for agronomic and yield parameters in to the prevailing conditions. This indicates that cultivars with better yield are well-adapted to the local environment that allowed the crop to absorb more nutrients and water, resulting in high herbage yield. The significant cultivar differences observed for herbage dry matter yield in the present study concurs with other reports (Monirifar, 2011; Sun *et al*., 2011). The wide range of herbage DM yield values observed in different reports could be attributed to varietal or environmental differences and/or their interactions.

Significantly the maximum DM yield (1.13 t ha^{-1}) was recorded from the highest seeding rate (20 kg ha^{-1}) while the least dry matter value (0.98 t ha^{-1}) was obtained from seeding rate of 10 kg ha^{-1} (Table 2). However, the yield obtained from 15 kg ha^{-1} and 20 kg ha^{-1} seed rates were not significantly differ. The non-significant differences between the intermediate (15 kg ha^{-1}) and the highest seeding rates (20 kg ha^{-1}) might be due to competition associated with high seeding rates and the ability of stand provided by the intermediate seeding rate to produce relatively high numbers of shoots per unit area, which compensated for the low seeding rate. Increasing the number of plants per unit area reduces the volume of air and soil that the individual plant can exploit, and therefore increases competition between plants for soil nutrients, carbon dioxide and light (Elfatih and Awad,2012).

Seed yield

The analysis of variance indicated that seed yield was significantly ($P < 0.01$) affected by the tested cultivars and different row spacing ($P<0.05$). However, seeding rate and the interaction effect of cultivar, row spacing and seeding rate did not significantly affected seed yield of alfalfa (Table 1). The maximum seed yield (21.9 kg ha^{-1}) was recorded for cultivar FG-09-09 while the minimum value (10.4 kg ha^{-1}) was obtained from Magna-801 cultivar. The increase in seed yield obtained from FG-09-09 indicating that this cultivar had a better genetic performance as compared to the others tested alfalfa cultivars. The seed yield obtained from the tested cultivars was low when compared with the yield reported by different authors (Dunbier *et al.*, 1983). The main reasons for low seed yield could be poor pollination and floret retention (Askarian 1993). Studies also indicated that genetic and environmental factors affect seed yield of alfalfa (Bolanos-Aguilar *et al.,* 2002).

Significantly the highest seed yield (16.9 kg ha^{-1}) followed by (15.5 kg ha^{-1}) were recorded respectively from row spacing of 50 and 35cm. While the lowest seed yield (30.18 kg ha^{-1}) was obtained from the narrowest row spacing (20 cm). The lower seed yield in the narrowest row spacing could be due to the fewer racemes/m^2. The wide row spacing promotes more branches, flowers per plant, higher percentage seed set, and higher seed yield per plant (Abadouz *et al.,* 2010). Even though different seeding rates didn't affected seed yield significantly, the lowest seeding rate produced more seed yield than the two highest seeding rates (Table 2). Other studies also point out that seed yield increased as sowing rate decreased probably due to a greater branch number (Askarian 1993) and subsequently more racemes/m^2. The higher sowing rates probably create greater interplant competition and resulting in a negative effect on seed yield. Literature also indicated that plant density is known to be an important factor in seed production, because competition between and within plants affects a plant's ability to produce vegetative and reproductive material (Askarian *et al.,* 1995). Moreover, seed yield of alfalfa varies because the growth and development of the seed yield components is strongly affected by the environment.

Studies have reported and recommended different results for optimum row spacing and seeding rate for alfalfa seed production (Rashidi *et al.,* 2010). Mustafa *et al.,* (2016) indicated that the highest seed yield was obtained from 25 cm row spacing with 4 kg ha^{-1} seed rate. Generally, the mean values related to seed yields recorded in this study were lower than those reported by Rashidi *et al.,* (2009). Variation among the yields may be due to differences in location, climatic conditions (moisture stress) and management techniques under researches were conducted. Hence, the results of this study suggest that among the various row spacing and seeding rates evaluated, row spacing of 35 cm wide with the lowest (10 kg ha^{-1}) seeding rate were found to be optimum for alfalfa seed production under AdamiTulu ecological conditions.

Table 1. Mean squares of ANOVA's for plant vigor, number of tillers per plant, plant height, leaf to stem ratio, seed and dry matter yield of alfalfa cultivars tested at Adami Tulu

Source of	**Df**	PV	NTPP	PH	LSR	DMY	SY

variation							
Rep	2	74.82	16.33	85.3	0.104	0.113	2083.5*
Cultivar (Cu)	5	347.87*	35.76*	1039.05***	0.448**	0.446**	2151.5***
Row spacing (RS)	2	427.92*	3.73	10.96	0.196	0.247	757.79*
Seeding rate (SR)	2	271.86	19.13	205.32	0.128	0.294*	111.8
Cu*RS * SR	44	155.86	17.47	97.48	0.089	0.078	163.07
Error	106	204.87	20.44	168.13	0.121	0.155	271.8
Total	161	-					

*Where, PV=plant vigorsity; NTPP= Number of tiller per plant; PH= Plant height, LSR= leaf to stem ratio, DMY=Dry matter yield, SY=seed yield, , *= significant at (P < 0.05), **= significant at (p<0.01), ***= significant at (P <0.001)*

Table2. Effect of cultivars, row spacing and seeding rates on different agronomic parameters, dry matter and seed yield of alfalfa tested at Adami Tulu condition

	Parameters					
Treatments	PV(%)	NTPP	PH (cm)	LSR	DM yield (t ha^{-1})	SY (kg ha^{-1})
Alfalfa cultivars						
Magna-801	64.44^{b}	11.91^{b}	36.77^{c}	0.88^{c}	0.91^{b}	10.4^{d}
Hunter river -(Check)	65.92^{b}	13.35^{ab}	51.32^{a}	0.86^{c}	1.08^{ab}	14.8^{bc}
FG-10-09	69.63^{ab}	12.14^{b}	49.57^{ab}	1.16^{a}	1.22^{a}	15.5^{bc}
Magna-788	74.81^{a}	14.73^{a}	50.55^{a}	0.96^{bc}	1.18^{a}	12.3^{cd}
FG-09-09	68.14^{ab}	12.43^{ab}	53.06^{a}	1.09^{ab}	1.09^{ab}	21.9^{a}
Alfalfa Italy	68.14^{ab}	11.70^{b}	43.28^{b}	0.86^{c}	0.91^{b}	17.1^{b}
Mean	68.5	12.7	47.4	0.97	1.06	15.4
LSD (0.05)	7.46	2.36	6.48	0.18	0.19	3.96
Row spacing						
20	65.92^{b}	12.95	47.15	0.92	1.09	13.6^{b}
35	68.15^{ab}	12.43	47.21	0.95	1.12	15.5^{ab}
50	71.48^{a}	12.76	47.91	1.04	0.99	16.9^{a}
Mean	68.5	12.7	47.4	0.97	1.06	15.3
LSD (0.05)	5.31	NS	NS	NS	NS	3.06
Seeding rates						
10	71.11	13.39	47.17	0.99	0.98^{b}	15.9
15	67.04	12.47	45.23	1.0	1.08^{ab}	14.6
20	67.41	12.27	45.87	0.92	1.13^{a}	15.5
Mean	68.5	12.7	46.09	0.97	1.06	15.3
LSD (0.05)	NS	NS	NS	NS	0.14	NS
CV	20.7	30.1	27.2	30.2	28.3	29.7

Where, PV=plant vigorisity; NTPP= Number of tiller per plant; PH= Plant height, LSR= leaf to stem ratio, DM=Dry matter, SY=seed yield Means followed by the same superscript(s) in the same column for each treatment are not significantly different, LSD= least significant difference, ns=Not significant,

Conclusions and recommendations

Alfalfa cultivarFG-09-09 was performed best as compared to the other cultivars in dry matter, seed yield and other parameters. Hence, by considering all agronomic and yield performances, FG-09-09 was selected as best performing cultivars in the study area. Although the highest forage dry matter yield was produced by the highest seeding rate (20 kg ha^{-1}), since there are no significant differences between seeding rate of 15 kg ha^{-1} and seeding rate of 20 kg ha^{-1}, it is logical to recommend the intermediate seeding rate (15 kg ha^{-1}) with row spacing of 35cm to be the optimal for alfalfa forage production. However, if the target is for seed production, row spacing of 35cm wide with the lowest (10 kg ha^{-1}) seeding rate should be used under Adami Tulu ecological conditions. Since this result were only shows the yield and yield components of alfalfa (*Medicago Sativa*), further studies regarding the nutritional composition and its effect on soil fertility are required. Studies that aim to integrate feeds that have better nutritive values into the feeding system are required to further evaluate feed intake, digestibility, level of inclusion (supplementary feeds), animal's responses, and anti-nutritional factors, for more efficient utilization of these well adapted feed resources. Moreover, on-farm evaluation and popularization of the recommended cultivar with its agronomic practice is crucial

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Evaluation of Cenchrus ciliaris ecotypes for dry matter yield and yield related attributes in Borana rangelands, Southern Ethiopia

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Abstract

We evaluated three ecotypes of Cenchrus ciliaris for dry matter yield and yield related characteristic for two year (2015, 2016) at Yaballo Pastoral and Dry land Agriculture Research Centre's research station in Borana rangeland, Ethiopia. We used six treatments with two replications for each ecotype. We collected data from three ecotypes of Cenchrus ciliaris with and without application of manure. Analysis of variance (ANOVA) was used to compare dry matter yield and seed yield. Our result showed that short height Cenchrus ciliaris plus manure produced high dry matter yield (2.8 ton ha^{-1}) and seed yield (0.14 ton ha^{-1}).However, the dry matter yield (DMY) (1.33 $tonha^{-1}$) and seed yield(62.8 $kgha^{-1}$) obtained from medium height Cenchrus ciliaris was significantly lower.Overall, manure application showed considerable change in dry matter yield and seed yield. Therefore, we recommend short height Cenchrus ciliaris with manure application for dry matter yield and seed yield than the two ecotypes, the tall and medium Cenchrus ciliaris).

Introduction

Rangelands in Africa are occupied by the pastoral and agro pastoral communities and cover 60% of the continent's land area (Nyangito et al., 2008). However, degradation is high in Borana rangelands. Rangeland restoration is assisting recovery of an ecosystem that has been degraded (Visser et al., 2007). Rangeland restoration is conducted with the aims of increase vegetation cover, increase biodiversity and to increase production potential to improve grazing capacity through determining suitable and perennial grass accessions (Visser et al., 2007).

Cenchrus ciliaris also known as African foxtail is a palatable, nutritious and warm season grass naturally occurring in the drier parts of the world that can establish with less than 300mm rainfall. It is a valuable bunched perennial grass adapted to arid and semi-arid environment. It tolerates drought, high temperature, and low rainfall and is adapted to sandy soil. *Cenchrus ciliaris is*an excellent grazing perennial grass suited to pasture and rangelands and has high soil binding capacity due to its clustered root system in the upper 8 to 10 cm layer of soil(Hacker and Waite, 2001;Rajkumari and Archana, 2012).

Cenchrus ciliaris grows vigorously when favorable conditions set in (Hacker and Waite, 2001; Rajkumari and Archana, 2012). These authors further investigated that different accessions of *Cenchrus ciliaris* have different performance in different countries such as Tanzania (Bogdan, 1977), Ghana (Fianu and Winch, 1983) and South Africa (Brockett and Gray, 1984) with the dry matter yield of 2 to 8, 5.4 to 6 and 6.2 to 8.1 t/ha, respectively.

Cenchrus ciliaris locally known as *Mata-guddeessa* is widely used in Borana rangelands and well responds to heavy grazing. It is not known under the conditions effects of sowing of different ecotypes on yield. The effects of different ecotypes of *Cenchrus ciliaris* on dry matter and seed yield were not known. Three ecotypes of *Cenchrus ciliaris* are observed in Borana rangelands. These ecotypes particularly differ in their height, spikelet and greenness. Therefore, we identified and divided based on their height, namely, short *Cenchrus ciliaris*, medium *Cenchrus ciliaris* and tall *Cenchrus ciliaris* ecotypes. This variation in height raised question whether these ecotypes have different performance in dry matter and seed yield after use in rehabilitation. Objectives of the study were 1) to determine which of the three ecotypes of *Cenchrus ciliaris* in the semi-arid Borana rangelands would be more productive in terms of dry matter and seed yield when used to rehabilitate degraded rangeland and2)to evaluate the dry matter yields and yield component response of *Cenchrus ciliaris* ecotypes to manure application

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Materials and Method

Study area

The Borana rangelands are characterized by an arid and semi-arid climate, with pockets of sub-humid zones. The average annual rainfall varies between 350 mm and 900 mm with a considerable variability of 21 to 68% among years (Kamara, 2001). Rainfall is bimodal, with 60% of the annual rainfall occurring between March and May (main rainy-season) followed by a minor peak between September and November (small rainy-season). The indigenous classification of climatic seasons corresponds to the measurements of monthly rainfall distribution.

The total land area studied was located between 4°45ˈ20″N and 4°5ˈ20″N as well as 38°22ˈ40″E and 38°9ˈ20″E in the Borana rangelands**.** This study was conducted on station at Yabello Pastoral and Dry land Agriculture Research Center**.** Vegetation is dominated by trees and shrubs mainly of the genera *Acacia*,; herbs mainly of the genera *Commelina, Pupalia*; and annual and perennial grasses mainly of the genera *Cenchrus, Heteropogon,, Chrysopogon, Bothriochloa, Cyperus, Digitaria, Sporobolus, Cynodon*, and *Chloris*. The area has four seasons; namely, main rainy season (*Ganna*), cold dry season(*Bona Adoolessa*), short rainy season (*Hagayya*) and hot dry season(*Bona hagayya*).Rainfall is bimodal with the main rain coming mainly between March and May while the short rains come between September and November (Angassa and Oba, 2007). Average annual rainfall ranges from 100 to 800 millimeters**;** the annual rainfall of this area is highly variable and characterized by recurrent drought that has unfavorable effect on livestock and rangeland production. The average temperature ranges from 15 to 24°C. Soil types are mainly chromic cambisols and luvisols, and eutric cambisols, fluvisols and nitisols. Generally Rainfall is unreliable, and hence does not support conventional agriculture.

Treatments and design

The trial was conducted using randomized block design with six treatments replicated three times. The treatments were:

- Tall *Cenchrus ciliaris*
- Medium *Cenchrus ciliaris)*
- Short *Cenchrus ciliaris*
- Tall *Cenchrus ciliaris* + manure
- Medium *Cenchrus ciliaris* + manure
- Short *Cenchrus ciliaris* + manure

Plot size and separations:

Plot size was 3m x 4m with a one meter (1m) border between each plot of *Cenchrus ciliaris*. Three meter was used between each of the three replications

The *Cenchrus ciliaris* were planted at about 6kg/ha. Manure application was at a rate of 10ton/ha (ten tone per hectare).

Data collection

The biomass was determined from four random quadrants from each plot using a quadrant size of 0.5m x 0.5m and cutting each site manually from within the plots using sickle. The plant samples were cut at15cm above ground surface. All samples were dried in an oven for 48hrs at $65^{O}C$ before weighing. Data were recorded for dry matter yields and seed yield of three ecotypes of *Cenchrus ciliaris*. The four $(0.5x0.5)m^2$ quadrates from each plot were combined, and then averaged for the total dry matter yield from each plot. The meteorological data such as rainfall and temperature were recorded during the experimental period and taken from Yabello weather station, which is 1km distance from the trial site.

Data analysis

The dry matter and seed yield were analyzed with ANOVA, using the GLM procedure of SAS (Version 9) computer software package (SAS, 2002). Means were separated after significance using Least Significance Difference; differences were declared at the alpha level of 0.05.

Standardized rainfall anomaly (SRA) values and the corresponding drought severity classes were computed as follows (Agnew & Chappel 1999);

$$SRA = (Pt - Pm)/\sigma, \text{-------------------------------} \quad (1)$$

Where: SRA=standardized rainfall anomaly, Pt=annual rainfall in year t, Pm= mean annual rainfall over a period of observation and σ =standard deviation of annual rainfall over the period of observation.

The drought severity classes based on SRA are extreme drought (SRA< −1.65), severe drought (−1.28>SRA>−1.65), moderate drought (−0.84>SRA>−1.28) and no drought (SRA>−0.84) was applied as indicated in Arragaw Alemayehu & Woldeamlak Bewket (2017): The Precipitation Concentration Index (PCI) was applied as indicated in Luis et al. (2000);

$$\mathbf{PCI=100\times \{\Sigma Pi^2/ (Pi)^2\}, ----------------------- (2)}$$

where: Pi=the rainfall amount of the i^{th} month; and $\Sigma\ Pi^2$ =summation over the 12 months.

PCI values less than 10 indicate uniform monthly distribution of rainfall, values between 11 and 20 indicate high concentration, and values above 21 indicate very high concentration.
The Coefficient of Variation (CV), the Precipitation Concentration Index (PCI), and the Standardized Rainfall anomaly (SRA) were used as statistical descriptors of rainfall variability (Bewket and Conway, 2007; Ayalew et al., 2012; Hadgu et al., 2013).

Coefficient of variation gives an estimate of the degree to which rainfall important for agriculture is either stable or changing. The coefficient of variation (CV) was calculated to evaluate the variability of rain fall. In order to study heterogeneity of monthly rainfall amount in the study area, it is given as

$$\mathbf{CV=(S/ \mu) -------------------------- (3)}$$

Where: S= Standard deviation and μ = Mean

Model: $Y_{ij} = \mu + T_i + e_{ij}$;

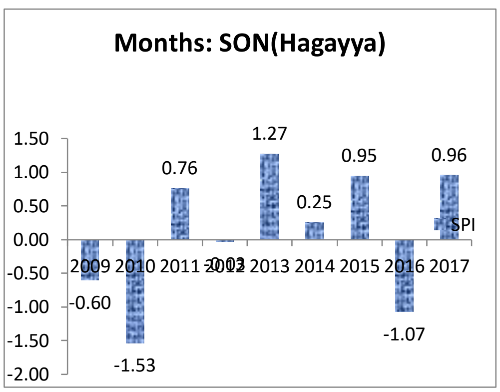
Where: Y_{ijk} = dependent variables (seed yield and dry matter), μ = overall mean; T_i = ecotypes of buffer grass effect;; e_{ij} = error term

Results and Discussion

Trends of two rainy seasons (main and short) are presented in figure 1 below using standardized precipitation index (SPI). The results showed that from total of 9 observed years (2009-2017),five(5)years were precipitation deficient but 4 years were with normal years (wet periods) precipitation .The dry matter yield and seed yield amount were greater in2015(less rainfall) than that of good year(2016)(Figure 3). This is attributed to the number of rainy days.

The result is logically falsified the data but data indicated that less year rainfall produced more dry matter and seed yield than that of good year. Therefore, precipitation parameters such as intensity, amount and duration are the most important factors for biomass production. The value ranged from 15-20 indicated there is seasonal variation and value ranged from 20-50 indicated there is highly seasonal variation (Dnald Gabriels, 2007) .Our result indicated that PCI value ranged from 18.12 to 26.72 for the two consecutive years(2015 and 2016), which indicated there was highly annual variation (Figure 2).

For dry matter yield and seed yield production the time of harvesting and duration are the most determinant. According to Hare (1983) cited in Gebremichel et al. (2014), CV is used to classify the degree of variability of rainfall events as less, moderate and high. When <20% it is less variable, between 20% and 30% is moderately variable, and greater than 30% is highly variable. This result showed that the rainfall variability was more that100%, which indicated highly variation within short distance (figure 2). However, the indigenous knowledge supported the result; the elder said that intensified rainfall in short time and longtime could have affected grass biomass and *finna*- suitable of weather condition for growth and health both for plants and animals - could affect biomass production. *Finna*is the most important factor in Borana pastoralists from production perspective; and it is not always positively correlated with amount, intensity and duration of rainfall.



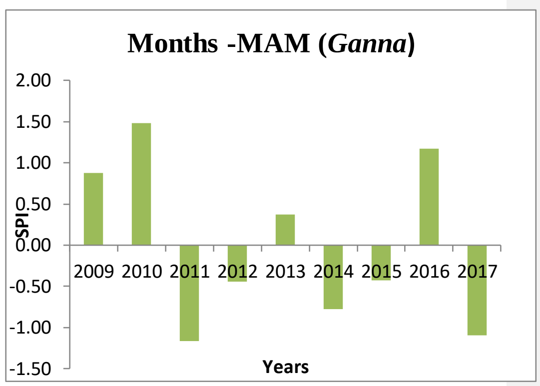


Figure 1: Trend of main rainy season using standardize precipitation (SPI), 2009-2017

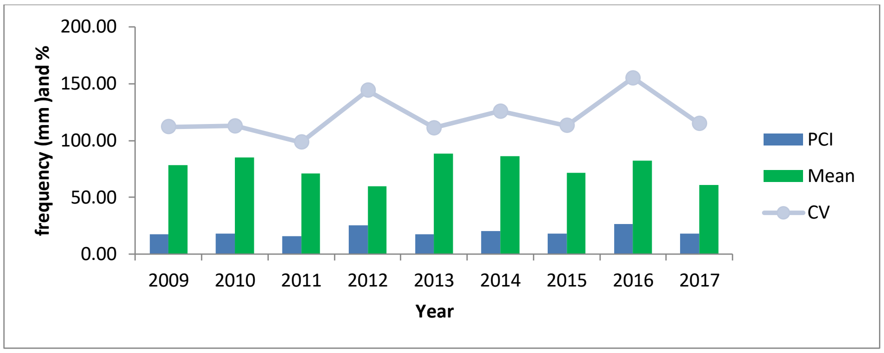


Figure 2: Mean of rain fall, precipitation concentration index (PCI) and coefficient variation

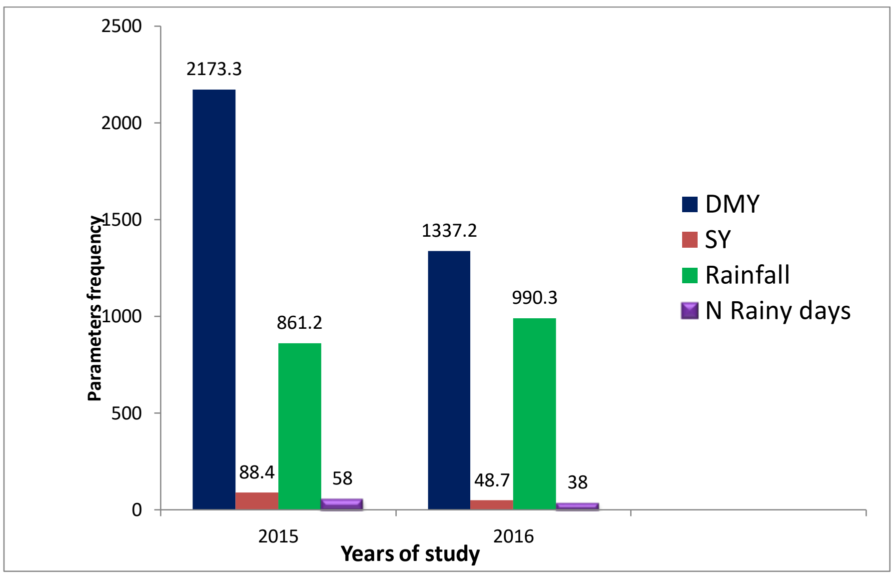


Figure 3: Mean of dry matter yield, seed yield, amount of rainfall and rainy days of 2015 and 2016

Mean of dry matter and seed yield of three *Cenchrus ciliaris* eco-types are presented in Table 1. Our result showed that there was a significant difference ($P<0.05$) among ecotypes and manure application. Accordingly, short height *Cenchrus ciliaris* treated with manure outperformed all the other ecotypes in both dry matter (2802.7 kg ha^{-1}) and seed (137.5 kg ha^{-1}) yields. On the other hand, medium height *Cenchrus ciliaris* without manure gave reduced amount of dry matter (1331.9 kg ha^{-1}) compared to the other ecotypes and manure treatment. But, regarding seed yield, application of manure did not show significant difference ($P>0.05$).Seed yield was the least for medium height *Cenchrus ciliaris* (62.8 kg ha^{-1}) without manure and manure treated medium height *Cenchrus ciliaris* (58.4 kg ha^{-1}).

Table 1. Mean±SE of dry matter and related attributes of*Cenchrus ciliaris* eco-types for 1st Year(2015)

Treatment	Dry Matter Yield (kg/ha)	Seed Yield (kg/ha)
Short *Cenchrus ciliaris*	2564.8 ± 417.3^{ab}	105.2 ± 7.7^{ab}
Short *Cenchrus ciliaris* + Manure	2802.7 ± 277.6^{a}	137.5 ± 29.4^{a}
Medium *Cenchrus ciliaris*	1331.9±197.3^{c}	62.8 ± 14.8^{b}
Medium *Cenchrus ciliaris*+ Manure	2099.9 ± 535.6^{ab}	58.4 ± 7.1^{b}
Tall *Cenchrus ciliaris*	2296.3 ± 475.1^{ab}	92.6 ± 13.8^{ab}
Tall *Cenchrus ciliaris*+ Manure	1944.1 ± 186.2^{b}	73.7 ± 9.3^{b}
CV	30.9	33.0

Mean dry matter and seed yield of three *Cenchrus ciliaris* eco-types for the second year is presented in Table 2. Our result showed that there was a significant difference *(P<0.05)* among ecotypes and manure use. Accordingly, Medium *Cenchrus ciliaris*with*out* manure application was outperformed all the other ecotypes in dry matter yield(1806.4±328kg ha^{-1}). Buttall *Cenchrus ciliaris*without manure resulted in high seed yield than other ecotypes(79.5±29.4kg ha^{-1}). On the other hand, tall *Cenchrus ciliaris* without manure produced lower amount of dry matter (79.5±29.4kg ha^{-1}) than the other ecotypes and manure treatment. But, regarding the seed yield tall *Cenchrus ciliaris* without application of manure showed significantly higher*(P>0.05*) than other ecotypes.

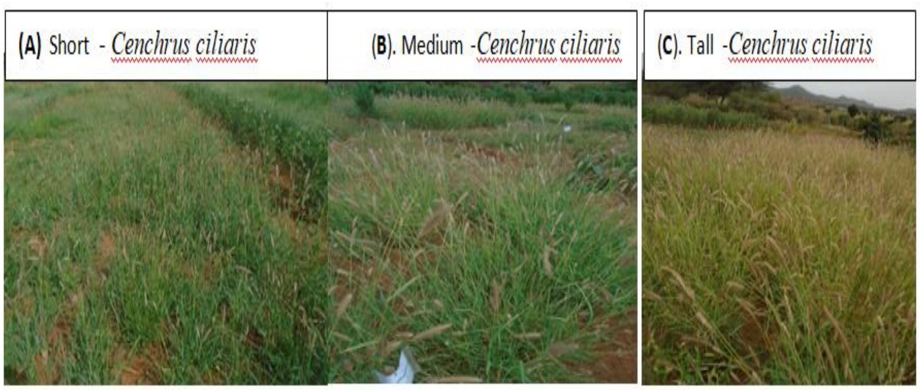
Table 2. Mean±SE of dry matter and related attributes of *Cenchrus ciliaris* eco-types for2nd Year(2016)

Treatment	Dry Matter (kg/ha)	Seed Yield (kg/ha)
Short *Cenchrus ciliaris*	1021.3±53.1^{bc}	41.8±9.6^{b}
Short *Cenchrus ciliaris*+ Manure	1468.3±36.8^{ab}	58.8±5.9^{ab}
Medium *Cenchrus ciliaris*	1806.4±328.7^{a}	41.3±13.9^{b}
Medium *Cenchrus ciliaris*+ Manure	1529.6±92.4.0^{b}	32.6±13.6^{bc}
Tall *Cenchrus ciliaris*	79.5±29.4^{c}	79.±2.4^{a}
Tall *Cenchrus ciliaris*+ Manure	1483.2±94.9^{ab}	38.0±3.3^{b}
CV	20.5	27.6

Mean of dry matter and seed yield of three *Cenchrus ciliaris* eco-types is presented in Table 3 as a combination of two consecutive study years. Our result showed significant difference *(P<0.05)* among ecotypes and manure use on the measured ecotypes. Accordingly, Short *Cenchrus ciliaris* treated with manure application was outperformed all the other ecotypes in dry matter yield (2135.5±130.7 kg ha^{-1}) and seed yield (121.0±11.9). Buttall *Cenchrus ciliaris* without manure resulted in less dry matter yield than other ecotypes (1505.2±232.5kg ha^{-1})but it is significantly lower than Short Cenchrus *ciliaris*+ Manure. On the other hand, Medium *Cenchrus ciliaris* with manure produced significantly less amount of seed yield (48.7 ± 7.3kg ha^{-1}) than short*Cenchrus ciliaris*, short *Cenchrus ciliaris*+ manure and tall *Cenchrus ciliaris*. Therefore, short *Cenchrus ciliaris* with application of manure produced significantly higher*($P>0.05$)* dry matter than tall *Cenchrus ciliaris.* Againshort *Cenchrus ciliaris* withmanure application produced significantly higher*($P>0.05$)* seed yields than other ecotypes except tall *Cenchrus ciliaris* (Table 3).

Table 3**:** Mean±SE of dry matter and seed yield of *Cenchrus ciliaris* eco-types, combination of two years(2015 and 2016)

Treatment	Dry matter (kg/ha)	Seed Yield (kg/ha)
Short *Cenchrus ciliaris*	1793.1 ± 234.9^{ab}	$83.4\pm6.4b^{C}$
Short *Cenchrus ciliaris*+ Manure	2135.5 ± 130.7^{a}	121.0 ± 11.9^{a}
Medium *Cenchrus ciliaris*	1569.1 ± 107.2^{ab}	58.9 ± 6.1^{cd}
Medium *Cenchrus ciliaris*+ Manure	1814.7 ± 247.8^{ab}	48.7 ± 7.3^{d}
Tall*Cenchrus ciliaris*	1505.2 ± 232.5^{b}	100.3 ± 14.2^{ab}
Tall*Cenchrus ciliaris*+ Manure	1713.7 ± 86.9^{ab}	66.0 ± 7.5^{cd}
CV	18.7	22.3



Picture 1. The three ecotypes of *Cenchrus ciliaris*

Conclusion and Recommendation

We evaluated three ecotypes of *Cenchrus ciliaris* (*Mata-guddeessa)* with and without manure for dry matter and seed yield on station at Yabello Pastoral and Dryland Agriculture Research in Borana rangelands of southern Ethiopia. The three *Cechrurs ciliaris* ecotypes (Tall, Medium and Short height) were identified in Borana rangelands. In our experiment they were evaluated with and without manure for dry matter and seed yield in two consecutive years. The result showed that the dry matter yield and seed yield of Cenchrus ecotypes plus manure application produced more in 2015 than in 2016, because of its rainy day length.

Therefore, Short *Cenchrus ciliaris*with manure application produced more dry matter yield &seed yield production than two ecotypes *(Tall and mediumCenchrus ciliaris)* in subsequent year. Duration of precipitation more determine biomass and seed yield than other rainfall parameters such as amount of rainfall and precipitation concentration and variability of rainfall. Overall, manure application showed considerable change in dry matter yield &seed yield.

Long term research of three ecotypes of *Cenchrus ciliaris* including nutritive values and impacts of the three ecotypes on soil physico-chemical properties need to be evaluated with more years in Borana semi-arid and arid rangelands of southern Ethiopia

Acknowledgement

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Evaluation of Cutting Frequency on Yield and Nutritional Quality of Herbaceous Forage Species in Enclosure of Borana Rangelands, Southern Ethiopia

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Abstract

A study was carried out in the semi-arid environments of Borana rangeland southern Ethiopia to determine the yield response of grass and non-grass species to four cutting frequencies over a two year period. Four treatments of cutting frequency i.e. cutting once after the end of main growing season (T1), cutting every week (T2), cutting every two weeks (T3) and cutting every three weeks (T4) in a randomized complete block design(RCBD) with three replications were employed. Sampling herbaceous vegetation attributes was carried out in 2015 and 2016. In total, 37 different herbaceous species comprising of 15 grass species and 22 non-grass species were sampled. Cutting frequency had a highly significant effect (P<0.01) on herbaceous biomass with yield decreasing as the number of cutting frequencies increased. Grass species composition, dried biomass and density were significantly affected (P<0.05) by frequency of cutting being the highest for T1. However, non-grass species richness, diversity and evenness were significantly affected (P<0.05) by treatments. Cutting grasses subsequently over years reduced species richness and diversity excepting when cut every three weeks which did not affect species richness but increased species diversity. Like grass, non-grass species richness was reduced when all the treatments were applied across subsequent years. Cutting both grass and non-grass species once after the end of main growing season (T1) enhanced percentages dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). Cutting both grass and non-grass species every week (T2) favored percentage crude protein (CP) and true in vitro organic matter digestibility (*TIVOMD). For short-term rangeland management, cutting once after main growing season per year can be recommended because of the high yield in herbaceous species composition, dried biomass, basal cover and density.*

Key words: *Grass species; Non-grass species; cutting frequency; rangeland management*

Introduction

Cutting frequency has been shown to produce different effects on the quantity and quality of forage grasses and legumes at different seasons of the year depending on the species of forage (Njarui and Wandera, 2004; Enoh *et al.,* 2005). The response to cutting of a forage plant depends up on its seasonal yield of carbohydrate storage, its growth habit and extent of inflorescence development (Dev, 2001). As pastures mature they are characterized by high content of fibre with a higher grade of lignification and low protein content (Enoh *et al.,* 2005). Most improved grasses fed at early stages of maturity are more digestible and are eaten in larger quantities than at more mature stages (Mero, 1985). Legumes contain higher CP and minerals than grasses and increase total DM intake when used as supplements to low CP grass diets (Mero and Uden, 1990). Herbaceous vegetation species have not been evaluated under frequent cutting regimes in Borana rangelands. But, unfortunately, we are experiencing a decline in production potential of wide rangelands in Borana. As it is well experienced by pastoralist in Borana, enclosure is one of the most effective forage preservation as standing hay and improvement of feed shortages for dry season on these rangelands. These enclosures involve prevention of livestock entering the rangeland, which may be only true about domestic animals and is recommended with various periods depending on region's ecologic situations and the severity of rangeland destruction or administrative goals and severity of feed shortages. Some of the dominant grasses species in Borana area are; *Chrysopogon aucheri, Pennistum mezanium, Chloris roxburghiana, Bothriochloa radicans, Centrums ciliaris, (*Angassa and Oba, *2010).* The surplus production from rangelands during rainy season is to be carefully preserved in various forms to meet the forage requirements of the lean periods. In Borana rangelands, government and non-government organizations are initiating hay making, particularly in enclosure, but only one cut for hay making and/or standing hay is to be taken in each year. Standing hay ('*Kalo'*) preservation for livestock is a long time traditional practice in the Borana range lands.The various cutting studies with herbaceous vegetation revealed that cutting interval is crucial to their performance and found that the main factor affecting growth, yield and persistence of swards is the defoliation intensity (Santos *et al.,* 2001b and Wadi *et al.,* 2004). The re-growth after defoliation is one of the most important physiological processes and it determines the sward structure (Matthew *et al.,* 1995). Proper cutting and harvesting management is vital for sustainable grassland/rangeland management. Cutting at suitable interval promotes tillering and increases the basal area of the tussocks of perennial grasses. It also promotes tillering and more effective seed formation as well as vegetative growth. Results of López-Chuken and López-Domínguez, (2012) showed significant highest yields with the least frequency of cutting. Hence, this indicate that the importance of a more detailed characterization of the enclosure management strategies with careful monitoring of the adopted grazing and grass cutting frequencies. Moreover, it leads to test cutting frequency on herbaceous vegetation from enclosure using main rainfall season in Borana rangeland. Therefore, the study was conducted with the objectives to evaluate the effects of cutting frequencies on herbaceous vegetation in enclosure using main growing season in Borana rangeland and to determine qualitative and quantitative yields of herbaceous vegetation attributes due to cutting frequency

Materials and Methods

Study area

The study was carried out in Yabello district of Borana zone, southern Ethiopia in communally owned enclosure. The rainfall of the area is distinctly bimodal pattern, viz. the main rainy season (*Ganna*) occurring from March to May which accounts 59% of the total rainfall of the area, and the short and small rainy season (*Hagayya*) which occurs in months from September to November that accounts 27% of the total rainfall of the study area. Droughts are common once every 5-10 years (Coppock, 1994). A prominent feature of the Borana ecosystem is the erratic and variable nature of the rainfall, with most areas receiving between 238 mm and 896 mm annually, with a high coefficient of variability ranging from 18% to 69% (Angassa and Oba, 2007).

Table 1. A summary of mean monthly temperature and total monthly precipitationat the study site for the study years (2015 and 2016)

Months	2015			2016		
	Average temperature (°C)	Total rainfall (mm)	Number of rainy days	Average temperatur e (°C)	Total rainfall (mm)	Number of rainy days
January	22.7	0	0	22.55	0.8	1
February	23.0	0	0	21.9	81.30	2
March	22.8	144.9	7	21.75	25.40	2
April	22.7	154.1	6	20.5	458.0	13
May	21.0	111.7	7	18.5	166.2	5
June	23.12	26.4	3	18.8	63.8	2
July	22.8	0	0	18.4	0	0
August	23.5	0	0	18.4	0	0
September	24.6	14.90	3	19.7	27.4	1
October	23.9	178.3	18	19.4	40.6	5
November	23.6	209.7	13	18.9	101.4	6
December	21.9	21.2	1	18.6	25.4	1
Total		861.2	58		990.3	38

Experimental design and treatments

The experiment was established within a communal enclosure which has been allowed for grazing only during dry seasons. A total of three experimental plots each with an area of 40m*40m were fenced with locally available bushes just during the onset of the main growing seasons i.e. mid-March to mid-May. Plots were separated from each other by 2m buffer strips. The experiment duration covered only the main growing seasons of 2015 and 2016.Treatments were randomly assigned to the plots in a randomized complete block design with three replications. The same plots were used across years. The treatments included four different cutting frequencies i.e. cutting once after the end of main growing season (T1), cutting every week (T2), cutting every two weeks (T3) and cutting every three weeks (T4).

Measurements

Cutting the aboveground swards to 10 cm stubble height was commenced 10 days after the onset of the main rainy season by using sickle in each year. The above ground biomass was divided in to non-grass and the grass species by randomly locating 40 quadrates each with $0.25m^2$ per plot. Data were not recorded separately for each subsequent cutting (first, second, third, fourth etc.). All cuttings of a plot were to the same height. All plant material was oven dried separately as grasses and non-grasses at 65^oC for 24 hours and then reweighed until the sample no longer loses weight. Annual yield was obtained by summing biomass from all cuttings of a given plot. Samples for herbaceous nutritive value analysis were only recorded in the first year assuming that nutritive value does not vary across two consecutive years. Grass and non-grass species composition, density, frequency, diversity, basal cover and dry matter were assessed. All herbaceous samples were scanned by a Near-Infrared-Spectrometer (NIRS) to estimate quality parameters at International Livestock Research Institute (ILRI).

Data analyses

Herbaceous species composition, richness, frequency, density, diversity, evenness, basal cover, nutritive value and dry matter were sorted and analyzed. The parameters were subjected to ANOVA using the GLM procedure of SAS Version 9 of computer software package (SAS, 2002). Means were tested for significance using Least Significance Difference and differences were declared significant at P<0.05.

Model: $Y_{ij} = \mu + Tc_i + e_{ij;}$

Where: $Y_{ijk =}$ dependent variables (species composition, richness, frequency, density, diversity, basal cover, dry matter yield and nutritional quality parameters), μ = overall mean; $Tc_{i =}$ Effect of cutting frequency; $e_{ij =}$ Error term

Results and Discussions

Overall herbaceous vegetation conformation

In total, 37 different herbaceous species comprising of 15 grass species and 22 non-grass species were sampled (Table 2 and 3). Herbaceous species richness in the current study is three less than that reported by Bikila and Tessema (2017) who reported 40 different herbaceous species in enclosure areas of Borana rangelands. Likewise, 30 herbaceous species involving 12 grass species and 18 non-grass species were recorded in 2015 while 24 herbaceous species encompassing of 10 grass species and 14 non-grass species were sampled in 2016.This might be mainly due to the disappearance of most important grasses and non-grass species due to subsequent cutting over years. The present study is in line with Solomon *et al.* (2006); Tessema *et al.* (2011) who reported that number of herbaceous species reduced in heavily grazed rangelands than in slightly grazed rangelands. Species richness for both grass and non-grass species was reduced across years i.e. from 12 in 2015 to 10 in 2016 for grass species and from 18 in 2015 to 14 in 2016 for non-grass species. This might be attributed to the effect of subsequent cuttings across years.

Overall, 2 annual and 10 perennial grasses were identified in 2015 while 3 annual and 7 perennial grasses were recorded in 2016. The number of annual grasses has increased while the number of perennial grasses decreased across years. This implies that application of treatments subsequently across years increased annual but decreased perennial grass species. This indicates that perennial grass species are replaced by annual species in rangelands associated with heavy grazing. According to Dreber and Esler (2011), heavy grazing favors annuals since they tolerate heavy grazing and trampling through various adaptive mechanisms, such as their small seeds may become easily buried in the soil. Similarly, temporal variation in vegetation species in semiarid African savannas could also be due to differences in phenology of herbaceous species in response to grazing (Snyman, 2004).Sixty percent, 33.33% and 6.67% of the grasses were desirable, highly desirable and less desirable by grazers, respectively. Similarly, 6.67% and 93.33% of the grasses recorded were desirable and less desirable by browsers (Table 2). *Sporobolus pellucidus, Themeda triandra, Chrysopogon aucheri, Aristida kenyensis and Cenchrus ciliaris were* the most dominant grass species while *Panicum maximum, Xerophytahumilis, Digitaria naghellensis* and *Dactyloctiniuma egyptica* were the least dominant grass species recorded in the study area.

Of the total 22 different non-grass species recorded, 17 were annuals and 5 were perennials. Total non-grass species richness was reduced from 18 in 2015 to 14 in 2016. The number of both annual and perennial non-grass species has decreased across years. Most of the non-grass species (59.09%) were less desirable while 4.55% and 36.36% were highly desirable and undesirable to grazers. In the same way, 45.45, 22.73, 22.73, and 9.09% of non-grass species were less desirable, desirable, undesirable and highly desirable to browser animal species (Table 3). *Barleria argentea, Chlorophytum gallabatense, Commelina africana* and *Indigofera spinose* were the most popular non-grass species whereas *Pupalia lappacea, Tribulus cistoides* and *Vigna friesiorum* were the least dominant non-grass species in the study area (Table 3).

Table 2. List of grass species with their life form, palatability categories in terms of grazers and browsers species count/0.12 ha under communally enclosed rangeland area in Borana, southern Ethiopia (*n* = 48).

List of grass species	Vernacular name	Life form	Desirability		Species count/0.12ha			Species composition (%)	Frequency (%)
			Grazers	Browsers	2015	2016	Total		
Sporobolus pellucidus	Salaqo	P	D	LD	298	227	525	16.91	83.33
Themeda triandra	Gaguro	P	D	LD	254	290	544	17.53	83.33
Chrysopogon aucheri	Alalo	P	HD	LD	765	729	1494	48.13	100.00
Digitaria velutina	Digitaria	A	D	LD	77	0	77	2.48	37.50
Aristida kenyensis	Bila	A	D	LD	212	46	258	8.31	70.83
Pennisetum mezianum	Ogondhicho	P	D	LD	13	0	13	0.42	25.00
Uknown	Mara tari	P	D	D	29	9	38	1.22	16.67
Cenchrusciliaris	Mata gudesa	P	HD	LD	36	31	67	2.16	58.33
Digitaria milanjiana	Hido	P	HD	LD	32	18	50	1.61	45.83
Xerophytahumilis	Aredo	P	D	LD	10	0	10	0.32	4.17
Panicum maximum	Loloqa	P	HD	LD	1	0	1	0.03	4.17
Uknown	Barchumatite	P	LD	LD	2	0	2	0.06	4.17
Dactyloctinium aegyptica	Dactyloctinum	A	D	LD	0	1	1	0.03	4.17
Digitaria naghellensis	Ilmogora	A	D	LD	0	2	2	0.06	4.17
Bothrio chloainsculpta	Mara sala	P	HD	LD	0	22	22	0.71	16.67
Species richness	15				12	10			
Annuals		4			2	3			
Perennials		11			10	7			
Desirable percentages			60	6.67					
Less desirable percentages			6.67	93.33					
Highly desirable percentages			33.33	0					

Note: A = annual, P = perennial, D = desirable, LD = less desirable, HD = highly desirable, UD = undesirable

Table 3. List of non-grass species with their life form, palatability categories in terms of grazers and browsers, species count/0.12ha under communally enclosed rangeland area in Borana, southern Ethiopia (n = 48).

List of non-grass species	Vernacular name	Life form	Desirability		Species count/0.12ha			Species composition (%)	Frequency (%)
			Grazers	Browsers	2015	2016	Total		
Barleria argentea	Agagaro hare	P	LD	D	131	150	281	44.75	95.83
Unknown	Baranbarro	A	LD	LD	1	0	1	0.16	4.17
Unknown	Bosoqe	P	UD	UD	2	0	2	0.32	4.17
Hibiscus aponeurus	Bungala	A	LD	D	23	5	28	4.46	37.50
Bidens pilosa	Cogogiti	A	UD	UD	2	0	2	0.32	8.33
Cissus rotundifolia	Cophi	P	UD	UD	3	0	3	0.48	12.50

Pupalia lappacea	Hanqare	P	LD	LD	1	0	1	0.16	4.17
*Rhynchosi a*species	Kalalafakata	A	LD	D	6	3	9	1.43	16.67
Chlorophytum gallabatense	Mirtu	A	LD	LD	42	32	74	11.78	66.67
Tribulus cistoides	Mogore	A	LD	D	3	0	3	0.48	4.17
Unknown	Qanxala	A	UD	D	3	0	3	0.48	4.17
Commelina africana	Qayo	A	HD	HD	60	28	88	14.01	79.17
Indigofera spinosa	Qilxiphe	A	LD	HD	7	45	52	8.28	70.83
Crabbea velutina	Qorsagara	A	LD	LD	7	2	9	1.43	20.83
Dorstenia barnimiana	Rari	A	LD	LD	21	0	21	3.34	29.17
Unknown	Singo	P	LD	LD	1	1	2	0.32	8.33
Tagetesminuta	Sunki	A	UD	UD	7	3	10	1.59	20.83
Ocimum forskalei	Urgo	A	UD	LD	2	7	9	1.43	20.83
Vign afriesiorum	Came	A	LD	LD	0	1	1	0.16	4.17
Athroisma boranense	Gurbi	A	UD	LD	0	24	24	3.82	29.17
Unknown	Qubaitidhaha	A	LD	LD	0	2	2	0.32	4.17
Unknown	Un NG	A	UD	UD	0	2	2	0.32	4.17
Species richness	22				18	14			
Number of annuals		17			13	11			
Number of perennials		5			5	3			
Desirable percentages			0	22.73					
Highly desirable (%)			4.55	9.09					
Less desirable (%)			59.09	45.45					
Undesirable (%)			36.36	22.73					

Note: A = annual,P = perennial, D = desirable, LD = less desirable, HD = highly desirable, UD = undesirable

Effects of cutting frequency on herbaceous vegetation structure

The overall yields of herbaceous vegetation attributes during the experimental period is summarized in Table 4.In this study, high cutting frequency can be compared to heavy grazing while less cutting frequency can be compared to light grazing in this current findings. Cutting frequency had a highly significant effect ($P<0.01$) on herbaceous biomass with yield decreasing as the number of cutting frequencies increased. Cutting herbaceous vegetation stands once after the end of main growing season gave a significantly higher total biomass yield than cutting every week. Overall herbaceous vegetation species composition, frequency, density and basal cover were the highest for cutting made once after the end of main growing season. Basal cover and biomass werethe lowest for cuttings made every week. The current result is in agreement with Tessema *et al.* (2011) who found high percentage basal cover and standing biomass for herbaceous species in lightly grazed areas in Abernosa cattle breeding ranch and Awash national park, Ethiopia. On the other hand, herbaceous species richness and diversity were the lowest for cuttings made once after main growing season.

Table 4: Overall herbaceous vegetation attributes across treatments

Treatments	Species richness	Species composition (%)	Frequency (%)	Density/ha in '000's	Diversity	Evenness	Basal cover (%)	Herbaceous biomass (ton/ha)
T1	9.00±0.73[a]	11.58±1.13[a]	56.02±2.50[a]	194.05±24.54[a]	1.46±0.14[a]	0.66±0.04[a]	57.58±3.27[a]	1.95±0.49[a]
T2	11.17±0.95[a]	9.25±0.73[a]	54.86±3.44[a]	159.41±20.84[a]	1.63±0.11[a]	0.68±0.03[a]	46.83±7.42[a]	1.04±0.08[b]
T3	12.00±1.21[a]	8.88±0.99[a]	53.22±2.21[a]	130.13±14.81[a]	1.75±0.14[a]	0.71±0.03[a]	56.46±4.19[a]	1.15±0.09[ab]
T4	12.50±1.57[a]	8.68±1.11[a]	49.87±1.95[a]	121.31±19.96[a]	1.61±0.09[a]	0.65±0.03[a]	55.42±2.71[a]	1.18±0.11[ab]
P value	0.18	0.15	0.4	0.08	0.34	0.62	0.31	0.0001

Effects of cutting frequencies on grass vegetation structure

The effect of treatments on grass vegetation structure is indicated in Table 5. Grass species composition, biomass and density were significantly affected ($P<0.05$) by the frequencies of cutting. Species composition percentage was highest for T1 (18.81%) followed by T4 (16.41%), T2 (14.76%) and T3 (12.69%) in that order. Similarly, grass density was highest for T1 (317760 ha^{-1}) and lowest for T3 (187630 ha^{-1}).The highest grass species composition percentage and density for T1 and the lowest species composition percentage and density for T3 and T2 might be due to the inability of grasses to resist frequent cutting. This finding is in agreement with Tessema*et al.* (2011) who reported that heavy grazing which can be equivalent to high frequency of cutting results in the reduction of species composition and density, compared with light grazing which can be equivalent to less frequent defoliation. Samuel *et al* (2018) reported that the difference between grazing and clipping was not significant in terms of biomass.

Grass biomass (ton/ha) was significantly highest ($P<0.05$) for T1 (1.9 ton/ha) and lowest for T2 (0.98 ton/ha) (Table 5). This is in accord with Lopez-Chuken and Lopez-Dominguez (2012) who reported that the highest biomass yield for *Cenchrus ciliaris* grass was attained from the least frequent cutting. Similar result was reported by Nasir *et al* (1993) who found that the highest biomass yield for Napier grass when cut at the end of the growing season. Reduction in biomass production as a result of increased defoliation frequency has been reported in several perennial grass species (Briske and Richards, 1995).Cutting once after the end of main rainy season (T1) allowed the grass to mature enough and provide excellent biomass yield. This result is in accord with Bolormaa *et al.* (2008) who found that grass biomass yield was less when cutting frequency was high. Similarly, Sain khuu (2006) reported that tillering and budding were the most sensitive stages for plant growth. During the budding period, nutrition is not sufficient to support growth of the reproductive parts of the plant. Plants are not capable of supporting rapid growth in shoots and roots simultaneously for an extended period of time. If rangeland is grazed severely, root growth stops and roots may die (Teel, 2000). Hence, rangelands grazed during the budding period may be expected to experience degradation. This may explain the observed decrease in yield when grass was cut frequently. Grass species richness, frequency, diversity and evenness were not significantly affected by frequency of cutting. This might be attributed to proximity of the experimental plots to each other.

Table 5: Grass vegetation structure across treatments (n=12)

Treatments	Species richness	Species composition (%)	Grass biomass (ton/ha)	Frequency (%)	Density/ha in '000's	Diversity	Evenness
T1	5.17±0.6[a]	18.81±3.16[a]	1.90±0.5[a]	66.94±4.33[a]	317.76±60.54[a]	1.1±0.09[a]	0.68±0.02[a]
T2	5.83±0.48[a]	14.76±1[ab]	0.98±0.07[b]	66.42±2.91[a]	251.74±24.23[ab]	1.14±0.11[a]	0.66±0.04[a]
T3	6.17±0.31[a]	12.69±0.73[b]	1.06±0.09[b]	59.21±2.08[a]	187.63±14.95[b]	1.11±0.12[a]	0.60±0.05[a]
T4	5.33±0.5[a]	16.41±1.78[ab]	1.08±0.11[b]	66.4±4.03[a]	228.34±31.58[ab]	1.05±0.1[a]	0.64±0.06[a]
P-value	0.30	0.04	0.02	0.34	0.04	0.93	0.69

Means with different letter superscripts along the column are statistically significant at P <0.05

Effects of cutting frequencies on non-grass vegetation structure

Non-grass species richness, diversity and evenness were significantly affected (P<0.05) by treatments while species composition, frequency, biomass and density were not significantly affected (P>0.05) by treatments (Table 6).In contrary to this finding, Moore *et al* (1982) found that clear cutting non-grass species greatly increased their frequencies. Species richness significantly varied from about 4 to 7 among treatments. Cutting every three weeks (T4) considerably favored non-grass species richness while cutting once after main growing season (T1) was not ideal for non-grass species richness. Non-grass species diversity and evenness significantly ranged from 0.36 for T1 to 0.64 for T3 and from 0.27 for T1 to 0.4 for T3, respectively. Grass species were more diverse and evenly distributed in the study area than the counterpart non-grass species (Table 5 and 6). Likewise, values for species richness, composition, frequency, dried biomass and density were lower for non-grass species than for its corresponding grass species. Non-grass species composition, frequency, density, diversity and evenness were favored by cutting every two weeks while cutting every three weeks favored dried biomass and species richness.

Table 6: Non-grass vegetation structure across treatments (n=12)

Treatments	Species richness	Species composition (%)	Frequency (%)	Non-grass biomass (kg/ha)	Density/ha in '000's	Diversity	Evenness
T1	3.83±0.17[b]	3.08±0.98[a]	43.40±4.58[a]	46.60±12.17[a]	48.75±12.63[a]	0.36±0.08[b]	0.27±0.05[b]
T2	5.33±0.49[ab]	3.14±0.66[a]	42.27±4.49[a]	60.07±11.5[a]	56.76±15.94[a]	0.49±0.06[ab]	0.3±0.04[ab]
T3	5.83±0.98[ab]	4.55±0.84[a]	46.73±4.73[a]	93.8±30.63[a]	152.5±92.19[a]	0.64±0.1[a]	0.4±0.04[a]
T4	7.17±1.17[a]	2.63±0.47[a]	36.93±2.29[a]	100.07±34.45[a]	36.99±7.62[a]	0.55±0.05[ab]	0.29±0.02[ab]
P-value	0.045	0.36	0.45	0.25	0.32	0.03	0.04

Effect of subsequent year's treatments on grass vegetation attributes

Grass species richness was not significantly affected by treatments in 2015 (P>0.05) while it was significantly affected by treatments in 2016 (P<0.05) (Fig 1(a)). Cutting once after the end of main growing season (T1) decreased grass species richness from about 6 in 2015 to 4 in 2016. Cutting every week (T2) reduced grass species richness from about 7 in 2015 to 5 in 2016. Similarly, cutting every two weeks (T3) reduced grass species richness from around 7 in 2015 to about 6 in 2016. Generally, cutting grasses subsequently over years reduced species richness. This result is in agreement with Lopez-Chuken and Lopez-Dominguez (2012) who found that defoliation intensities resulted in the death of grass species by limiting rhizome growth, root-tip degeneration and seed productivity. In the present study, however, subsequent cutting every three weeks (T4) across years did not changed grass species richness (Fig 1(a)).

Grass species frequency, diversity and evenness were not significantly affected by treatments across years (P>0.05) (Fig 4, 6 and 7 (a)). Grass species composition, oven dried biomass, frequency, density, diversity and evenness were not significantly affected by treatments in 2015 (Fig 2-7 (a)). In the contrary, species composition, oven dried biomass and density were significantly affected by treatments in 2016 (P<0.05) (Fig 2, 3 and 5 (a)). This might be due to differences in rainfall, as rainfall is higher in 2016 than in 2015. Higher rainfall in tropical environments promotes rapid growth of grass species, leading to higher seed production and larger seed banks. Grass species composition was significantly the highest when cut once after the end of main growing season and the lowest when cutting was made every two weeksin 2016. Species composition was about two times greater in 2016 than in 2015 when cut once after the end of main growing season. This might be attributed to the higher amount of total rainfall recorded in 2016 than in 2015 (Table 1).

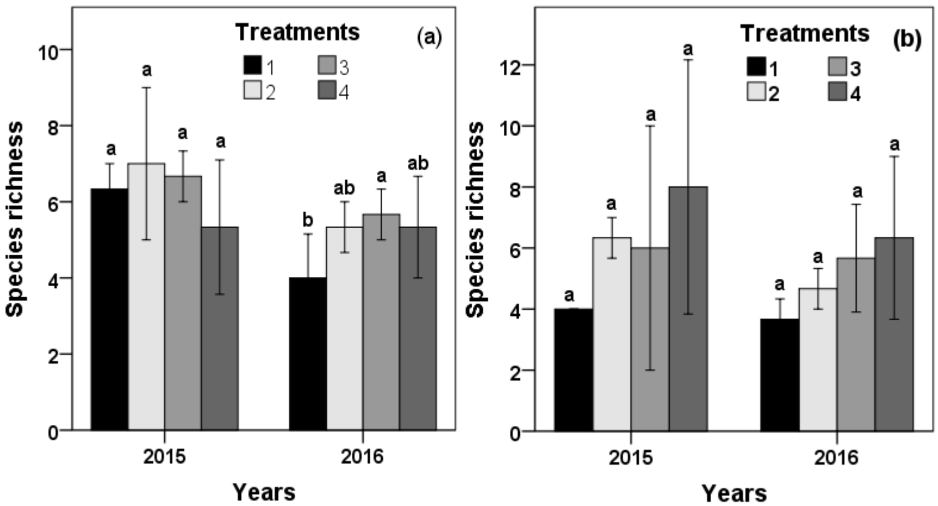

Figure 1. (a) Mean (± standard error) grass species richness (number of different species per plot) for treatments across years. (b) Mean (± standard error) non-grass species richness (number of different species per plot) for treatments across years.

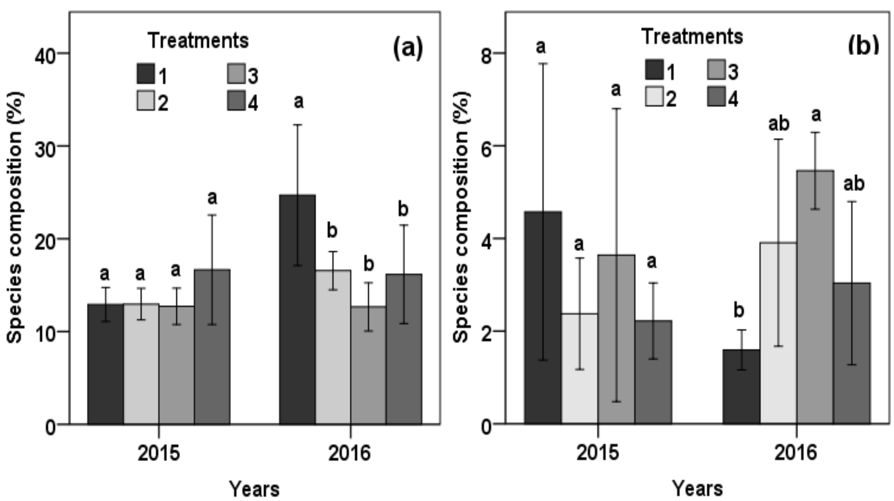

Figure 2. (a) Mean (± standard error) grass species composition (%) for treatments across years. (b) Mean (± standard error) non-grass species composition (%) for treatments across years.

Grass biomass slightly soared for T2, T3 and T4 from 2015 to 2016. Grass biomass considerably increased from about 1 ton/ha in 2015 to about 3 ton/ha in 2016 when cutting was made once after end of main growing season (T1) due to the higher amount of annual rainfall in 2016 than in 2015 (Fig 3 (a)).Frequency increased for T1, T2 and T4 from 2015 to 2016 while decreased for T3 from 2015 to 2016 (Fig 4 (a)). Density considerably increased from 223410 per hectare in 2015 to 412110 per hectare in 2016 for T1 and slightly increased from 236810 per hectare in 2015 to 266670 per hectare in 2016 for T2 while decreased across years from 2015 to 2016 for T3 and T4 (Fig 5 (a)).On the other hand, grass species diversity non-significantly decreased for T1, T2 and T3 from 2015 to 2016, but non-significantly increased for T4 from 2015 to 2016 (Fig 6 (a)). Grass species evenness non-significantly decreased for T2 and T3 and non-significantly increased for T1 and T4 from 2015 to 2016 (Fig7 (a)).

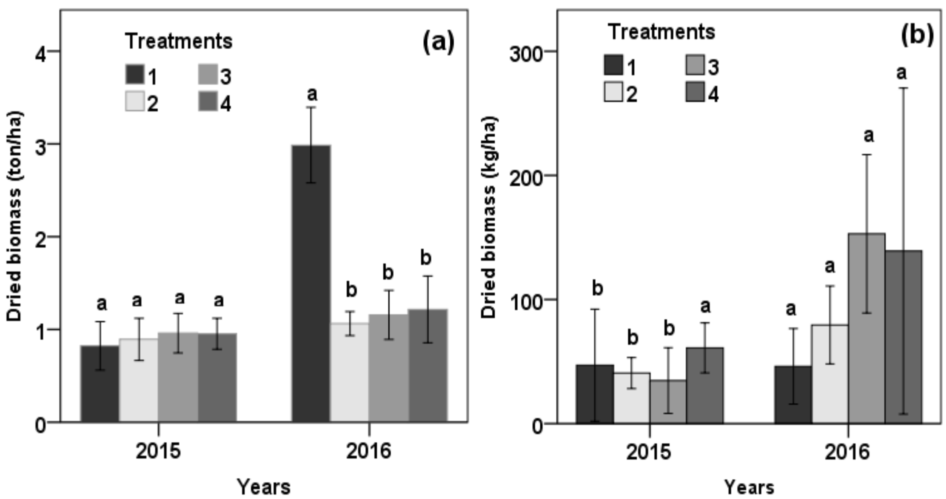

Figure 3. (a) Mean (± standard error) grass species oven dried biomass (ton/ha) for treatments across years. (b) Mean (± standard error) non-grass species oven dried biomass (kg/ha) for treatments across years.

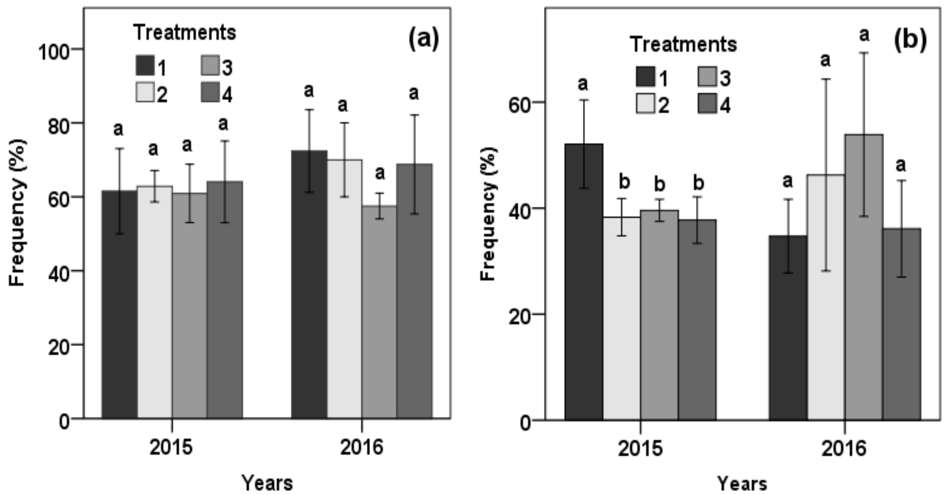

Figure 4. (a) Mean (± standard error) grass species frequency (%) for treatments across years. (b) Mean (± standard error) non-grass species frequency (%) for treatments across years.

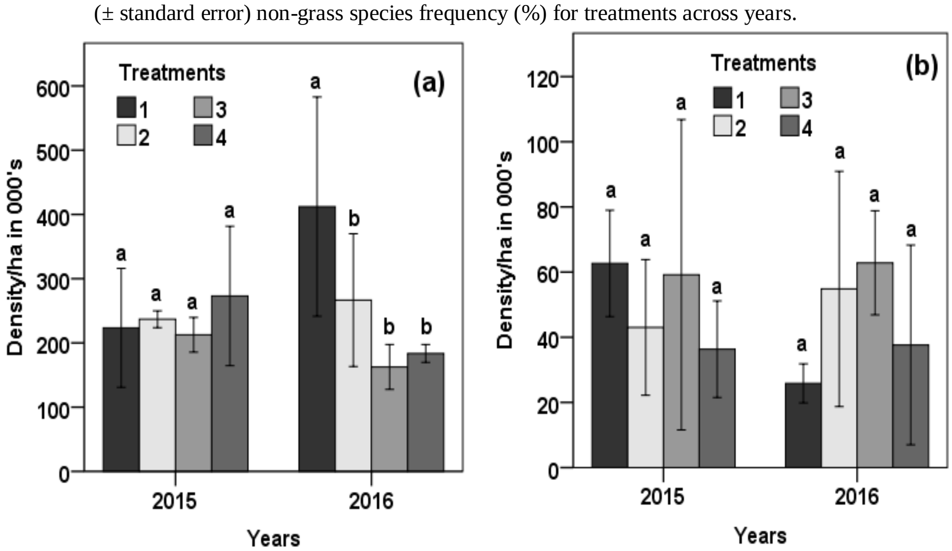

Figure 5. (a) Mean (± standard error) grass species density (number per hectare) for treatments across years. (b) Mean (± standard error) non-grass species density (number per hectare) for treatments across years.

Effect of subsequent year's treatments on non-grass vegetation attributes

Like grass, non-grass species richness was reduced when all the treatments were applied across subsequent years though non-grass species richness was non-significantly affected by treatments in both 2015 and 2016 (Fig1 (b)). Non-grass species richness was relatively the highest for T4 and the lowest for T1 in both years. Non-grass oven dried biomass and frequency were significantly affected by treatments during the first year, but non-significantly affected by the applied treatments during the following year. On the other hand, species composition, diversity and evenness were significantly affected by the applied treatments in 2016 which, however, were non-significantly affected by treatments in 2015 (Fig 2, 6 and 7 (b)). All the last three treatments (T2, T3 and T4) increased non-grass species composition excepting T1 which decreased species composition when applied successively across years (Fig 2 (b)). Likewise, T2, T3 and T4 considerably increased non-grass oven dried biomass while T1 did not change non-grass oven dried biomass when applied subsequently across years (Fig 3 (b)). Grass oven dried biomass was by far greater than the counterpart non-grass oven dried biomass (Fig 3 (a) and (b)).

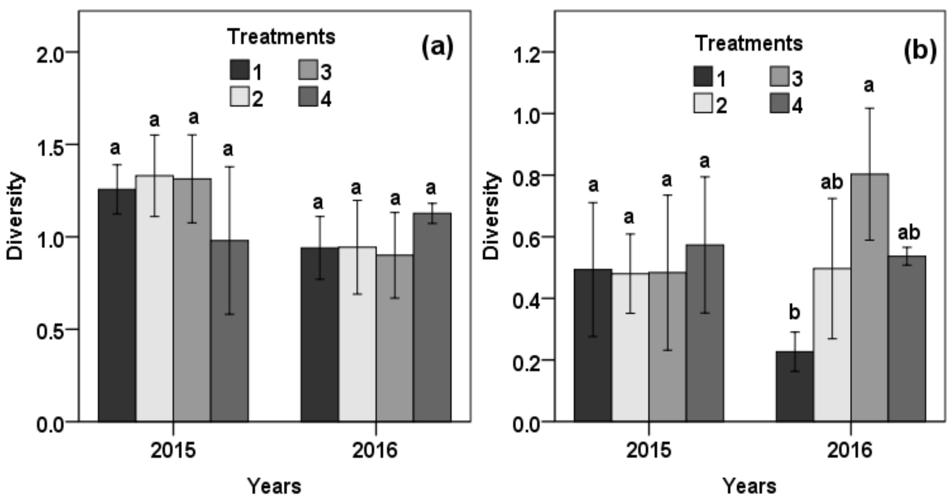

Figure 6. (a) Mean (± standard error) grass species diversity for treatments across years. (b) Mean (± standard error) non-grass species diversity for treatments across years.

Cutting once after end of main growing season (T1) and cutting every three weeks (T4) decreased non-grass species frequency while cutting every week (T2) and cutting every two weeks (T3) increased non-grass species frequency when treatments were applied continually across years (Fig 4 (b)). Non-grass species density decreased when cutting was made once after main growing season while it increased when cutting is made every week (T2), every two weeks (T3) and every three weeks (T4) subsequently across years (Fig 5 (b)). Grass species were more frequently and densely observed in the study area than its counterpart non-grass species (Fig 4 and 5 (a) and (b)). Cutting once after end of main growing season (T1) decreased non-grass species diversity and evenness while T2, T3 and T4 increased both non-grass species diversity and evenness when the treatments are applied consecutively across years (Fig 6 and 7 (b)). Grasses were more diverse and evenly distributed compared to its corresponding non-grasses in the communally enclosed rangeland unit under semi-arid environments of Borana rangelands (Fig 6 and 7 (a) and (b)).

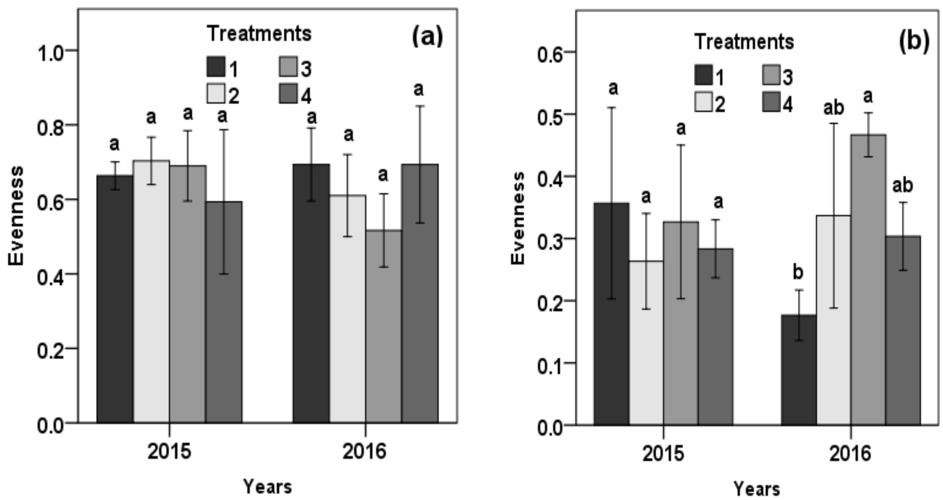

Figure 7. (a) Mean (± standard error) grass species evenness for treatments across years. (b) Mean (± standard error) non-grass species evenness for treatments across years.

Effect of subsequent year's treatments on herbaceous species basal cover and biomass yield

Although it is statistically non-significant, cutting once after main growing season and cutting every three weeks had a positive effect on overall herbaceous vegetation basal cover when applied successively across years (Fig 8 (a)). The increase in the cover of herbaceous vegetation with mowing is similar to results from other studies (Davies*et al.* 2011).In the contrary, cutting every week and every two weeks have a negative effect on overall herbaceous species basal cover when applied subsequently across years though the difference among treatments in both years is not prominent (Fig 8 (a)). A highly significant difference ($P<0.001$) among treatments was noticed for herbaceous species dried biomass only in the second year (Fig 8 (b)). This might be attributed to the effect of successive cutting across years and high amount of rainfall in the second year compared to the first year. All the applied treatments increased the amount of oven dried herbaceous species biomass when applied continually across years (Fig 8 (b)). The increment of herbaceous biomass across years for all treatments is due to the increment in the amount of rainfall from the first year to the second year (Table 1).This finding is in agreement with Davies *et al* (2012) who found that forage biomass production was approximately doubled by the second year after mowing.

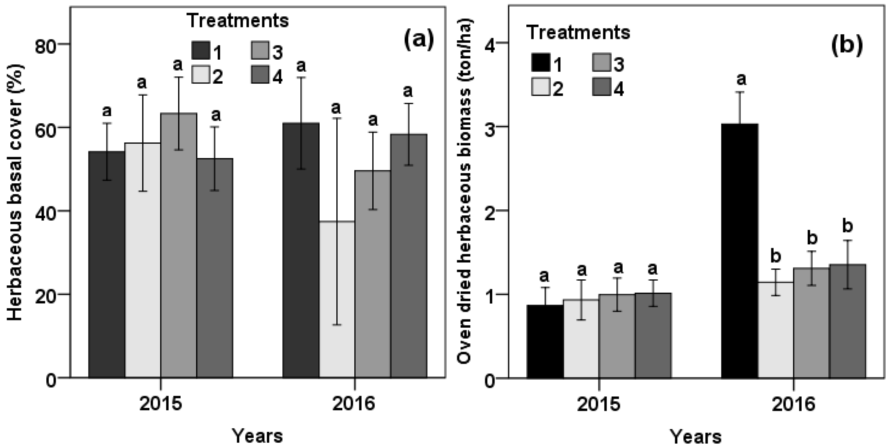

Figure 8. (a) Mean (± standard error) herbaceous species basal cover (%) for treatments across years. (b) Mean (± standard error) herbaceous species oven dried biomass (ton/ha) for treatments across years.

Nutritive value of grass and non-grass species across treatments

Grass DM and OM percentages significantly (P<0.01) ranged from 91.57% and 89.77% for T1 to 92.85 % and 86.05 % for T2, respectively (Table 8). Similarly, NDF, ADF, ADL were highly significantly (P<0.01) the lowest for T2 and highly significantly the highest for T1. In the contrary, ash, CP and TIVOMD were highly significantly ranged from 10.23%, 3.25% and 39.01% for T1 to 13.95%, 14.44% and 66.8% for T2, respectively. The highest percentage of CP, Ash and TIVOMD for grasses was found with the more frequent cutting which is in agreement with Lopez-Chuken and Lopez-Dominguez (2012) who indicated that the highest percentage of CP and ash for *Cenchrus ciliaris* was attained for more frequent and severe defoliation. In comparison, values for percentages DM,OM, NDF, ADF, ADL and TIVOMD yields were higher for grasses compared to the corresponding non-grass species (Table 7 and 8).

Non-grass DM percentage was the highest for T1 and the lowest for T3. Likewise, OM percentage was highly significantly (P<0.01) the highest for T1 and the lowest for T3 (Table 9). Percentage CP and TIVOMD were significantly ranged from 11.94 to 18.01 for T1 and from 70.71 to 80.46 for T2. Non-grass ash percentage highly significantly ranged from as low as 13.96 for T1 to as high as 19.18 for T3. Non-grass species ADF and NDF percentages were not significantly (P>0.05) affected by the applied treatments while ADL percentage was significantly (P<0.05) affected by the applied cutting frequencies (Table 8). Percentage values for ash, CP and TIVOMD were comparatively higher for non-grass species than the counterpart grass species.

Table 7: Chemical composition of grass species

Treatments	DM (%)	Ash (%)	OM (%)	N (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	TIVOMD (%)
T1	92.85±0.01[a]	10.23±0.78[b]	89.77±0.78[a]	0.52±0.01[d]	3.25±0.06[d]	76.53±1.03[a]	50.42±1.15[a]	8.93±0.24[a]	39.01±0.55[c]
T2	91.57±0.15[b]	13.95±0.31[a]	86.05±0.31[b]	2.31±0.11[a]	14.44±0.67[a]	67.79±0.47[c]	38.83±1.11[c]	5.83±0.1[b]	66.80±3.5[a]
T3	91.93±0.22[b]	12.62±0.06[a]	87.38±0.06[b]	1.89±0.11[b]	11.81±0.67[b]	72.70±0.71[b]	43.20±0.68[b]	5.91±0.14[b]	61.13±2.14[a]
T4	91.99±0.1[b]	12.91±0.2[a]	87.09±0.2[b]	1.50±0.09[c]	9.36±0.56[c]	70.45±0.94[bc]	44.35±0.6[b]	6.24±0.22[b]	53.96±1.24[b]
P value	0.001	0.002	0.002	0.0001	0.0001	0.0004	0.0002	0.0001	0.0001

Table 8: Chemical composition of non-grass species

Treatments	DM (%)	Ash (%)	OM (%)	N (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	TIVOMD (%)
T1	89.73±0.55[a]	13.96±1.42[b]	86.04±0.78[a]	1.91±0.08[c]	11.94±0.48[c]	55.07±1.69[a]	34.86±0.96[a]	6.14±0.95[a]	70.71±1.59[b]
T2	89.03±0.13[a]	17.78±0.31[a]	82.22±0.58[b]	2.88±0.1[a]	18.01±0.61[a]	53.06±1[a]	31.33±2.28[a]	4.17±0.11[b]	80.46±1.24[a]
T3	88.97±0.1[a]	19.18±0.06[a]	80.82±0.53[b]	2.65±0.01[ab]	16.59±0.05[ab]	52.76±1.1[a]	32.38±1.95[a]	4.27±0.31[b]	75.36±2.63[ab]
T4	89.19±0.42[a]	18.24±0.2[a]	81.76±0.12[b]	2.51±0.1[b]	15.67±0.63[b]	52.59±1.6[a]	32.9±2.13[a]	3.95±0.5[b]	75.07±3.06[ab]
P value	0.22	0.009	0.009	0.0002	0.0002	0.57	0.63	0.03	0.04

Conclusion and recommendations

Overall herbaceous vegetation species biomass yield, composition, frequency, density and basal cover were higher for cutting made once after the end of main growing season (T1) than other treatments. Cutting both grasses and non-grasses subsequently over years reduced species richness. However, grass species richness was not changed when subsequently cut every three weeks (T4) across years. Grass species oven dried biomass was by far greater than the counterpart non-grass. Cutting once after main growing season (T1) and cutting every three weeks (T4) had a positive effect on overall herbaceous vegetation basal cover when applied successively across years. Cutting once after the end of main growing season (T1) enhanced percentages of DM, NDF, ADF and ADL for both grass and non-grass species. Cutting every week (T2) favored percentage crude protein and TIVOMD for both grass and non-grass species.

For short-term rangeland management, cutting once after main growing season per year can be recommended because of the high yield in herbaceous species composition, dried biomass, basal cover and density. However, the long term effects of this treatment need to be assessed. Cutting herbaceous species every week favored ash, CP and TIVOMD percentages while cutting once at the end of main growing season favored herbaceous species DM, NDF, ADF and ADL percentages.

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Adaptation Trial of Desho Grass for Fodder Production at Mechara, Eastern Oromia

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Abstract

The experiment was undertaken at Mechara Agricultural Research Center (McRAC) of on-station site for two consecutive years. The aim of the study was to identify the best adaptable and high biomass yielder of Desho grass (Pennisetum pedicellatum) lines for fodder production in study area. Four Desho grasses lines were evaluated in Randomized Complete Block Design (RCBD) with three replications. The result revealed that regeneration percentage, plot cover, vigor and leaf to stem ratio were not shown significant difference (P>0.05) between Desho grass lines. However, plant height and dry matter (DM) yield were differ significantly (P<0.05) between four Desho grass lines. The highest DM yield were produced from Areka-DZF # 590 (28.74t/ha) and Kulumsa-DZF#592 (26.14t/ha) lines. The value of leaf to stem ratio were 0.71 and 0.66 respectively for Areka-DZF # 590 and Kulumsa-DZF#592 lines. Therefore, based on the result, Areka-DZF#590 and Kulumsa-DZF-#592 lines were well adapted and performed under Mechara condition. These selected Desho grass lines should be further demonstrated and scaled-up at Mechara on-farm condition and similar agro-ecologies of Hararghe areas

Key Words: *Desho grass, Dry matter yield, Leaf to stem ratio, Lines.*

Introduction

Despite its large number of population (CSA, 2016), the production and productivity of livestock in Ethiopia is low. The major setback is shortage in quantity and quality of feed resources (Tegegne and Assefa, 2010; Yayneshet, 2010). To combat existing livestock nutritional constraints, the use of locally available forage plants as feed resources is highly recommended as they are familiar to smallholder farmers, grow with low inputs and are adaptable to local agro-ecological conditions (Anele *et al*., 2009)

Desho grass ***(****Pennisetum pedicellatum)* is among the indigenous grass of Ethiopia belonging to the Poaceae family of monocot angiosperm plants. The grass is native to tropical and sub-tropical Africa and tropical Asia (FAO, 2010). It grows in its native geographic location, naturally spreading across the escarpment of the Ethiopian highlands (Smith, 2010). Desho grass is used for multiple purposes in Ethiopia. Desho grass is used as a year round livestock fodder. It is a very palatable species to cattle and sheep (Ecocrop, 2010). It is mainly grown on small home plots used for livestock fodder, soil conservation practices, and sold for income generation as small business opportunity mostly for high land Ethiopian farmers (IPMS 2010; Shiferaw *et al*. 2011; Leta *et al.*, 2013). To maintain the sustainability of the intervention, the plot is permanently made inaccessible to free grazing livestock; instead a cut-and-carry system is encouraged (Danano, 2007). Due to its rapid growth rate, Desho grass provides regular harvests, even reaching monthly cuts during the rainy reason. Once a year, just before the dry season, sufficient grass is harvested and stored as hay and can prepared as silage to feed the livestock until the rains return (Danano, 2007).

Ethiopian Ministry of Agriculture and Rural Development was documented planting of Desho grass as an example of a locally tried and tested land management technique as a successful to mitigate land degradation (Bimrew *et al*, 2017). On the other hands, very little work has been done in collection and conservation of indigenous forage species, which have invaluable importance in the livelihood of the farmers. In west Hararghe, livestock serve as source of milk, meat production, draft power and income generation (Abdi *et al.*, 2013).

The Hararghe beef cattle locally called 'Harare Sanga' is very famous in domestic markets of larger cities like Addis Ababa (Estefanos *et al.*, 2014). However, there was only seasonal based access for zonal and terminal market due to feed scarce and less market oriented production system (Birmaduma, 2018). Milk marketing is the daily income for livelihood in Hararghe farmer next to 'chat' *(*Abdi *et al., 2013).* Due to feed scarcity and fluctuation, milk availed form market is seasonal and the price of the milk is highly fluctuated (personal observation) in West Hararghe. Therefore, adequate quantity and quality of feed resource is crucial for animal production in mostly dairy and beef cattle**.** Hence, introduction of high yielding and nutritious indigenous forage species like Desho grass is the notable issue to minimize feed shortage in both quality and quantity especially during dry season. Therefore, the study was intended to identify the best adaptable and high biomass yielder of Desho lines for fodder production in study area.

Materials and Methods

Description of study area

The study was conducted in Mechara Agricultural Research Center (McARC) on-station site during 2015– 2017 cropping season for two years. McRAC found 40° 19’ latitude and 08° 35’ E longitude with an altitude of 1,700 meters above sea level. It has located at 434 km east of Addis Ababa in Dara Labu District, West Hararghe zone of Oromia. The major soil type of the center is sandy loam with reddish color. The ambient temperature of the area ranges from 14 to 26ºC with the average of 16ºC with average annual rainfall of 96 mm/year (McARC, 2017).

Experimental materials and Design

Four indigenous collected Desho lines Areka-DZF#590, Kulumsa-DZF#592, KK2-DZF-589 and KK1-DZF#591 were collected from Debre Zeit Agricultural Research Center and evaluated in

RCBD with three replication. The plot size used for experiment was 10.5 m^2. The spacing of 40, 50 and 75 cm were used respectively between rows plots and replication. Desho grass was planted using vegetative root splits in 8 rows on a well prepared soil. The spacing between rows and plants were 40 and 15 cm, respectively. Weeding and related management practices were applied according to the grass's requirements. urea was applied during the establishment.

Data collection: Data on regeneration percentage, plot cover, stand vigor, leaf to stem ratio and herbage yield were collected.

Statistical analysis

All data was analyzed with General Linear Model (GLM) procedure of SAS version 9.0. The mean separation was carried out using least significance difference (LSD) at 5% probability level. The statistical model for the analysis data was:

$$\mathbf{Yijk = \mu + Aj + Bi + eijk}$$

Where; Yijk= response of variable under examination

μ = over all mean

Aj = the jth factor effect of treatment/ lines

Bi = the ith factor effect of block/ replication

eijk = the random error

Results and Discussions

Performance of Desho grass lines

The agronomic and biomass yield performance of Desho grass lines are presented in table 1. The result revealed that the agronomic performance of regeneration percentage, plot cover, plant vigor, leaf to stem ratio were not shown significance difference ($P>0.05$) between Desho grass line. However, plant height and dry matter yield were differ significantly ($P<0.05$) between Desho grass lines. High mean of regeneration percentage (97.92 %) was recorded from Desho grass lines due to good management at the establishment and after cuttings. The climate condition and soil type might also contribute for the high regeneration percentage recorded for the tested Desho lines.

The mean value recorded for plot cover of Desho lines was 95.38 %. Numerically higher plot cover were produced from Areka-DZF # 590 (96.3%) followed by Kulumsa-DZF #592 (96.2%) lines. The lowest plot cover value (93.4%) was obtained from KK2-DZF # 589 line. This finding was comparable with the report of Tekalegn *et al*. (2017) who indicated that plot cover values of (95.8%) and (99.2%) respectively for Areka-DZF # 590 and Kulumsa-DZF #592 lines at Wondogenet Agricultural Research Center, Southern Ethiopia. This indicate that the ability of Desho grass adaptability at different environments and soil type due to Desho grass is indigenous forage species for Ethiopia.

Numerically the highest plant vigor percent were recorded from Kulumsa-DZF #592 (93.67%) and Areka-DZF # 590 (91.7 %) of Desho grass lines. This finding also comparable with Tekalegn *et al*. (2017) who report plant vigor of 98.3 and 96.3 % respectively for Kulumsa-DZF #592 and Areka-DZF # 590 Desho grass lines

Plant height is an important parameter contributing to yield in forage crops (Tessema *et al.*, 2002). The result revealed that plant height performance were significantly (P <0.05) differ among Desho grass line considered in this experiment. The line Areka-DZF # 590 (92.67 cm) and KK1-DZF # 591 (92.6 cm) had higher plant height where as KK2-DZF # 589 (71.27 cm) was shown lowest plant height. This finding was comparable with Bimrew *et al*. (2017) who reported mean values of 94 cm and 87 cm for plant height of Desho lines respectively at mid and high land altitude of northern Ethiopia. The plant height performance of Desho grass also evaluated with respect to cutting/ harvesting time. The first harvest produced the higher mean plant height than the second harvest (Fig 1)

Accordingly plant height values of 47.33, 48.00, 48.67 and 42cm during the first harvest and 45.4, 44.6, 45 cm and 29.27 cm at the second harvest were produced from Areka-DZF # 590, KK1-DZF # 591, Kulumsa-DZF #592 and KK2-DZF # 589 Desho grass lines, respectively.

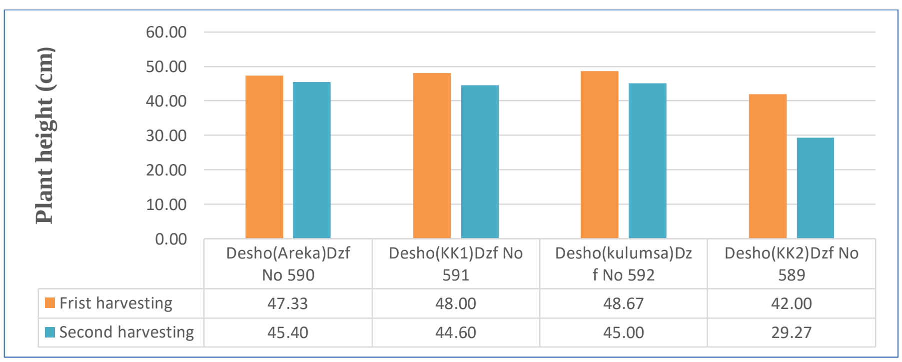

Fig 1. Plant height (cm) of Desho grass lines

The result showed that there was no significant difference (P>0.05) among the Desho grass lines on leaf to steam ratio. However, numerically the higher values of leaf to stem ratio were produced by Areka-DZF # 590 (0.71) followed by Kulumsa-DZF #592 (0.66) lines, The lowest leaf to steam ratio was observed form KK2-DZF # 589 (0.51) of Desho line. The leaf to stem ratio value recorded for Areka-DZF # 590 Desho line was comparable to the mean value of LSR (0.72) of Desho grasses reported by Tekalegn *et al.* (2017). However, the result of current study was below the finding of Bimrew (2016) who reported LSR of 1.25, 1.18 and 0.8 at harvesting dates of 90, 120 and 150 respective. The difference in LSR recorded might be due to the difference in stage of maturity to harvest.

The analysis of variance for dry matter yield indicated a significantly difference ($P<0.01$) values between considered Desho grass lines The highest DM yield values of Desho grass lines were produced from Areka-DZF # 590 (28.74t/ha) followed by Kulumsa-DZF #592 (26.14 t/ha) . Whereas the lowest DM yield (20.31 t/ha) was observed from KK2-DZF # 589 line. The DM yield recorded in current study was better than finding of Bimrew at al. (2017) who reported mean DM yield of 16.84 and 14.62 t/ha respectively at mid and high land agro-ecologies of Northern Ethiopia. The variation in DM yield might be due to soil type, stage of harvesting and management system.

Dry matter yield produced during different harvest were also compared among the tested Desho line. Accordingly, the mean DM yield of 28.74,23.59,26.98 and 20.31 t/ha were recorded at the first harvest while DM yield of 30.52,28.62,30.98 and 23.2 were produced at the second harvest from Areka-DZF # 590, KK1-DZF # 591, Kulumsa-DZF #592 and KK2-DZF # 589 Desho grass lines, respectively (fig 2). The current finding was in line withTekalegn *et al.* (2017) who reported dry matter yield of 30.3 , 28.43 and 30.9 t/ha respectively for Areka-DZF # 590, KK1-DZF # 591 and Kulumsa-DZF #592 at Wondogenet Agricultural Research Center Southern Ethiopia. However, Genet *et al.* (2017) reported the lower dry matter yield than current finding due to different days of harvesting This difference might be due to the difference in Desho lines, agro-ecology and stage of harvesting.

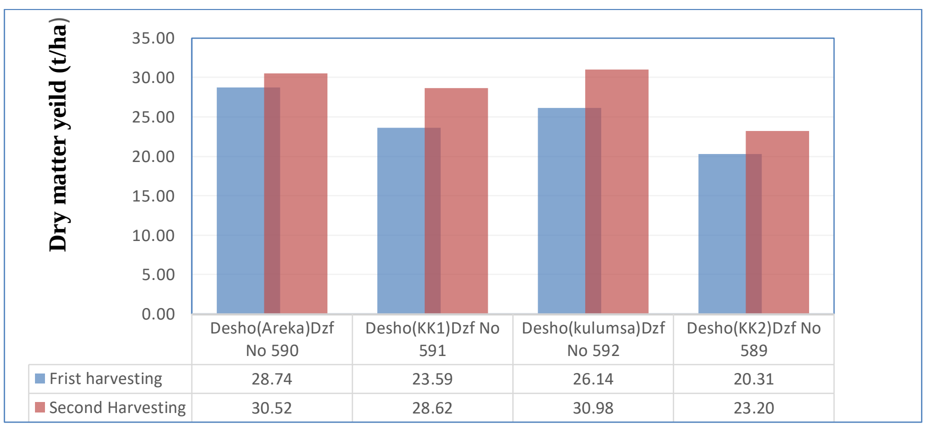

Fig 3. Dry matter yield (t/ha) of Desho grass lines

Table 1: Performance of Desho grass lines at Mechara on station

Treatment /Accessions	R (%)	PC (%)	PV (%)	PH(cm)	LSR	DMY (t/ha)
Areka-DZF # 590	98	96.3	91.67	92.73[a]	0.71	28.74[a]
KK1-DZF # 591	97.83	95	90.33	92.6[a]	0.59	23.59[b]
Kulumsa-DZF #592	98.67	96.23	93.6	93.67[a]	0.66	26.14[ab]
KK2-DZF # 589	97.17	93.9	90.67	71.27b	0.51	20.31[c]
Mean	97.92	95.38	91.6	87.6	0.62	24.69
CV	0.62	1.0	1.76	9.0	14.8	5.2
LSD (5%)	1.21	1.85	3.22	15.76	0.18	2.557
Sig.	Ns	Ns	Ns	*	Ns	**

R (%) = Regeneration percentage, PC (%) = plot cover, PV (%) = Plant Vigor, PH (cm) = Plant Height in cent meter, LSR= Leaf to stem ratio, DMY= Dry matter yield in ton per hectare

Conclusions and Recommendation

The results revealed that there were not significant differences (P>0.05) in regeneration percentage, plot cover, vigor and leaf to stem ratio between Desho grass lines. However, plant height and dry matter yield were revealed significance difference (P<0.05) between Desho grass lines. Among the evaluated Desho lines, Areka-DZF#590 and Kulumsa-DZF#592 were performed best mainly in dry matter yield.. *Therefore, based on the result, Areka-DZF#590 and Kulumsa-DZF-#592 lines were well adapted and performed under Mechara condition. These selected Desho grass lines should be further demonstrated and scaled-up at Mechara on-farm condition and similar agro-ecologies of Hararghe areas*

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Effect of seeding rate and row spacing on yield performance of fodder oat (Avena sativa) grown at mid-altitude of western Oromia

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Abstract

Fodder oat is amongst the most important forage crop cultivated in different areas of the country. It is a fast growing, palatable, succulent and nutritious fodder crop. In this frame, two year field study was carried at Bako agricultural research center during the 2014-2016 cropping season. The objective of the study was to evaluate the effects of seeding rates and row spacing on the yield performance of fodder oat (Avena sativa) cultivar under the agro-ecology of Western Oromia. Traits evaluated were; herbage dry matter (DM) yield, plant height, panicle length and seed yield. The experimental layout was factorial arrangement in randomized complete block design with three replications. Results from analysis of variance indicate that, of the total sources of variation, the row spacing had the greatest effect on herbage DM yield explaining 13.63 of the total variation. However, plant height, panicle length and seed yield were affected more due to blocking explaining 316.91, 70.32 and 146.39 of the total variation, respectively. Seeding rate and row spacing showed significant effect on herbage DM and seed yield, but did not affected the plant height and panicle length. Similarly, the interaction of seeding rate and row spacing was also significant only for herbage DM and seed yield. The highest herbage DM yield was recorded at 20 cm row spacing with 80 kg/ha seeding. Whereas, higher seed yield was gained when growing oat at 30 cm row spacing with 70 kg/ha seeding and thus, can be recommended for herbage and seed production, respectively.

Key words: fodder oat, herbage yield, seed yield

Introduction

Livestock is an integral part of the farming system in Ethiopia. The success and prosperity of livestock farming is mainly determined by adequate and timely availability of feed. The scarcity of quality forage and grazing resources in the country has made the livestock to suffer continuously with malnutrition resulting in their production potential at sub optimum level as compared to other countries (Adugna *et al.,* 2000). Therefore, a significant proportion of livestock is underfed. On the other hand, the continued and long term feeding with poor quality results in malnutrition in animal (Adane and Girma, 2008). Therefore, to conquer the feed scarcity in the country, utilization of low cost feed technologies that are easy and available within the limit of the resources poor farmers has paramount importance. With this view, introduction, evaluation and dissemination of different improved forage species have been carried so far in different parts of Ethiopia including Western Oromia.

One of such potential forage species for integration in to the existing livestock feeding system is annual fodder oat (*Avena sativa*), which is a well adapted fodder crops mainly in altitude range from 1700-3000 m.a.s.l. with 500-800 mm mean annual rainfall (Mengistu, 2008). It is an erect annual fodder crop up to 1.5m tall. . Normally implied in agriculture, cropping is human manipulation of the system (Onwueme and Singh, 1991). This implies that high performance or productivity of any crop not only as a result of its genetic potential but also needs skill full management stride from farmers. Routine cropping practice beginning with initial site selection until harvesting requires a wise planning of the activities, out of which the plant spacing and seeding rates are determinant factors among other yield influencing one (Tarawali *et al.,* 1995). Seeding rates as well as the row spacing is considered an important factor to optimize plant population as the establishment of an adequate and uniform crop stand is critical to achieve high yield. Therefore, it is of crucially important to manipulate the level of seeding rate and row spacing in order to increase crop productivity.

Although one variety of fodder oat was released by Bako agricultural research center for Bako and similar agro-ecologies, the optimum seeding rate and row spacing required for the maximum yield performance has not been identified yet. Therefore, there was a strong need of undertaking further evaluation of this promising tropical forage crop in terms of its yield response at varied seeding rate and row spacing. Hence, based on this background the experiment was carried out to establish the optimum seeding rate and row spacing for production of fodder oat (*Avena sativa*) variety under Bako condition.

Materials and methods

Description of the study area

The study was conducted at Bako Agricultural Research Center (BARC) from 2014 to 2016 cropping seasons. The center is administratively located at Gobu Seyo district of East Wollega zone of Oromia Regional State at a distance of 250 km west of the capital city on the way to Nekemte town. The location represents mid-altitude sub-humid maize growing agro-ecology of Ethiopia. Bako is situated at latitude and longitude of 9°06'N and 37°09'E, respectively, and it lies at an altitude of 1650 m above sea level with a mean monthly minimum and maximum temperatures of 11.23^{0}C and 31.74^{0}C, respectively. During the study period, the area receives an annual rainfall of about 1316.7 mm where the highest rain was received between May and September. About 60% of the soil of BARC is reddish brown in color and clay-loam in texture (Wakene, 2001).

Experimental layout, design and treatment

One outstanding variety of fodder oat (Bate), which was recently released as a new variety was used for the study. The experiment was a laid out in factorial arrangement of treatment in a randomized complete block design with three replications. Factor 1, was the seeding rate consisted of three seeding proportions (i,e 60, 70 and 80 kg/ha) and whereas, the second factor consisted of three level of row spacing (I,e 20, 25 and 30 cm). In all, a total of 27 plots of 3x2m was established out and demarcated with a spacing of 1.5m between each plot and 2m between blocks. Seed of fodder oat was drilled in row as per the treatment arrangement on early august during the two experimental years.. Except seeding rate and row spacing, which varied as per the treatment, other agronomic practices were kept uniform to all experimental plots.

Data collection

In order to estimate fresh biomass yield, two adjacent rows from the center of each plot were taken when oats were at dough stage (Akililu and Alemayehu, 2007) but the rest middle rows were left uncut for seed yield records. The harvested biomass was manually chopped into small pieces using sickle and a subsample of 200gm fresh weight were taken and dried at 65^{o}C to consistent weight for 72 hrs in an oven for herbage dry matter (DM) yield determination. Estimation of seed yield was made from the remaining uncut middle rows.

At herbage harvest for dry matter yield determination, randomly ten plants were selected from each plot to record plant height and panicle length agronomic traits. Plant height was determined by measuring the height of randomly selected plants from ground level to the tip of the main stem. Similarly, panicle length was also taken by measuring the length of panicle from the base to the tips of the panicle. Then, the average value of plant height and panicle length taken from the ten plants was used.

Statistical analyses

The data was subjected to ANOVA using GLM Procedure of SAS (SAS, 2002, version 9.1.3) software. Seeding rates, row spacing and their interaction were considered as independent variables in the model for yield and yield components estimation. Least significant difference at 5% level of significance was used for comparison of means when treatment effect is significant. The model fitted for the data analysis is shown as:

$$\mathbf{Yijk = \mu + Si + Rj + Bk + (Si*Rj) + Eijk,}$$

Where; Yijk = response variable; μ = overall mean effect; Si = seeding rate effect; Rj= row spacing effects; Bk = block effect; Si*Rj= seeding rate and row spacing interaction effect; Eijk = random error

Results and Discussion

Analysis of variance (ANOVA)

Analysis of variance for herbage DM yield, plant height, panicle length and seed yield are presented in Table 1. The row spacing had the greatest effect on herbage DM yield explaining 13.63 of the total variation. Following this variable, seeding rate was the largest sources of variation or herbage DM yield, explained 12.31 of the total variation. For plant height, panicle length and seed yield, block effects was more important than seeding rate and row spacing effects explaining 316.91, 70.32 and 146.39 of total variance respectively. On the other hand, interaction effects of seeding rate with row spacing had shown significant effects on herbage DM yield and seed yield, but not for plant height and panicle length. This indicates that varying the row spacing for varied seeding rate becomes important for higher herbage DM and seed yield than plant height and panicle length.

Table 1: Proportion of variance explained and statistical significance from ANOVA for herbage dry matter yield, plant height, panicle length and seed yield

Sources of variation	Parameters measured			
	DMY	Pht	PL	SY
Block	3.51	316.91	70.32	146.39
SR	12.31***	278.91	8.84	70.96*
RS	13.63***	217.46	5.36	76.67*
SR*RS	8.17***	89.07	4.80	125.26**

Note: *** ($P<0.001$); ** ($P<0.01$); * ($P<0.05$) SR= seeding rate; RS= row spacing; SR*RS= interaction of seeding rate with row spacing; DMY= dry matter yield; Pht= plant height; PL= panicle length; SY= seed yield

Seeding rates

The effects of seeding rate was significant on the herbage DM and seed yield ($P<0.05$), while no significant effect was observed for plant height and panicle length ($P>0.05$) measurements. The higher herbage dry matter yield (5.07 t/ha) was observed at 80 kg/ha seeding rates and followed by 70 kg/ha and 60 kg/ha in their respective order. In contrary to this, seed yield was higher at the lower seed rates (60 kg/ha) followed by 70 kg/ha=80 kg/ha seed rate.

Row spacing

Similar to the seeding rates, the effects of row spacing was also significant on the herbage DM and seed yield (P<0.05), but not for plant height and panicle length (P>0.05). Herbage DM yield was higher when oat was sown at narrower spacing (20 cm) than the relatively wider spacing used in the current study. However, seed yield was found higher at the relatively wider row spacing (30 cm) than the other tested row spacing.

Seeding rate and row spacing interaction

Herbage dry matter yield

A trend of difference in the herbage DM yield due to interaction between seed rate and row spacing was recorded to be more prominent due to different row spacing interaction with the highest seed rate (80 kg/ha). Herbage DM yield increased with increasing seeding rates under the 20 and 30 cm row spacing and was relatively greatest at the highest seeding rate (80 kg/ha) in the case of both row spacing. Whereas, under 25 cm row spacing, herbage DM yield was initially increased from 3.89 t/ha at the lower seeding rate (60 kg/ha) to a maximum of 4.05 t/ha at the medium seeding rate then declined to 3.85 t/ha at the highest seeding rates (80 kg/ha).

The study result revealed that, the herbage DM yield was getting improved by 52.1 and 26.6 % when the seeding rate increased from 60 to 80 kg/ha under 20 and 30 cm row spacing respectively. This suggests that, growing of fodder oat at narrower row spacing (20 cm) and higher seed rates (80 kg/ha) is the best combination and produces more than 50% herbage DM yield than the remaining combinations. The higher herbage DM yield obtained from the lower row spacing (20 cm) than the wider one (30 cm), at 80 kg/h seed rate might be attributed to the fact that, at the relatively wider row spacing, each row would receive a higher number of seeds increasing the number of plants per row. Hence, the intra-row plants would suffer from increasing plant to plant competition during the early plant establishment stage and this could have explained the lower dry matter yield in wider row spacing than the narrower spacing.

Table 2: Mean herbage DM yield of fodder oat as affected by the interaction of seeding rates and row spacing

SR (kg/h)	Raw spacing (cm)			Mean	SEM
	20	25	30		
60	3.62^{b}	3.89^{b}	2.79^{b}	3.4	0.6
70	4.26^{b}	4.05^{b}	3.76^{b}	4.0	
80	7.55^{a}	3.85^{b}	3.80^{b}	5.1	

[a,b,c,d] Means within a row with different superscripts differ significantly (P < 0.05); SEM (Mean ± SE) = standard error of means; SR= seeding rate

In agreement with the present study finding, Moyer *et al.*, (2002) stated that, crops seeded in narrow rows often yield more and compete more favorably with weeds than crops grown in wide rows. Moreover, this might also resulted due to the better light interception and decreased inter-row competition between plants (De Bruin and Pederson, 2008). The higher herbage DM yield obtained at narrower row in the current study also agrees with a study with sorghum crops reported by Snider *et al.* (2012). The author found that, higher biomass production of sorghum crop with a narrower row spacing of 19 cm.

Seed yield

Results showed that the effects of seeding rate and row spacing interaction on seed yield were also found to be significant (P<0.05). Such a case indicates the interactions of seeding rate and row spacing. The highest seed yield (26.09 Q/ha) was observed when fodder oat grew at a medium seeding rate (70 kg/ha) and wider row spacing (30 cm), showing that seed yield can be managed by increasing the row spacing with moderate seeding rates. This significant superiority might be related to optimum plant density that can efficiently use the available growth factors (Aravind, 2011). Whereas, the lowest seed yield was recorded when growing oat at 80 kg/ha and 25 cm row spacing. However, other interactions produced almost comparable and intermediate seed yield per hectare.

Table 3: Mean seed yield of fodder oat as affected by the interaction of seeding rates and row spacing

SR (kg/h)	Raw spacing (cm)			Mean	SEM
	20	25	30		
60	15.66^{bc}	12.74^{c}	14.12^{bc}	14.2	1.84
70	13.41^{bc}	13.97^{bc}	26.09^{a}	17.8	
80	17.87^{bc}	18.00^{b}	16.17^{bc}	17.3	

[a,b,c,d] Means within a row with different superscripts differ significantly (P < 0.05); SEM (Mean ± SE) = standard error of means; SR= seeding rate

In disagreement to the result obtained in the current study, highest seed yield at narrower row spacing than relatively wider row spacing from spring canola (Brassica napus L.) cultivar was reported by Yazdifar and Ramea (2009). This variation might be attributed to the variation in the nature of the crop used in the study. The graphical presentation of herbage DM yield and seed yield across experimental years is shown in Fig 1 below.

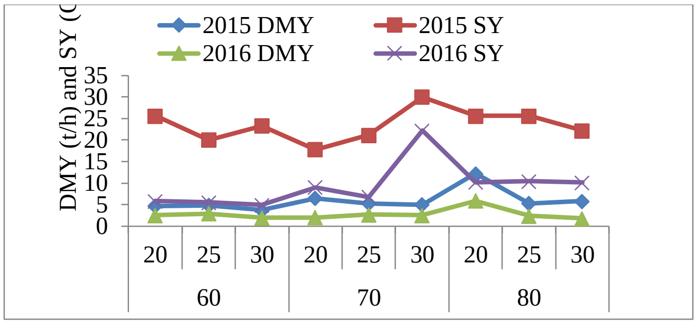

Fig 1: herbage dry matter and seed yield trends of fodder oat as affected by interaction of seeding rate and row spacing over experimental years

In general, the trend of herbage DM and seed yield across the two experimental years (Figure 1) showed that, herbage DM and seed yield of fodder oat was significantly influenced by seeding rate and row spacing. Despite their difference in magnitude between the two experimental years, which in turn attributed to the favorable whether condition for growth in 2015 than 2016, higher herbage DM yield was recorded when fodder oat was sown at a rate of 80 kg/ha with 20 cm row spacing. Whereas, seed yield was higher at 70 kg/ha with 30 cm row spacing.

Conclusion and Recommendation

On the basis of two years field study, the herbage dry matter yield and other yield traits considered for fodder oat was significantly varied with seeding rate and row spacing under investigation. Seeding rate, row spacing and their interaction showed significant effect only on herbage dry matter and seed yield attributes, but did not influenced the plant height and panicle length. Generally, results from interaction effect indicates that, the higher herbage dry matter yield was obtained when growing oat at 80 kg/ha and 20 cm row spacing whereas, higher seed yield was resulted at 70 kg/ha and 30 cm row spacing. Hence, it is logical to recommend the establishment of fodder oat at 20 cm row spacing with 80 kg/ha seeding for herbage production while row spacing of 30 cm with seeding rate of 70 kg/ha will be used if the target is seed production.

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Evaluation of Maize-Intercropped with Forage Legumes under Different Planting Patterns on Yield and Yield Components of Maize and Fodder in West Hararghe, Oromia

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Abstract

Intercropping is the main activity of the farmers in Hararghe Zones mainly due to land shortage. The study was conducted for two consecutive years (2015/16 to 2016/17) at Mechara Agriculture Research Center on-station of Daro Labu and Farmers Training Center (FTC) of Habro Districts of West Hararghe Zone. The objectives of the experiment were to evaluate the influence of cropping patterns in intercropping forage legumes with Maize on Maize and legumes yield and yield components and to determine the appropriate cropping patterns in Maize- forage legumes intercropping. The experiment was designed in a randomized complete block design (RCBD) with four replications. The treatments were sole Maize (Melkasa-4), sole Dolichos lablab, sole Vetch, intercrop by pattern of Dolichos lablab at spacing 37.5cm between Maize, Dolichos lablab intercrop at 25 cm spacing between Maize, Vetch intercrop at 37.5 cm spacing between Maize and Vetch intercrop at 25 cm spacing between Maize. The highest mean value of Maize grain yield (40.57qt ha^{-1}) was obtained from sole Maize at Mechara on station while the lowest grain yield was recorded from double rows Vetch intercropped with Maize at Bareda farmer training center (17.4qnt ha^{-1}) and average values of Maize grain yield (28.86qtha^{-1}) was obtained from Maize-forage legumes intercropping in different planting patterns. The study result revealed that Maize-forage legumes intercropping did not affect Maize grain yield but Maize grain yield decreases with double rows intercropping with legumes followed by single row. Therefore, production of Maize Dolichos lablab intercropping in single row is recommended for West Hararghe area and other similar agro ecologies.

Key Words: -Biomass, Forage, Grain yield, Intercropping, Legumes

INTRODUCTION

Intercropping provides opportunity to harness available resources by cultivation of two or more crops planted simultaneously in the same land that provides the possibility of yield benefit and minimize crops failure (Sarkar *et al.*, 2000, Bhatti *et al.*, 2006). A major benefit of intercropping is increase in production per unit area compared to sole cropping through the effective use of resources (water, nutrients, and solar energy), reduces weed competitions and stabilizes the yield (Nasri *et al*. 2014).Legumes contribute to maintaining the soil fertility via N fixation, which is increased in intercrops due to the more competitive character of the cereal for soil inorganic N.

This leads to a complementary and more efficient use of N sources by the crops in the intercrop system (Nyasasi and Kisetu, 2014). Thus its design improved system for a given agro ecological situations based on their superiority over the existing system which is adapted by the farmers of the area in terms of their biological productivity and stability of production with the least harm of the ecosystem. Farmer generally takes decisions on the technologies to adopt on the bases of cost, risk and return calculation. In small-scale farms, the farmers raise as a risk minimizing measures against a total crops failures (Pour*et al*., 2016).

World population growing exponentially and it has to fulfill their food requirements. An attractive strategy for increasing productivity and labor utilization per unit area available land is to satisfy land use. Thus, the only way to increase agricultural production is to increase yield per unit area (Hirpa, 2013). This can increased by growing several crops simultaneously or in succession with each other in farm devoted to short maturing annual crops (Thayamini *et al*., 2010). Some times intercropping systems suppressed growth and yield of legumes by the dominant crop (Hirpa, 2013). Biological of intercropping due to exploration of large soil mass compared to monoculture (Takele *et al*. 2017). This advanced agro technique has been practiced in past decades and achieved the goal of agriculture. Many studies on intercropping have focused on cereal based intercropping (Langat; *et al.,* 2006;Hugar and Palled, 2008) proved the success of intercropping. However, intercropping also has the advantage of improving forage quality in terms of nutritional contents. As Javanmard *et al*. (2009) report that intercropping of legumes with Maize significantly reduced NDF and ADF content therefore, Maize-legumes intercrops could substantially increase forage quantity and quality and decrease requirements for protein supplements as compared with the Maize monocultures.

In Hararghe as whole, intercropping is the main and indigenous activity of the farmers in due to land shortage. Most of the farmers are practicing intercropping of different crops for different reasons like to minimize total crop failure and efficient land utilization are the main target. Mixtures of Maize-legume showed advantages in land use efficiency expressed as LER than monoculture Maize (Javanmard*et al.,* 2009).Inter-cropping or associated cropping is an indigenous technique of crop production, which is widely practiced in small-scale farm systems in the tropics. However, there is no knowledge on the impact of intercropping different crops in different planting patterns on yield and yield components of the main crops. Most of time practice, not complementary crop and inappropriate pattern. Therefore, in this experiment was to evaluate the influence of cropping patterns in intercropping forage legumes with Maize on both Maize and legumes yield and yield components and to determine the appropriate cropping patterns in Maize- forage legumes intercropping at district of West Hararghe, Oromia.

MATERIAL AND METHODS

Description of Study Area

The study was conduct at Mechara Agriculture Research Center on station of Daro Labu and Farmers Training Center (FTC) of Habro Districts, West Hararghe Zone of Oromia during

2015/16 to 2016/17 cropping season (May to January). The experimental sites are located at a distance of 434kmand390 km to the east of capital city, Addis Ababa.The study sites represent major agro ecological conditions where intercropping is commonly practiced. Daro Labu and Habro district is located at latitude of40°19.114 and 8°48.13North and longitude of08°35.589 and 40°32.3East respectively. It also has Altitude ranges from 1350 to2450 m.a.s.l and 1754 to 2383m.a.s.l. respectively for Daro Labu and Habro district (Climate data from Mechara Metrological Station, 2009-2014 and Habro District Agriculture office, 2016).

The nature of rainfall is very erratic and unpredictable causing dangerous erosion. The area have a bimodal rain fall type ranging from 900 to 1300mm (average of 1094mm) and average temperature of 20ºC for Mechara Agriculture Research Center, on station and 600 to 1000mm (average of 800mm) and temperature of 21ºC for Habro District at Bareda Farmer Training Center. The predominant production systems in the districts are mixed livestock-crop production system. The crops that growths in study area are cereals such as Maize, sorghum, haricot bean, *teff* to large tree fruits like mango, banana, and avocado especially coffee is the brand crop of the study area

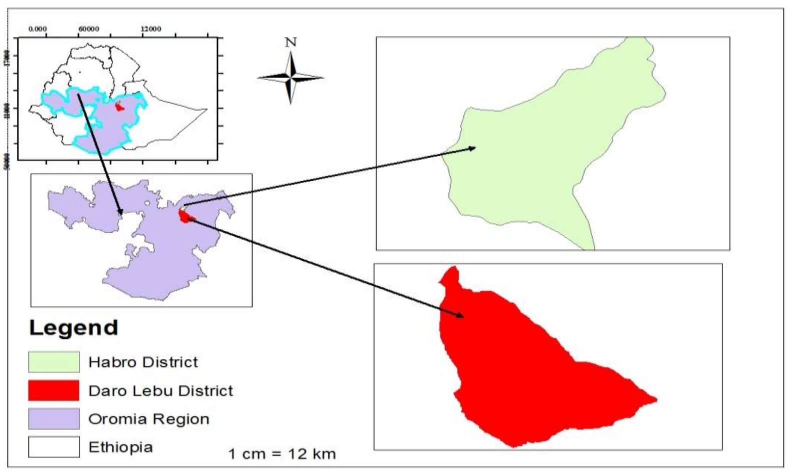

Figure 1: Map of study area

Treatments and Experimental Design.

The experiment was conducted in randomized complete block design with four replications (CRBD) and seven treatments. The treatments were includes; intercropping lablab at spacing of 37.5 cm between Maize rows (T1), intercropping lablab at spacing of 25 cm between Maize rows in two rows (T2), intercropping Vetch at spacing of 37.5 cm between Maize rows (T3)intercropping Vetch at spacing of 25 cm between Maize in two rows(T4), sole Maize (T5),sole Vetch (T6) and sole *Dolichos lablab (T7)*.

Agronomic Management Practice

The experiment was carried out for two successive cropping seasons. The plot size were 4.5m x 5m (total area 22.5m^2) and each plots has six rows for sole and intercropped Maize and five and ten rows for single and double intercrop legumes. Forage-legumes used for this activity were Dolichos lablab and Vetch. Dolichos lablab was sown at the space of 20cm between plants while Vetch was sown by drilling techniques of spacing 30cm between rows at the seed rate of 30kg/ha. Maize was hand sown with spacing 75cm and 30cm respectively between rows and plants. DAP and UREA fertilizers at the rate of 100 kg/ha was applied under Maize after developed two to three ear in the rate of 50kg/ha for both sole and intercropped treatment before legumes has been sown. During sowing, two seeds were sown per hill and thinned to single plant per hill week after emergency. Hoeing and weeding were taken place manually a week after emergence. For all treatments, there is no any pesticide/ herbicide has been used. Both intercrop legumes (Lablab and Vetch) was sown after 35 and 25 days respectively of first and second year. The plant per hill is similar to Maize; two seeds per hill and thinned to single plant per hill week after emergency for lablab. It was hand sown with spacing of 37.5cm x 20cm and 25cm 20cm for single row between Maize and double rows between Maize, respectively. Vetch was sown by drilling with spacing of 37.5cm between Maize and 25cm between Maize for two rows. After the crop attained full maturity stage, Maize and legumes were harvested.

Data Collection

Legumes green fodder biomass was taken at 50% flowering from 0.25m^{2}areas using metal quadrangle of 50cm * 50cm from each plots. It was recorded and weighted with digital sensitive balance. During data collection for green fodder biomass, great attention was given for number of plant included in metal quadrangle. Both sole and intercropping lablab in one row between Maize has two plants per metal quadrangle while four plants in double rows per metal quadrangle. Vetch data was taken in the same with lablab except absence determination of plant numbers per metal quadrant angle since Vetch was drilled. Data of days to 50% tasseling and days to maturity of legumes were monitored and recorded as days after emergency at harvesting. Pod number per plant and number of branch per plants was randomly recorded from five plants and average has been taken. Plant aspect and grain yield data were followed similar with Maize.

Maize stover biomass was recorded from all plots at the stage of harvesting for grain yield. From all plots, five plants randomly selected and harvested above the ground. Then the plant has been weighted after the cob removed from the stalk and the stover biomass per hectare calculated from weight obtained from five plant time's plant number stand count at harvest. Number of days to 50% teaseling and number of days to physiological maturity of Maize were monitored and recorded as days after emergency. Physiological maturity of Maize was recorded when a black layer appeared at the tip of the Maize kernel (detachment of kernel from the cob). Cob number per plant was randomly recorded from five plants and average has been taken. Stand count at thinning and stand count at harvesting was counted for all plots at the stage legume intercropping and harvesting respectively. Grain yield was harvested from all rows. The yield was adjusted and weighted at 12.5% of moisture content to calculate actual grain yield per hectare.

Land Equivalent Ratio (LER)

Assessing yield advantages was calculated though land equivalent ratio**.** An index of intercropping advantage that indicated the amount of inter-specific competition or facilitation in an intercropping system (Fetene 2003)

$$\mathbf{LER} = \frac{Y_{is}}{Y_{ss}} + \frac{Y_{iv}}{Y_{sv}}$$

Where Y_{is} and Y_{ss} are the yields of intercrop and sole cropping of Maize and Y_{iv} and Y_{sv} are the yields of intercrop and sole cropping of legumes. A LER more than 1.0 reveals an intercropping advantage or a demonstration that inter-specific facilitation is higher than inter-specific competition so that intercropping results in greater land-use efficiency. LER less than 1.0 reveals mutual antagonism in the intercropping system. As a result, a LER less than 1.0 has no intercropping advantage and indicates that inter-specific competition is more than inter-specific facilitation in the intercropping system (Fetene, 2003; Wahla *et al*. 2009).

Statistical Analysis

Collected data were subjected to analysis of variance (ANOVA) using (SAS version 9.1.3). Significance differences between treatment means were delineated using Least Significance Difference (LSD) test at 5% probability level.

RESULTS AND DISCUSSIONS

Influence of forage legumes on Maize trait

The ANOVA result of forage legumes intercropping in Maize is presented in Table 1. The mean values of Maize yield and agronomic traits due to different planting patterns within forage legumes did not significantly differ (P>0.05) at both study sites.

This might be attributed to increased nutrients availability in the soil fixed by the legumes because of the legumes' rhizobium association property. In line with this finding, Kwafo*et al.* (2011) also reported that intercropping forage legumes with Maize did not significantly affect the growth and grain yield of Maize in savanna zone of Ghana.

Days of 50% flowering

The mean number of days to flowering Maize up to 50% within treatment at both site did not show significant difference (P>0.05) but numerically different. The number of days required for

Maize to attain 50% flowering ranged from 56 to 61 days. The minimum days were record forT_3 (57.25 days) at Mechara and T_5 (56 days) at Habro district. This variation may be due to soil type difference.

Plant height

The result showed that plant height was not significantly ($P > 0.05$) affected by cropping pattern system. The mean averages of Maize height in different cropping pattern were 159.8 cm at Daro Labu and 131.06cm at Habro district. The maximum Maize plant height (165.18 cm) was attained for T_3at Daro Labu and for T4 (133.3 cm) at Harbro.The minimum plant height were recorded for T1 (153.17cm)at Daro Labu and for T2 (126.8cm) at Habro district. In general, the height of Maize for intercropping treatments were higher than sole sown Maize this might be due to the more efficient use of N sources by the crops in the intercrop system (Nyasasi and Kisetu 2014).

Maize Stover Yield

The analysis of variance shows that the average Maize stover biomass were not significant ($P > 0.05$) influenced by forage legumes intercropping established in Maize at different patterns. However, forage legumes intercropping in Maize had significant different in stover yield within the tested locations. Similarly, Hongchun *et al.*(2013) reported that intercropping with Maize did not disturbed by peanut associated with mono cropping this might be due to legumes crops were naturally have the capacity of nitrogen fixation to soil and made conducive environment for soil microbial.

The average mean yield of Maize stover were 21.54 t/ha Daro Labu and 13.68 t/ha at Habro districts. At Daro Labu site the highest stover yield were recorded for sole Maize (23.89t/ha) followed by T_3 (22.62t/ha) and the lowest stover yield were obtained for T4 (19.33t/ha). While at Habro district the highest value was recorded for T1 (15.62t/ha) followed by T_5 (14.62t/ha) and lowest value were recorded forT_4 (11.56t/ha). At both locations T_4 (Maize +lablab at 25 cm between Maize and lablabin one row) produced the least value of Maize stover yield this was due to *Dolichos lablab* canopy suppress the Maize crop, however, there had no significance variation within other treatment. Therefore, the forage legumes have no adverse effects on both grain and stover yields of Maize and hence are suitable for intercropping with Maize for feed production. Similarly, Kabirizi *et al. (*2005) and Abubeker *et al.*(2006) reported that there were no differences in Maize stover and grain yields between the mono crops and the forage legumes-Maize intercropping practice

Maize Grain Yield

The analysis result of Maize cob number and grain yield of forage legumes intercropped in Maize is presented in Table1. The mean value across all treatment at both location were not show significance variation ($P > 0.05$), however, numerically had different value. This indicated that a significant nitrogen might be fixed by forage legumes which could have a contribution for

Maize grain yield. Grain yield of Maize was ranged from 40.57 qu·ha^{-1} to 17.4 qu ha^{-1}.Inthe production of Maize, cob number had direct relation with grain yield. The cob numbers of Maize were ranged from 1.04 to 1.2.The highest cob number might be from the low competition of crops caused from optimum combined population density of Maize and lablab crops.

The average grain yield of Maize at both sites were not showed significance variation ($P > 0.05$). Mean value of 39.00 qu.ha^{-1} was recorded at Daro Labu site while 18.72qu·ha^{-1} was obtained at Habro site. The result was in line with Takele *et al*. (2017) who reported that the maximum grain yield of 4843.3 kg·ha^{-1} was obtained in Maize + common bean cropping system. The highest grain yield was recorded at Daro Labu site. This is due to rain fall fluctuation during study period at Habro district. The maximum grain yield (40.57 qu·ha^{-}1) was obtained from sole Maize followed by T_3 (39.16 qt/ha^{-1}) at Daro Labu site. The highest grain yield of sole Maize (T5)site (21.5 qu·ha^{-1}) followed by T2 (18.97qu·ha^{-1}) were recorded at Habro, however, the lower yield were recorded inT_3 (17.13 qu·ha^{-1}).The result suggested that Maize grain yield was reduced with increasing competition of the component crops. However, when compared the sole Maize (T5) with forage legumes intercropped in Maize treatments, the overall benefits ofintercropping hadfound to be advantageous than sole cropping.

Table1: Mean values of some traits of Maize as affected by different planting patterns and legumes intercropping

Treatments	Locations													
	Mechara on station							Habro district (Bareda FTC)						
	D50%	PH (cm)	Cb/ plt	SCT	SCH	BM ha^{-1}	Gy qt ha^{--1}	D50%	PH(cm)	Cb/ plt	SCT	SCH	BM t ha^{-1}	Gy qt ha^{--1}
Maize + Vetch 37.5 cm between Maize and Vetch one row (T1)	61.25	153.71	1.14	94	89	20.23	37.96	58.63	129.5	1.03	85	65.13	15.8	18.97
Maize + Vetch 25 cm between Maize and Vetch one row (T2)	60.75	159.21	1.16	97	89.75	21.64	38.2	57.25	126.8	1.1	88.86	59.25	14.15	17.4
Maize +D/lablab 37.5 cm between Maize and D/lablab one row (T3)	60.0	165.18	1.18	95.9	90.75	22.62	39.16	57.38	132.9	1.06	85.13	69.38	11.56	17.13
Maize +D/lablab 25 cm between Maize and D/lablab one row (T4)	60.13	162.56	1.2	94.5	90	19.33	39.14	58	133.3	1.08	87.13	66.38	12.4	18.59
Sole Maize (T5)	60.68	158.4	1.15	99.9	89.13	23.89	40.57	56	132.9	1.04	82.88	69.63	14.62	21.5
Overall Mean	60.6	159.8	1.17	99.2	89.62	21.54	39.00	57.45	131.06	1.06	85.8	65.9	13.68	18.72
CV	1.48	4.75	7.83	6.38	6.64	26.52	13.39	3.44	5.41	7.5	14.1	20.53	29.43	32.08
Significance	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Ns= Non significance, CV= coefficient of variation, LSD= least significance difference, D50%= Days of %0% flowering, P (cm) = Plant height in cent meter, BMtha^{-1} = Biomass in ton per hector, Gyqtha^{-1}= Grain yield in ton per hector, T= treatmen

Influences of Maize on forage legumes traits

The analysis result of Maize influences on forage legumes trait are presented on Table 2.

Days of 50 % flowering :

The analysis result indicates that days of 50%forage flowering were shown a significance (P< 0.001)difference among the tested treatments The overall mean of days to 50% flowering for forage legumes was 78.94 at Daro Labu and 92.25 days at Habro site. The longest days was record forT_1 (87.25) and short days for T7 (69) days at Daro Labu. Where as it were took(108.25) days forT4 and short days (75) forT_6.

Number of legumes bear branch and Herbages yield

Different patterns of intercropping practice of forage legumes under Maize were indicated a significance difference (P< 0.05) on number of branch or canopy and biomass yield of forage legumes at both sites. The result of both parameters was shown direct relation within each other. As analysis of variance indicated, the highest number of branch were recorded from T6 (14.66) andT3 (27.66)while the lowest value was obtained from T3 (9.31) and T1 (11.84), respectively at Daro Labu and Habro sites. Similarly, the result confirmed that the highest herbage yield were recorded from T4 (84.77t/ha) and T7 (97.38t/ha) while the lowest herbage yield were recorded from T1 (15.23t/ha) and from T2 (20.6 t/ha), respectively at Daro Labu and Habro sites.

The current result was in line with Jalal *et al.* (2017) who reported that there was a significant effect of treatments interaction on seed and biomass yield of bitter Vetch. Different researches also was indicated that sole crop have greater biomass than intercropping. This idea illustrated by Temesgen *et al.* (2015) that high plant density might be reduced light interception per plant and it is likely that mutual shading affect source capacity to supply a second ear with photo assimilate. But while consider the land economy when the value of land equivalent ration is greater than one intercropping have important for crop failure, quality, and quantity of yield increment. As Eskandari et *al*. (2016) reported intercropping improves forage quality compared with cereals monoculture, and produces more dry matter compared with legumes sole crop.

Number of pods and forage Legumes grain yields

One of the most yield determinant components is pods that legume plant produces. The result of pod number per plant for *Dolichos lablab* and Vetch intercrop with Maize were illustrated in Table 2. The average pod number among treatment exhibited highly significant (P<0.0001) difference. The overall average pod numbers per plant of *Dolichos lablab* and Vetch sown under Maize were 42.2 and 59.4, respectively. However, the highest mean pod numbers per plant were recorded for sole lablab (67.3) at Daro Labu site and for T_4 (86.8) at Habro site. Compare with the intercropping patterns, sole cropping of Vetch had the highest pod numbers at Daro Labu, but highest for single rows at Habro district. This was might be due to good performance of Maize at Daro Labu than Habro district that increases resources competition. Similar report by Jalal *et al.*

(2017) found that in intercropping patterns, sole cropping of bitter Vetch had the highest pod numbers.

Regarding grain yield of legume forages, different patterns of intercropping and sole sowing have shown highly significant ($P<0.0001$). The highest forage legumes seed yield were recorded at T7 from Daro Labu (9.63qt/ha) and Habro (7.25qt/ha) sites, while the lowest forage grain yield were obtained for T_1 at Daro Labu (0.31qt/ha) and Habro (1.96qt/ha) sites. The result of current study has shown yield and yield components among forage legumes were different value in similar pattern. *Dolichos lablab* yield and yield components indicated more compatible than Vetch. This might be due to the effect of canopy of Maize on Vetch that reduces light interception per plant (photosynthesis) and the compatibility attribute of crop was different. Similarly, according to Temesgen *et al.,* (2015) who reported that high plant density might have reduced light interception per plant and it was likely that mutual shading affect source capacity to supply a second ear with photo assimilate.

Table. 2. Two years mean values of some traits of fodder legumes as affected by different planting patterns and Maize intercropping

Treatments	Locations									
	Mechara on station					Habro district (Bareda FTC)				
	D50%	NoBr	BM t ha^{-1}	Pd No/plt	GY qt ha^{-1}	D50%	NoBr	BM t ha^{-1}	Pd No/plt	GY qt ha^{-1}
Maize + Vetch 37.5 cm between Maize and Vetch one row (T1)	87.12[a]	10.46[c]	15.23[b]	17.2[b]	0.31[c]	81.62[c]	11.84[b]	25[b]	30.0[c]	1.96[c]
Maize + Vetch 25 cm between Maize and Vetch one row (T2)	85.12[a]	11.38[bc]	20.39[b]	14.1[b]	0.34[c]	81.62c	13.31[b]	20.6[b]	26.3[c]	2.25[c]
Maize +*D/lablab* 37.5 cm between Maize and *D/lablab* one row (T3)	75[c]	9.31[c]	63.93[a]	74.3a	4.89[b]	105.25[a]	27.66[a]	78.1[a]	105.7[a]	6.27[a]
Maize +*D/lablab* 25 cm between Maize and *D/lablab* one row (T4)	76[c]	10.53[c]	86.77[a]	65.3[a]	5.44[b]	108.25a	26.66[a]	78.4[a]	86.8[b]	6.07[ab]
Sole Vetch (T6)	81.12[b]	14.66[a]	23.65[b]	16.5[b]	1.70[c]	75.88[d]	15.05[b]	30.9[b]	28.1[c]	4.38[b]
SoleDolichos lablab(T7)	69[d]	13.40[ab]	59.98[a]	67.3[a]	9.63[a]	100.88[b]	24.56[a]	97.4[a]	79.5[b]	7.25[a]
Mean	78.94	11.62	44.99	42.5	3.72	92.25	19.85	55.1	59.4	4.70
CV	2.9	16.2	50	22.1	32.0	2.5	20.1	38.1	13.4	25.4
LSD (5%)	3.449	2.833	33.912	14.16	1.796	3.448	6.018	31.63	12.02	1.799
P-value	***	**	**	***	***	***	***	**	***	***

CV= coefficient of variation, LSD= least significance difference, D50% = Days of 50% flowering, NoBr = Number of branch per plant, BMt ha^{-1} = Biomass in ton per hectare, Pd No/plt = pod number per plant, GY qt ha^{-1} = grain yield in quintal per hector,
FTC= Farmer training center

Intercropping Advantage

The productivity advantage of Maize+ Dolichos *Lablab* and Maize +Vetch intercropping system was assess with land equivalent ratio. As shown in Table3, cropping system showed significant ($P < 0.05$) effect on partial land equivalent ratio of Maize total LER.**1.**

Partial and total land equivalent ratio (LER)

Analysis results indicated that the Land Equivalent Ratio in all treatments were more than one (Table 3). This could be a useful indicator that Maize and forage legumes intercropping have advantage than sole cropping. This could be because of morphological differences between two crop and creation of different stages and utilization of the resources. The analysis of variance was showed significant differences in LPLER ($P<0.05$) and VPLER ($P <0.001$) at Daro Labu and VPLER ($P<0.05$) at Habro sites, while the other parameters at both locations did not show a significance difference. TLER of 1.55and 1.84 were recorded, respectively at Daro Labu and Habro sites for T3, where as TLER value of 1.59 and 1.99 were recorded for T4, respectively at Daro Labu and Habro sites. Current result was comparable with Takele *et al*. (2017) that indicated the maximum TLER of 2.2 from Maize + Common Bean-Mung Bean. Pourtaghi (2004) was announced in intercropping of Maize and Pinto bean and intercropping of Sorghum and Soybean, the highest value of LER is achieved at the highest density of both plants. The variation in the value of TLER was due to difference in time and place in ecological niche, consumption of nutrients and water and crop compatibility.

Table 3. Partial and total land equivalent ratio (LER) onMaize-Legumes intercropping.

Treatments	Location (Districts)									
	Daro Labu					Habro				
	MPLER	LPLER	VPLER	TDLER	TVLER	MPLER	DPLER	VPLER	TDLER	TVLER
Maize + Vetch 37.5 cm between Maize and Vetch one row	0.985	-	0.22	-	1.21	0.88	-	0.48	-	1.45
Maize + Vetch 25 cm between Maize and Vetch one row	0.975	-	0.24	-	1.22	1.2	-	0.63	-	1.37
Maize +D/lablab 37.5 cm between Maize and D/lablab one row	1.01	0.54	-	1.55	-	0.99	0.92	-	1.84	-
Maize +D/lablab 25 cm between Maize and D/lablab one row	1.00	0.59	-	1.59	-	0.84	0.81	-	1.99	-
Mean	0.99	0.71	0.49	1.57	1.2	0.98	0.92	0.7	1.92	1.41
CV	14.39	23.21	13.83	9.14	9.54	36.86	31.07	24.78	32.82	16.43
LSD	0.22	0.28	0.14	0.33	0.26	0.29	0.5	0.3	1.42	0.52
P-value	Ns	*	***	Ns	Ns	Ns	Ns	*	Ns	ns

Ns= Non significance, CV= coefficient of variation, LSD= least significance difference, MPLER; Maize partial land equivalent ratio, LPLER; Lablab partial land equivalent ratio, VPLER; Vetch partial land equivalent ratio, TLER; total land equivalent ratio

Conclusion and Recommendations

Maize-forage legumes intercropping in different patterns did not affect Maize grain and stover yield. Maize yield decreases with double rows forage than single row for both forage legume crops. Intercropping in single row increased pod per plant of legumes and cob per Maize than double rows. The LER showed that intercropping had a major advantage over sole cropping in terms of food and animal feed production. Hence, from the finding, Maize with *Dolichos lablab* and Maize with Vetch intercropping in single row have more advantageous than all intercropping patterns for popularized at farmer level for food- feed production. Therefore, Maize with lablab and Maize with Vetch intercropping in single row were recommended for demonstration to the study area

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Effect of dry season cutting management on subsequent forage yield performance of Napier grass (Pennisetum purpureum) grown under sub-humid climatic condition of western Oromia, Ethiopia

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Abstract

The trial was conducted at Bako Agricultural Research Center (BARC) during 2015-2017 cropping seasons with the objective to evaluate the effect of dry season cutting management on subsequent forage yield and growth performance of Napier grass. The experiment was arranged in 3x2 factorial combinations in a completely randomized block design with three replications. Traits measured were, herbage dry matter (DM) yield (whole, leaf and stem), leaf to stem ratio (LSR), plant height (PH) at harvest and number of tiller produced. Results from analysis of variance revealed that whole DM yield and tiller number were more affected by cutting height, whereas leaf and stem DM yield and LSR were affected by harvesting time. Interaction of harvesting time and cutting height had shown no significant influence on either of the parameters studied. The whole, leaf and stem DM yield, leaf to stem ratio were significantly varied (P<0.05) across the harvesting time, but not plant height and tiller number (P>0.05). However, cutting heights affected whole DM yield and tiller number, while the rest parameters were not affected significantly (P>0.05). The whole and stem DM yield was higher at the end, lower during the beginning and intermediate at the middle of the dry season harvest. With regards to cutting height, cutting of Napier grass at 30 cm height yielded more whole DM and tiller number than 20 cm cut. Even though the total herbage yield shows trend of increment across the harvesting times, a tendency of reduction was observed with the advancement in production years. Indicating Napier grass producers should refrain from harvesting the grass during the dry season. If they need to use their pasture, however, lax cutting at 30 cm height at the beginning of the dry season is acceptable in terms of better leaf yield and leaf to stem ratio.

Key words: Napier grass, herbage yield, dry season cutting

Introduction

Increased livestock production can only be achieved through the cultivation of high quality forages with high yielding ability that are adapted to biotic and a biotic environmental stress (Kahindi *et al.,* 2007). Some of such forage species are Napier grass (*Pennisetum purpureum*). Napier grass is widely distributed in tropical and sub tropical regions of the world. It is highly productive in areas with good soil fertility and high rain fall growing well up to 2000 m. a. s. l (Kumar, 2013). It is an adaptable, vigorous and withstands considerable periods of drought. It also rapidly recovers from stagnation of growth with the onset of rains after extended dry periods (Sollenberger *et al.,* 1990). Moreover, it has the advantage of withstanding repeated cutting, and four to six cuts in a year and can produces 50-150 tones fresh herbage yield per hectare (Purseglove, 1972).

Good grass management is equally as important as selecting the right species and establishing them correctly in the proper location. With appropriate management practices, Napier grass could provide a continual supply of green forage throughout the year so it suits small scale, intensive farming (Angima *et al.,* 2002). Of the management practices, grazing or cutting management during dry seasons play an important role in determining yield, quality and longevity of the pasture. Tudris *et al,* (2002) indicated that, grassland farmers tend to cut or graze their pasture to a very low level (0-10 cm) from the beginning of wet seasons and continued throughout the drought period. This may lead to a reduction in pasture yield during subsequent re-growth. These findings highlight the importance of optimum cutting height and cutting time during the dry season and its varying effects on yield and quality of the pasture.

So far, most research on Napier grass conducted at Bako agricultural research center and elsewhere in Ethiopia have concentrated on maximizing the yield and quality of this species through variety development and by exploiting agronomic attributes such as cutting height, cutting dates, fertilizer application, etc during the main rainy season. However, no study has been carried yet to examine the impact of harvesting this species during the dry season. The present study was set up to supply such information. Hence, this work is initiated with the intention to evaluate the effect of harvesting at varied height and time during dry season on the forage yield and growth performance of Napier grass.

Material and methods

Description of the study area

The experiment was conducted at BARC in East Wollega Zone of Oromia at latitude of 9°06’N and longitude of 37°09’E.The center lies at an altitude of 1650 m a.s.l with a mean monthly minimum and maximum temperature of 11.23 °C and 31.74 °C, respectively. The study area is characterized by its sub-humid climatic condition where the wet season extends from June to September and the actual dry periods occur from November to march (Bako research center, metrological station).

Experimental land preparation and planting

Eighteen plots each of which measuring 6 m^2 were established on a single field for uniformity of soil and topography. Experimental sites were properly cleared, ploughed and labeled out for ease of planting. Napier grasses cuttings having 3 nodes were planted with 2 nodes deep at an angle of about 30-45^o, at a spacing of 60 cm and 50 cm between rows and cuttings respectively. Diammonium phosphate (DAP) fertilizer was applied to all plots during plantation at a rate of 100 kg/ha whereas urea was applied at the rate of 50 kg/ha close to the root slips once the Napier grass was well established (Tessema *et al.,* 2003). The experimental site was weeded and fenced to prevent accidental grazing.

Experimental design and treatments

The experiment was arranged in 3x2 factorial combinations in a completely randomized block design with three replications giving a total of 18 observations. The treatment was composed of 2 cutting height (20 and 30 cm) and 3 dry season cutting management (at the beginning, mid and end of the dry season) .

Data collection

For herbage yield measurement in dry season, the middle one rows of each plot were harvested manually with sickle. The fresh weight of the cut biomass was measured just after mowing with suspended field balance. Then composite sub-samples of 200 gm per treatment were taken and oven dried at 65^{o}C for 72 hours until constant weight attained to determine the herbage dry matter yield. Five plants selected randomly from each plots at harvest were partitioned into leaves and stem and were oven dried to constant weight at 65 ^{o}C for 72 hours for leaf and stem dry matter estimation and leaf to stem ratio determination.

To determine plant height, main shoot of randomly selected five plants were recorded from ground level to tip of the stem from each plot at harvesting and the average of these was taken as plant height. Similarly, total numbers of active growing tillers were taken from randomly selected plants from each plot and average of these as number of tillers per plant.

Data analysis

General Linear Model (GLM) procedure of SAS (SAS, 2002, version 9.1.3) was used to analyze the data. Above ground cutting height, cutting time and their interaction were considered as independent variables in the model for herbage yield estimation and growth parameters. The model fitted was:

$$\mathbf{Yijk = \mu + Ti + Hj + Bk + (Ti*Hj) + Eij,}$$

Where; Yijk = response variable; μ = overall mean effect; Ti = cutting time effect; Hj= cutting height effects; Bk = block effect; Eijk = random error. Significantly different means were separated using least significant difference (LSD) test at 5% level of significance.

Results and Discussion

Analysis of variance (ANOVA)

Analysis of variance (ANOVA) for whole DM yield, leaf and stem fractionate DM yield, leaf to stem ratio, plant height and tiller number of Napier grass harvested during the dry season is presented in Table 1. The above ground cutting height had the greatest effect on whole dry matter yield and total number of tiller explaining 390.0 and 684.5 of the total variance respectively. However, with the exception of plant height which is more affected by blocking, for leaf and stem dry matter yield and leaf to stem ratio variables harvesting time was more important in terms of variance explained. Since interaction of harvesting time and cutting height did not showed significant effect on none of the parameters, only main effects are presented and discussed in Table 2 and 3.

Table 1: Analysis of variance (ANOVA) for whole DM yield, leaf and stem fractionate DM yield, leaf to stem ratio, plant height and tiller number of Napier grass

Class Variables	DF	Parameters measured					
		WDMY	LDMY	SDMY	LSR	PHT	TN
Block	2	24.9	0.97*	0.06	0.58	149.29*	28.8
HT	3	229.9**	2.6***	1.05**	4.91***	54.13	123.04
CH	1	390.0**	0.06	0.07	0.0002	21.13	684.5**
HT*CH	3	53.3	0.03	0.32	0.36	0.35	19.3

** = (P < 0.05); ** = (P < 0.01); *** = (P < 0.001; HT= harvesting time; CH= cutting height , HT*CH= interaction effect of harvesting time and cutting height; WDMY= whole dry matter yield, LDMY= leaf dry matter yield; SDMY= stem dry matter yield; LSR= leaf to stem ratio; PHT= plant height; TN= tiller number*

Dry season harvesting time

The mean effects of dry season cutting management on DM yield and growth characteristics of Napier grass is presented in Table 2. With the exception of plant height at harvest and total number of tillers (P>0.05), all yield parameters measured were significantly varied (P<0.05) with the dry season cutting time. The study revealed that, Napier grass harvested at the end of the dry season gave the higher whole DM (33.34 t/ha) yield whereas, whole DM yield received when Napier grass harvested at the beginning of the dry season was lower as compared to the remaining harvesting times under consideration. The higher whole dry matter yield resulted at the end of the dry season harvest might be attributed to the accumulation of dry matter built up during the previous dry season when this treatment left un cut up to the end of the dry season. According to Minson (1990) report, herbage yield of Napier grass may be affected by the harvesting day after planting, where herbage yield tend to increased due to the rapid increase in the tissues of the plant.

Table 2: Mean dry matter yield attributes (whole, leaf, stem), leaf to stem ratio, plant height and tiller number of Napier grass as affected by different dry season harvesting time

Parameters	Dry season harvesting time			SEM	SL
	Beginning	Mid	End		
WDMY	24.63^{c}	28.45^{b}	33.34^{a}	1.24	**
LDMY	2.91^{a}	2.37^{b}	2.13^{b}	0.13	***
SDMY	1.22^{c}	1.45^{bc}	1.78^{a}	0.09	**
LSR	2.40^{a}	1.73^{b}	1.22^{c}	0.11	***
PHT	158.33	156.72	157.72	1.21	ns
TN	39.22	34.44	39.11	1.72	ns

^{a,b,c} Means within a row with different superscripts differ significantly; SEM= standard error of means; SL= significance level; WDMY= whole dry matter yield; LDMY= leaf dry matter yield; SDMY= stem dry matter yield; LSR= leaf to stem ratio; pht= plant height; TN= tiller no

Statistically significant difference in leaf and stem DM yield were seen across the dry season harvesting time. The higher leaf DM yield was recorded during the beginning of the dry season harvesting time followed by middle harvest and end harvesting time respectively. However, in contrast to this result, higher stem DM yield was obtained when Napier grass was harvested at the end of the dry season than the rest harvesting times. This might be attributed to the fact that proportion of leaves might continuously decreased and that of the stem part may increase depending on advancement in maturity. This might resulted to increased leaf yield during the beginning harvesting time and higher stem yield at the end of the dry season harvesting time and vice versa (Anash *et al.*, 2013),.

LSR was also significantly varied (P<0.001) across the dry season harvesting time which was higher at the beginning of the dry season harvesting time followed by middle harvest and end harvesting time. Decrease in LSR with advancement in harvesting time is a function of the longer periods of physiological growth stimulating stem growth at the expense of leaf production

(Butt *et al.*, 1993). Anash *et al.* (2013) also reported that, the LSR increased in early stage of plant phenology while it decreased with increase in maturity after reaching a maximum growth.

Cutting height

The mean whole, leaf and stem DM yield, leaf to ration, plant height and tiller number as affected by above ground cutting height is presented in Table 3. The only parameters affected significantly ($P<0.01$) due to cutting height were whole DM yield and tiller number. However, the rest parameters were not significantly ($P>0.05$) varied with cutting height.

Table 3: Mean dry matter yield attributes (whole, leaf, stem), leaf to stem ratio, plant height and tiller number of Napier grass as affected by different above ground cutting height

Parameters	Cutting height		SEM	SL
	20	30		
WDMY	26.59^{b}	31.25^{a}	0.88	**
LDMY	2.35	2.40	0.09	Ns
SDMY	1.49	1.55	0.07	Ns
LSR	1.69	1.69	0.08	Ns
Pht	156.25	157.33	0.86	Ns
TN	35.19^{b}	41.36^{a}	1.21	**

^{a,b,c} Means within a row with different superscripts differ significantly; SEM= standard error of means; SL= significance level; WDMY= whole dry matter yield; LDMY= leaf dry matter yield; SDMY= stem dry matter yield; LSR= leaf to stem ratio; pht= plant height; TN= tiller no

The whole DM yield and total number of tiller produced were higher when Napier grass was harvested at 30 cm height as compared to 20 cm cutting height. According to Harris (1978), the beneficial effects of lax cutting of pasture are related to greater size and levels of residual plant variables following cutting, such as residual leaf area, the number of growing points and the amount of stubble reserves remaining. Moreover, the higher whole DM yield and tiller number produced at 30 cm cut than 20 cm cut might be related to the fact reported by Walton (1984). The author stated that, cutting near the ground level cause loose of more photosynthetic parts, and thus uses longer time for re-growth than the high level of cutting. Thus, the result from this experiment suggested that the optimum cutting height for Napier grass should not be lower than 30 cm heights in order to achieve good re-growth compared to cutting to relatively ground level or 20 cm above ground level. In agreement to the result obtained in the current study, increased total DM yield and average DM of Napier grass with increased cutting height was reported by

Sumran *et al.* (2009). However, in consistent to the result recorded for tiller number in the present study, the same author reported that, number of tillers produced was not significantly affected by cutting height. This difference might be related to the variable environmental condition under which the experiments were conducted.

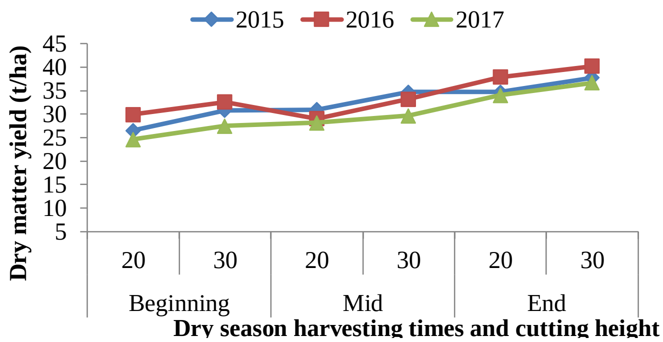

Fig 1: Trend of herbage dry matter yield of Napier grass over the three experimental years

The trend of herbage DM yield of Napier grass harvested during the dry season at different harvesting time and cutting height showed by Fig. 1. The total herbage DM production was positively increased with advancement in harvesting time across the experimental years. The graph indicates that even if there is no statistical ($P>0.01$) variation among study periods, higher herbage DM yield was noticed during the first (2015) year followed by second (2016) year and was lower in the third (2017) year of production. The lower herbage DM production with the advancement in production years could be a consequence of harvesting Napier grass during the dry period under moisture stress condition, leading to gradual loose of plants. This finding is in line with the suggestion given by Tekletsadik *et al*. (2004) who says farmers should refrain from harvesting their pasture during the dry periods if they desire to produce maximum yield and get maximum benefit in the subsequent wet seasons and production years.

Conclusion and Recommendation

The result of the study confirmed that, the herbage dry matter yielding potential and growth characteristics of Napier grass could be highly influenced by the different harvesting time and cutting height practices during the dry season. Cutting height has affected only whole DM yield and tiller number, which was higher when Napier grass harvested at 30 cm cutting height than 20 cm cutting height throughout the stage of harvesting times. However, with the exception of plant height at harvest and tiller number, all measurements taken were significantly varied with the harvesting time investigated. The whole and stem DM yield was higher at the end of the dry season harvesting time, whereas leaf DM yield and leaf to stem ration was higher when Napier grass was harvested at the beginning of the dry season.

Generally, since there is a tendency of herbage yield reduction with the advancement of production years, it is advisable to refrain from harvesting the grass during dry periods. However, if the farmer needs to use their grass during the dry season, lax cutting at 30 cm height at the beginning of the dry season is recommended.

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Effect of Fertilizer Application Versus Forage Legumes Intercropping on Agronomic Parameters, Yield and Crude Protein content of Napier grass (Pennisetum purpureum) at Adami Tulu and Arsi Negele

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Abstract

The experiment was conducted at Adami Tulu Agricultural Research Center (ATARC) and at Arsi Negele with the objectives to evaluate the effect of inorganic and organic fertilizers application and inclusion of forage legumes intercropping on agronomic, yield and crude protein (Cp) performance of Napier grass. The treatments consisted of sole Napier grass without fertilizer (T1), 46 N + 100 DAP kg ha^{-1} (T2), 7.48 t ha-1 of cattle manure (T3), Napier grass + Lablab intercropping (T4), Napier grass + Alfalfa intercropping (T5), sole Lablab (T6) and sole Alfalfa (T7). The experimental plots were laid out in a Randomized Complete Block Design-(RCBD) with four replications. Non-significant (P > 0.05) effect were observed among the treatments on agronomic traits at Adami Tulu and Arsi Negele sites. Significantly the highest total herbage DM yield (13.4t ha-1) was recorded for Napier + Alfalfa intercropping treatment at Arsi Negele site while non-significant variation (P> 0.05) between treatments were detected for herbage DM yield at Adami Tulu site. The maximum CP content was recorded for the second year (P<0.05) compared to the first year (P>0.05) at both sites. The mean CP content was 12.8 %, with values ranging from 11.1% for sole Napier grass to 13.8% for 46 kg ha-1 of N + 100 kgha-1 of DAP fertilizer at Adami Tulu during the second year. Slightly higher mean CP content was 14.6 %, with values ranging from 12.8 for sole Napier grass to 16.7 % for Napier grass + Alfalfa mixture at Arsi Negele with in similar experimental year. Inclusion of cattle manure at a rate of 7.48 t ha-1 was showed comparable dry matter yields with 46 kgha-1 of N + 100 kg ha-1 of DAP applied at all sites. The total land equivalent ratio (LER) for herbage DM yield were 1.49 and 1.56 at Adami Tulu and 1.7 and 1.65 at Arsi Negele site respectively for intercropping of Napier grass +Lablab and Napier grass +Alfalfa traitements. The total LER for mixed crops was greater than one. This indicated that the mixed species are, at least, partly complementary in resource use and there is a biological yield advantage in intercropping. Hence it is important to recommend cattle manure at a rate of 7.48 t ha-1 and forage legumes(Lablab and Alfalfa) intercropping in Napier grass as the best options for optimum yield and quality Napier grass biomass production in areas where adequate moisture or irrigation is available.

Key words: Cattle manure**,** Cropping system, Forage legumes, Intercropping, Napier grass

Introduction

The livelihood of the community in the mid rift valley of Oromia mainly depends on the production of livestock as source of food, income, prestige and security in times of hardship. The area has a great potential for livestock production. However, the production and productivity of livestock is very low mainly due to the shortage of feed resources. Increases in human populations and expansion of arable lands in the area resulted in the reduction of grazing lands. The existing grazing lands are also gradually brought under cultivation and the livestock are forced mainly to graze on poor marginal areas and use low quality crop residues (Fikrineh *et al.*, 2012). These feed resources are in the extent that they fail to meet even the maintenance requirements of animals especially when the dry season persists for long periods. The nutritional quality of crop residues is insufficient to satisfy the minimum requirements of the animals (Bilatu *et al*., 2013; Ahmed *et al*., 2010). To alleviate the feed shortage, development of cultivated forage species suitable for the existing climatic condition is very crucial. Hence, production of adaptable forage species with high herbage yield and quality is very important to tackle feed shortage and degraded natural pasture/grazing lands.

Napier grass (*Pennisetum purpureum)* is one of the most important species and commonly used by many farmers today due to its wide ecological range of adaptation, drought tolerance, ease of propagation and management, its growth rate and high yield (Orodho, 2006; ILRI, 2010a; ILRI, 2013). Despite of its widely adapted and high herbage yield the grass is deficient in CP and energy content. The grass contains an average CP content of 9 % and digestibility of about 62 % and with DM of about 15 percent (ILRI, 2010b). Humphreys (1991) also indicated that Napier grass contains low to moderate (6-12 %) CP during the wet season, but declines to less than 5 % during the dry period. Below a critical level of 6 - 8 % CP in cattle diet, digestibility and voluntary intake of forage are likely to be reduced. Hence it should be supplemented mainly with protein sources feed stuffs in order to meet the maintenance and production requirements of the livestock (Kabirizi *et al*., 2007).

Different management strategies such as optimum date of harvesting (Taye *et al.*, 2007), height of harvesting at cutting and plant spacing (Tessema, *et al.*, 2002) were conducted to improve the biomass and nutritive quality of Napier grass. Efforts also done in improving the yield and quality of Napier grass through fertilization and use of concentrate supplements. However, such methods of improving Napier grass quality through fertilization or use of concentrates to supplement Napier grass diets is not affordable by the smallholder farmers. On the other hands, the importance of herbaceous forage legumes in increasing herbage production of grasses and quality of feed produced has been recognized (Mwangi *et al.,* 2004). Including a legume in fodder grasses production would not only provide a nitrogen source to promote grass growth but enhance the quality of the basal feed. Legumes benefit grasses by contributing nitrogen to the soil through atmospheric fixation, decay of dead root nodules or mineralization of shed leaves.

The inclusion of a legume in Napier grass based diet has shown to improve animal performance in terms of milk production because of their high nutrient contents (Muinga *et al*., 1992). Forage legumes are also the cheaper feed supplements than the commercial concentrates (Njarui and Wandera, 2000) and can easily be grown by the small-holder farmers. In order to exploit the potential of these legumes, a better knowledge is needed on how to fit these legumes into existing farming systems. However, information on effect of different fertilizer sources application and herbaceous legumes intercropping on Napier grass performance in the rift valley condition is lacking. Hence, this study was conducted with objective to evaluate the effect of different sources of fertilizer application and forage legumes intercropping on agronomic, yield and quality performance of Napier grass at rain fed and irrigation condition.

Materials and Methods

Description of the study area

The experiment was conducted at Adami Tulu on-station and Arsi Negele district (Gorbi derara FTC) sites. Adami Tulu and Arsi Negele districts are located in the mid rift valley, at about 167 and 225 km respectively in south of Addis Ababa on Hawasa road. Adami Tulu research center lies at latitude of 7º 9' N and 38º 7' E longitude. Its altitude is about 1650 meters above sea level. It has an average annual rainfall of 760 mm (Teshome *et al.,* 2012). The average annual minimum and maximum temperature of the area at the study year were 11.8ºc and 28.3ºc (ATARC, 2017).

Arsi Negele district is located in West Arsi zone of the Oromia Regional State. The district capital is about 225 km south of the capital Addis Ababa. Geographically, it is situated in the Ethiopian central rift valley system at 7^0 09'-7^0 41' N and 38^0 25'-38^0 54' E. The altitude of the district ranges from 1500-2300 masl. The study area covers three agro-ecological zones (low, mid and high land) based on temperature, rainfall, altitude and vegetation and that ranges from 1500-2300 m.a.s.l (ICRA, 2002). The high altitude zone occupies the largest area followed by mid and low altitude climatic zones, respectively. Average annual temperature varies from 10-25 Cº while annual rainfall varies between 500-1000 mm (ORS, 2004). About 80% of the district is sub-tropical, while 20% belongs to the temperate agro-climatic zone.

Treatments and Experimental Design

The treatments comprised sole Napier grass without fertilizer (T1), 46 kgha-1 of N + 100 kgha^{-1} of DAP (T2), 7.48 t ha^{-1} of cattle manure (T3), Napier grass + Lablab intercropping (T4), Napier grass +Alfalfa intercropping (T5), sole Lablab (T6) and sole Alfalfa (T7). Cattle manure treatment was set by calculating according to Douglas Beegle (1997) which stated that a tone of cattle manure contains 8.55 kg of N. The treatments were arranged in RCBD with four replications. The replications containing seven plots resulting to twenty eight plots in total with each plot measuring 3.4 m x 2.9 m with five rows. The spacing used were 0.5 m between plants and 1 meter between rows. Distance between plots and replications were 1 m and 1.5 m, respectively**.** Plots in each replication were randomly assigned to the five treatments.

Experimental Procedures and Field Managements

Adapted varieties of Napier grass (ILRI 14984), Lablab (*Lablab purpureus*) and Alfalfa (Hunter river) were used. Napier grass was planted by using cuttings in each hole and the material was planted at 45^{o} angle (ILRI, 2010b). After germination of Napier grass, seed of *Lablab purpureus* and Alfalfa were drilled in between the rows of Napier grass in a seeding rate of 15 kg ha^{-1}and 5 kg ha^{-1} (ILRI, 2010b) respectively. For Napier grass + inorganic fertilizer treatment, DAP fertilizer was applied at 100 kg ha^{-1} at its recommended rate at the establishment time while nitrogen fertilizer was applied after one month of establishment of Napier grass and after each cut. Cattle manure was applied for Napier grass + cattle manure treatment on the day of Napier grass establishment and after each cut (Orodho, 2006). The plots were kept free from weed throughout growth period.

Data collected

Data on agronomic and yield parameters were collected following the standard procedures. Plant heights were measured on the harvest date as the distance between the soil surface and the highest point of every plant, while the basal circumference was measured using meter around the base of Napier grass. Tiller number per plant was determined by direct counting of the tillers from five plants that were randomly selected. For herbage yield determination, Napier grass was harvested when it reached about 1 m height whereas the legumes were harvested at 10 % flowering when maximum growth in most entries was reached. The harvest was taken from the middle two rows of each plot at 10 cm height above the ground. After each harvest the total dry matter yield was determined by taking fresh samples of 500 g of each plant parts (stem and leaf). The harvested green biomass was separated into grass and legume components. The fresh weight was taken in the field using a top-loading field balance. Fresh subsamples was taken from each plot and each plant species separately, weighed and chopped into short lengths (2-5cm) for dry matter determination. The weighed fresh subsample (FWss) was oven dried at 65^{O}C for 72 hours and reweighed (DWss) to give an estimate of dry matter production. The dry matter production (t ha-^{1}) was calculated as:

$$\mathbf{DM = 10 \times TotFW \times \left(\frac{DWss}{HA}\right) \times FWss}$$

Where: TotFW = total fresh weight from plot in kg;

DWss = dry weight of the sample in grams

FWss = fresh weight of the sample in grams.

HA = Harvest area meter square and

10 = is a constant for conversion of yields in kg m^{2} to t ha-^{1}

The dried samples were used for DM estimation using methods described by AOAC (2000). Total nitrogen was determined following Kjeldahl procedure as described by Cottenie (1980). Similarly, the forage samples were taken and separated into leaf and stem components and weighed to determine leaf to stem ratio.

The LER was used as the first criterion for mixed stand advantage for both legumes and grasses. LER verifies the effectiveness of intercropping for using the resources of the environment compared to sole cropping (Mead and Willey, 1980; Dhima *et al.,* 2007). When LER is greater than 1, the intercropping favors the growth and yield of the species. In contrast, when LER is lower than 1, the intercropping negatively affects the growth and yield of plants grown in mixtures (Caballero *et al.*, 1995; Dhima *et al.,* 2007). The LER values for this experiment were calculated as:

$$\mathbf{LER} = \frac{YNL}{YN} + \frac{YLN}{YL}$$

Where; YNL and YLN are the yields of Napier grass and legumes as intercrops, respectively;
YN and YL are the yields of Napier grass and legumes as sole crops, respectively,

Data Analysis

All collected data including agronomic parameters, biomass yield and CP were analyzed using ANOVA by the general linear model procedure of SAS (SAS, 2003) version 9.1. Means were separated using least significant difference (LSD) at 5 % significant level.

Results and Discussion

The agronomic performance of Napier grass tested with different treatments at Adami Tulu on-station and Arsi Negele FTC sites are presented in Table 1. The analysis result showed that there were no significant difference (P>0.05) observed between the tested treatments on evaluated agronomic parameters. Numerically the highest value of basal circumstance, number of tiller per plant and plant height were recorded for Napier grass + inorganic fertilizer treatment at Adami Tulu site. While at Arsi Negele site, Napier grass + cattle manure recorded the maximum basal circumstance, number of tiller per plant and plant height. The lowest value of basal circumstance was recorded for Napier grass-Lablab mixture at Adami Tulu and Arsi Negele sites. Sole Napier grass without fertilizer produced the lowest value in number of tiller per plant at Adami Tulu and plant height at Arsi Negele sites while Napier grass +Lablab mixture produced the minimum value of number of tiller per plant and plant highest respectively at Arsi Negele site and Adami Tulu site. Generally, the highest mean yield of basal circumstance, number of tiller per plant and plant height were recorded at Arsi Negele site as compared to Adami Tulu probably due to better moisture in the area. Moreover, the non-significant differences in agronomic performances among the tested treatments could be due to the nutrients available in the soil (Carvalho *et al.*, 2000).

Table 1. Effect of inorganic fertilizer, cattle manure, Lablab and Alfalfa intercropping on agronomic parameters of Napier grass at Adami Tulu and Arsi Negele sites

Cropping system	Descriptions	BC (cm)		NTPP		PH (cm)	
		Adami Tulu	Arsi Negele	Adami Tulu	Arsi Negele	Adami Tulu	Arsi Negele
Sole	Sole Napier grass without fertilizer	142.1	142.2	51.7	58.6	131.7	155.6
Fertilizer application	Napier grass + inorganic fertilizer	150.4	144.8	55.3	60.5	135.5	155.7
	Napier grass + cattle manure	142.8	150.3	55.0	60.6	129.7	156.7
Intercropping	Napier grass +Lablab mixture	134.4	141.4	52.3	57.0	128.4	156.7
	Napier grass +Alfalfa mixture	135.3	142.5	52.0	57.5	130.4	155.7
Mean		140.9	144.2	53.2	58.8	131.2	156.1
LSD ($P<0.05$)		50.7	17.98	41.7	20.92	16.7	25.81
CV (%)		30.2	10.4	31.1	29.9	10.7	13.9
SL		NS	NS	NS	NS	NS	NS

[1]*BC= Basal circumference, NTPP =Number of tiller/plant; PH=Plant Height, LSD=Least significant difference, CV=Coefficient of variation, SL= significance Level,*

The effect of different fertilizer sources and forage legumes intercropping on DM yield of Napier grass is indicated in Table 2. The data on the total DM yield showed that there were no significant ($P>0.05$) difference among the tested treatments at Adami Tulu site while the treatments showed a significant difference in total biomass DM yield performance at Arsi Negele site. Significantly the highest (13.4 t ha^{-1}) total DM yield was obtained from Napier + Alfalfa mixture followed by Napier + Lablab mixture (13.3 t ha^{-1}) while the least value was recorded from sole Napier grass treatment (9.6t ha^{-1}) at Arsi Negele site. There was no significant difference ($p>0.05$) between the control and the fertilized Napier grass treatments but, statistically there was significant ($p<0.05$) different between the sole Napier grass without fertilizer and forage legumes intercropped treatments. Similarly, comparable and non significant ($p>0.05$) total DM yield were recorded among fertilized and forage legumes intercropped treatments. The result of DM yield obtained at Adami Tulu site is similar with Njoka *et al*. (2006) which did not observe significant effect ($P>0.05$) in DM yields of Napier grass when it is intercropped with forage legumes. Desalegn A, (2017) also reported the non significant ($p>0.05$) DM yield difference between Napier grass intercropped with Alfalfa and sole Napier grass. The better DM yield recorded at Arsi Negele site for the intercropping treatments as compared to pure Napier grass could be due to the moisture status of the experimental soil and complementary effect of legumes and Napier grass that raised the productivity per unit of land. Moreover, forage legumes provided soil cover reducing water loss from soil by evaporation and minimizing the effects of weeds in the intercrops (Giller *et al.* 1994). Generally, the highest (12.0 t ha^{-1}) mean of the total dry matter yield was recorded from Arsi Negele site as compared to Adami Tulu (11.1 t ha^{-1}) probably due to better soil moisture and fertility of the study area.

Table 2: Effect of inorganic fertilizer and cattle manure application and forage legumes (Lablab and Alfalfa) intercropping on Napier grass dry matter yield (t ha^{-1}) at Adami Tulu and Arsi Negele.

Cropping system	Descriptions	Adami Tulu		Arsi Negele	
		NG	Total (NG+FL)	NG	Total (NG+FL)
Sole	Sole Napier grass without fertilizer	10.3	10.3	9.6^{b}	9.6^{b}
Fertilizer application	Napier grass + inorganic fertilizer	10.94	10.94	12.1^{ab}	12.1^{ab}
	Napier grass + cattle manure	9.94	9.94	11.7^{ab}	11.7^{ab}
Intercropping	Napier grass + Lablab mixture	10.89	12.05	12.1^{ab}	13.3^{a}
	Napier grass + Alfalfa mixture	11.72	12.35	12.7^{a}	13.4^{a}
Mean		10.76	11.1	11.65	12.0
LSD ($P<0.05$)		3.94	3.9	2.6	2.5
CV (%)		30.2	29.6	18.6	17.7
SL		NS	NS	*	*

[2] Figures having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

[1]*NG = Napier grass, Forage legumes, LSD=Least significant difference. CV=Coefficient of variation, SL= significance Level, NS= Non significant*

The dry matter yield (t ha^{-1}) performances of Lablab and Alfalfa in sole and intercrop with Napier grass tested at Adami Tulu and Arsi Negele sites are presented in Table 3. The result indicated that the forage legumes DM yields were significantly ($P < 0.05$) affected by the cropping system. Lablab produced significantly more ($P < 0.05$) forage DM than Alfalfa, both as a sole crop and as a intercropping in Napier grass (Table 3). Relatively higher mean of forage legumes DM yield was recorded at Arsi Negele (1.67 t ha^{-1}) as compared to Adami Tulu (1.47 t ha^{-1}) site. Hence, these forage legumes (Lablab and Alfalfa) had performed well in biomass yield production and shown good compatibility in intercropping with Napier grass at the study area.

Table 3. Lablab and Alfalfa dry matter yield (t ha^{-1}) in sole and intercrop with Napier grass at Adami Tulu and Arsi Negele sites

Cropping system	Forage Crop (Variety)	Adami Tulu	Arsi Negele
Sole	Lablab	2.65^{a}	2.7^{a}
	Alfalfa	1.45^{b}	2.06^{a}
Lablab-Napier grass mixture	Lablab	1.16^{bc}	1.2^{c}
Alfalfa- Napier grass	Alfalfa	0.63^{c}	0.7^{d}
Mean		1.47	1.67
LSD (P < 0.05)		0.67	0.23
CV (%)		24.1	7.3
SL		**	**

[2]*Figures having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ*
[1]*LSD=Least significant difference. CV=Coefficient of variation, SL= significance Level,*

The effect of different fertilizer sources and forage legumes intercropping on leaf to stem ratio (LSR) and crude protein content of Napier grass are shown in Table 4. LSR is one of the parameters to be taken to evaluate the quality of specific forage type. The analysis result showed that there were no significant differences (p>0.05) observed for leaf to stem ratio among the tested treatments. However, numerically the highest LSR was obtained from sole Napier grass at Adami Tulu site while at Arsi Negele the maximum value was recorded from Napier + Lablab mixture treatment (table 4). In the first experimental year of all the two sites, there was no significantly different (p>0.05) values of CP content observed while at the second year, a significant (p<0.05) difference in CP contents were recorded among the tested treatments. According to the second year data, the maximum (13.8 %) CP contents value was recorded for 46 kgha-1 of N + 100 kgha-^{1} of DAP fertilizer and Napier + Alfalfa mixture (13.7 %) at Adami Tulu site. Similarly, at Arsi Negele site, the highest CP value was recorded from Napier + Alfalfa mixture (16.7 %) followed by Napier + Lablab mixture (15.9 %). The differences in CP contents observed at the two sites could be due to the variation of climatic and soil type of the experimental area and/or their interactions (Diriba *et al*., 2014). The least CP values were recorded from sole Napier grass (11.1%) and (12.8%) at Adami Tulu and Arsi Negele sites respectively. The higher CP content value recorded for the intercropped treatments as compared to the others could be due to the effects of forage legumes. Forage legumes fix atmospheric N_2 and therefore have a higher protein and feed value than associated grasses where soil N is low (Schwenke and Kerridge, 2000). Niang *et al.* (1998) showed that CP content of Napier grass associated with leguminous shrubs (*Calliandra* and *Sesbania*) increased from 11.3 to 17.8% in Napier grass. Studies also indicated that intercropping of Napier grass with Lablab resulted in CP content of about 15% (Nsahlai *et al*., 1996; MacDonald *et al*., 2002). Similarly Njoka *et al*. (2006), Taye *et et al*. (2007) and Ojo *et al*. (2013) noted the increases in CP content of Napier grass due to Lablab intercropping and harvested together as a mixture.

Table 4. Effect of inorganic fertilizer, cattle manure, Lablab and Alfalfa intercropping on leaf to stem ratio and crude protein content of Napier grass at Adami Tulu and Arsi Negele sites

Cropping system	Descriptions	LSR		CP			
		Adami Tulu	Arsi Negele	Adami Tulu		Arsi Negele	
				Year 1	Year 2	Year 1	Year 2
Sole	Sole Napier grass without fertilizer	5.4	4.9	11.9	11.1^{b}	12.6	12.8^{b}
Intercropping	Napier grass-Lablab	4.3	5.7	13.5	13.2^{ab}	13.6	15.9^{ab}
	Napier grass-Alfalfa	5.1	5.3	12.4	13.7^{a}	12.8	16.7^{a}
Fertilizer application	Napier grass + inorganic fertilizer	5.0	5.6	12.5	13.8^{a}	13.2	13.3^{ab}
	Napier grass + cattle	4.8	5.2	13.1	12.2^{ab}	11.3	14.3^{ab}
Mean		4.9	5.4	12.7	12.8	12.7	14.6
LSD ($P<0.05$)		2.21	2.2	3.7	2.4	4.07	3.5
CV (%)		27.3	24.7	9.7	10.3	15.5	13.2
SL		NS	NS	NS	*	NS	*

[2] Figure having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

[1]*LSR =Leaf to stem ratio CP=Crude Protein, LSD=Least significant difference.CV=Coefficient of variation, SL= significance Level, NS= Non significant.*

The land equivalent ratio (LER) values for dry matter yield of Napier grass intercropped with Lablab and Alfalfa are indicated in Table 5. Napier + Lablab mixture treatment resulted in the highest value of LER (1.7) at Arsi Negele while it produced the lowest (1.49) at Adami Tulu site. The total LER values were higher at Arsi Negele as compared to Adami Tulu site. It also showed that intercropping of Lablab and Alfalfa with Napier grass increased the total LER of the mixture than sole Napier grass. Onwueme and Sinha (1991) also indicated that LER greater than 1.0 implies for that particular crop combination, intercropping yielded more than growing the same number of stands of each crop as sole crops. Whereas LER of less than 1.0 implies that intercropping was less beneficial than sole cropping. Hence, the LER values recorded for dry matter yield of the Napier grass + legume mixture indicate that establishment of Napier grass + Lablab or Napier grass + Alfalfa intercropping is advantages than pure stand.

Table 5: Land equivalent ratio (LER) for dry matter yield of Napier grass intercropped with Lablab and Alfalfa at Adami Tulu and Arsi Negele sites

	Adami Tulu			Arsi Negele		
Intercropping systems	Napier grass	Legumes	Total	Napier grass	Legumes	Total
Napier grass + Lablab mixture	1.05	0.44	1.49	1.26	0.44	1.7
Napier grass + Alfalfa mixture	1.13	0.43	1.56	1.32	0.33	1.65
Mean	**1.09**	**0.435**	**1.525**	**1.29**	**0.385**	**1.675**

Conclusions

It was observed that comparable forage dry matter yield with better quality was obtained from forage legumes intercropping and fertilized treatments as compared to the pure stands of Napier grass. Significantly the highest total herbage DM yield were recorded for Napier grass + forage legumes intercropping treatment at Arsi Negele site. Cattle manure also produced equivalent DM yield and CP improvement as inorganic fertilizer source at Arsi Negele in the second year. Moreover, the land equivalent ratio also indicated that intercropping Lablab and Alfalfa in Napier grass has significant advantage than growing Napier grass in pure stands. Hence, it is important to demonstrate and further popularize Napier grass + Lablab and/or Napier grass + Alfalfa intercropping practice as well as cattle manure in areas where adequate moisture or irrigation is available. On the other hands, further studies are needed to evaluate the effect of legume intercropping and fertilizer applications on soil fertility improvement and their economic advantages.

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Effects of Cissus, Euphorbia, Sansevieria and Ipomoea Species Encroachment on Herbaceous Species Composition in Borana Zone, Southern Ethiopia

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Abstract

The study was conducted in three districts of Borana Zone towards the end of growing season, with the objective of examining effects of encroaching (cissus, euphorbia, sansevieria and ipomoea) species on their inside and outside canopy herbaceous species composition in Borana rangelands. Within each encroached areas, 20 m x 20 m main plots were laid out. Then four sub quadrants with 1 m x 1 m size were randomly placed inside and outside canopy of the encroaching species to determine understory herbaceous composition. The collected data was analyzed using General Linear Model (GLM) procures for significance test at alpha level of 0.05; and least significant differences test was used for mean separation for comparison of impacts of encroaching species. The four main encroaching (cissus, euphorbia, sansevieria and ipomoea) species were used to examining the impact rangeland herbaceous vegetation. As Pastoralists' perception, most of these species are less important in the rangelands because they reduce rangeland production and productivity. They reduce important grass species and increase less desirable plant species in the rangelands. In this study, litter cover was significantly different ($P < 0.05$) between inside and outside canopies of the four encroaching species; however, was not significant for dry matter yield. Except for Ipomoea hildebrandtii, the effects of other encroaching species were not significantly different ($P < 0.05$) in herbaceous richness and diversity at inside and outside canopies.

Key words: *Encroachment, canopy, herbaceous species and dry matter yield*

Introduction

Encroaching species can dramatically alter the habitat of native species through changes in structure and composition of vegetation and the availability of food resources (Dan Bachen, 2011). Therefore, encroaching species are now considered as one of the primary causes of native species degradation in rangelands and are considered as a major cause of the reduction and extinction of many species of the world. Mostly invading species degrade to human health and wealth, alter the structure and functioning of otherwise undisturbed ecosystems, and/or threaten native biological diversity (Vitousek et al., 1997). The interactions between climate change and exotic invasive species may combine to increase invasion risk to native ecosystems (Bradley 2009).

Encroachment has been among the major threats to the livelihoods of Borana pastoralists and their ecosystems (Gemedo et.al, 2006a); not only woody plants but also other encroaching species, such as *cissus, euphorbia, sansevieria and ipomoea species* are encroaching in Borana range rangeland threatening the productivity of the rangeland. Understanding the ecological requirement and characteristic of different encroaching species is an option for encroaching species management. The encroaching species compete with desirable grass for soil moisture and nutrients, microclimatic condition that leads to suppress grass productivity (Roques et.al, 2001).

Most parts of rangelands are encroached by undesirable encroaching *(cissus, euphorbia, sansevieria and ipomoea)* species shrub where pastoralists pointed out as a major threat on rangeland production and productivities. These resulted in poor production of feed for livestock. Most of encroaching species are thorny and tufty growing that makes unable to grow desirable plant species that contribute to livestock feed. Hence, for proper management the overall characteristics/ effects of each encroaching *(cissus, euphorbia, sansevieria and ipomoea)* species should be studies spatially in rangeland of Borana. So the purpose of this study is to assess the impact of encroaching *(cissus, euphorbia, sansevieria and ipomoea)* species encroacher on rangeland ecosystem and to suggest options for their management.

Objective

- To examine the effect of encroaching on herbaceous species of the rangelands in selected districts of Borana zone.

Materials and Methods

Description of the study area

The study was conducted in Dire, Yabello and Arero districts of Borana zone, which is a semi-arid environment in the habitats of four highly encroaching (*cissus, euphorbia, sansevieria and ipomoea)* species. Yabello is located at a distance of 563 km from Addis Ababa in southern part of Ethiopia while Arero and Dire are located at equidistant (100 km), each to east and southern of Yabello town, respectively.

Site selection and household survey

In each study district two pastoral associations (Pas), which have rangelands encroached by the study species *(cissus, euphorbia, sansevieria and ipomoea)* were selected to study their effects on vegetation of encroached areas. During site selection, pastoral communities took the lead and identified encroacher areas by encroaching *(cissus, euphorbia, sansevieria and ipomoea)* species. Further, from each district 34 pastoralists were interviewed purposively from this each of the two PAs to collected data on household perception on the effects of the encroaching species and their ecological requirement, their importance and their impacts on rangelands.

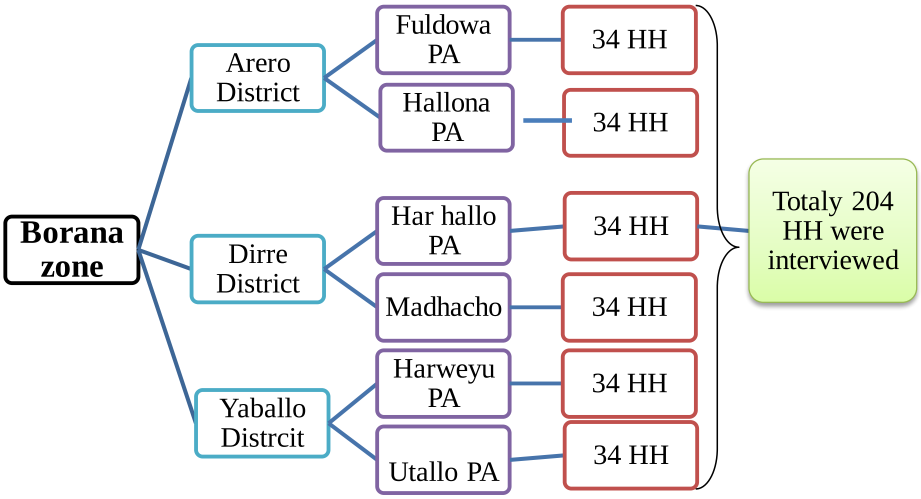


Figure 1: Survey design used in sampling the households

Sampling and data collected

Systematic stratified sampling method was used to collect vegetation data after stratifying the rangeland into encroached and non-encroached by the study species. In order to collect vegetation data quadrant was randomly thrown in the habitats of encroaching species after laying out main plot of 20 m x 20 m size from each habitat of the study species, i.e., from encroached and non-encroached habitats. Then four sub quadrants of 1 m x 1 m size was randomly placed in encroached and non-encroached habitats of the encroaching species to determines basal cover, litter cover, soil erosion and compaction, and herbaceous species richness, diversity and dry matter yield of rangelands. All these data were collected towards the end of growing season, i. e. in May.

Data analysis

Plant diversity of the rangeland was analyzed using Paleontological Statistical software (PAST, version 3.10) (Hammer et. al, 2001). General linear model (GLM) was used to compare the effect of encroaching species on rangeland by comparing encroached and non-encroached habitats' basal cover, litter cover, soil erosion and compaction, and herbaceous richness, diversity and dry matter yield. All statistical analyses were performed using SAS software (version 9.0; SAS Institute, 2002) and least significant differences (LSD) test was used for means comparison at alpha level of 0.05.

The model of ANOVA used was: **Yij = μ + Lj + ej**

Where: Yj = observation (basal cover, litter cover, herbaceous richness, diversity and dry matter yield), μ = the overall mean, Lj = habitat effect and ej = error effect

Results and Discussion

Pastoralists' perception towards the importance of encroaching species

According to pastoralists' perception about 96.7% of *Cissus rotundifolia*, 100% *Euphorbia nubica*, 81.2% *Sansevieria ehrenbergii* and 94.4% of *Ipomoea hildebrandtii* were less important for pastoralists' livelihood. Besides, about 3.3%, 0%, 18.8% and 5.6% of *Cissus rotundifolia, Euphorbia nubica, Sansevieria ehrenbergii* and *Ipomoea hildebrandtii*, respectively, were perceived as important species (Table 1). The study species, namely, *Euphorbia nubica (Annoo), Sansevieria ehrenbergii (Cakkee), Cissus rotundifolia (Cophii kooraa, and Ipomoea hildebrandtii (Omborokkee)* are adversely affecting rangeland condition and its productivity because these species were reduced the rangeland feed resources and accessibility by grazing animals. The result indicated that *Sansevieria ehrenbergii* is substantially important compared to the three *encroaching (Cissus rotundifolia, Euphorbia nubica* and *Ipomoea hildebrandtii)* species. Because *Sansevieria ehrenbergii* was used as feed resources especially, in dry season, when severe feed and water shortage. According to the interviewed community, the main cause of these encroachments by the study species *(cissus, euphorbia, sansevieria and ipomoea* species*)* was ban of rangeland fire. A study by Gemedo (2004) also confirmed that besides overgrazing due ban of rangeland fire has significant contribution to the current encroachments in the Borana rangelands.

Table 1: Response on importance of four encroaching species

ypes of encroaching Species	Total number of respondents (N = 204)			
	Important		Less important	
	N	Percentage %)	N	Percentage %)
Cissus rotundifolia	5	3.3	199	96.7
Euphorbia nubica	0	0	204	100
Sansevieria ehrenbergii	25	18.8	179	81.2
Ipomoea hildebrandtii	8	5.6	196	94.4
Total	38	27.9	778	71.2

Effects of Cissus rotundifolia species on rangeland species composition

The effects of *Cissus rotundifolia* on rangeland species composition is shown in Table 2. A total of 24 herbaceous plant species, which belong to 11 families were encountered in the studied sites. Of these total herbaceous plant species recorded in the study sites, eight species were grass species and sixteen species were non-grass species. From a total grass species recorded in the non-encroached study sites, the most palatable, productive and perennial species *were Digitaria naghellensis, Cynodon dactylon,* and *Chrysopogon aucheri.* However, these important species are declining in the encroached habitats of *Cissus rotundifolia.* This indicated that *Cissus rotundifolia* species has negative impacts on rangeland's palatable species due to its competition for resources and thicket formation that reduce the rangeland production and productivity. Angassa (2008) also reported that the loss of perennial grasses on Borana rangeland was linked to bush encroachment. However, in our study the less desirable species such as *Solanaceae* families and *Pupalia lappacea* were found in the encroached than non-encroached habitats of *Cissus rotundifolia*.

A few grass species like *Digitaria milanjiana* and Forbes like *Commelina Africana* were found in the encroached than non-encroached habitats of *Cissus rotundifolia* due to protection from grazing. The result also showed that the species of *Sporobolus pellucidus* was found at the highest relative frequency and density, followed by *Commelina africana* in encroached habitat of *Cissus rotundifolia*; *Cyperus* species, followed by *Sporobolus pellucidus* had the highest relative frequency and density in the non-encroached canopy of *Cissus rotundifolia* compared to other encroaching species. The encroachment of *Cissus rotundifolia* species across the Borana rangeland has driven a decline and alteration of plant species composition which have feeding values for pastoralists' livestock. Farley et al. (2005) report that conversion of natural grassland species to other encroaching species alter species composition, which results in both community structure and ecosystem function.

Table 2: The relative frequency and density (RF and RD, respectively) of herbaceous species in the encroached and non-encroached habitats of *Cissus rotundifolia*

Scientific name	Vernacular name	Family name	Encroached		Non-encroached	
			RF	RD	RF	RD
Sporobolus pellucidus	Salaqoo	*Poaceae*	9.43	8.73	13.46	15.85
Indigofera spinosa	Qilxiphee	*Fabaceae*	1.89	0.44	7.69	4.27
Cyperus species	Saattuu	*Poaceae*	11.32	14.41	9.62	6.10
Digitaria naghellensis	Ilmogorii	*Poaceae*	0.00	0.00	3.85	2.44
Endostemon kelleri	Urgoo	*Lamiaceae*	7.55	2.62	5.77	3.05
Aristida kenyensis	Bilaa	*Poaceae*	3.77	2.18	15.38	26.22
Chrysopogon aucheri	Alaloo	*Poaceae*	0.00	0.00	1.92	1.22
Commelina africana	Qaayyoo	*Commelinaceae*	7.55	8.73	3.85	3.05
Cynodon dactylon (L.) Pers.	Sardoo	*Poaceae*	7.55	6.55	7.69	14.63
Chionothrix species		*Amaranthaceae*	0.00	0.00	7.69	8.54
Tagetes minuta L.	Suunkii	*Asteraceae*	1.89	0.87	0.00	0.00
Oxygonum sinuatum (Meisn.) Dammer	Mogoree	*Fabaceae*	3.77	2.62	7.69	8.54

Cloris roxbargana		*Poaceae*	0.00	0.00	1.92	0.61
Hibiscus crassinervius	Bungaala	*Malvaceae*	5.66	3.93	0.00	0.00
Solanum somalense Franchet	Hiddii gaagee	*Solanaceae*	3.77	1.75	0.00	0.00
Crabbea velutina S. Moore	Qorsa garaa	*Acanthaceae*	1.89	0.44	0.00	0.00
Indigofera species		*Fabaceae*	1.89	0.44	0.00	0.00
Chionothrix tomentosa Rendle	Gurbii daalattii	*Amaranthaceae*	7.55	4.37	0.00	0.00
Zaleyapentandra (L.)C.Jeffrey	Araddoo	*Aizoaceae*	1.89	0.44	0.00	0.00
Digitaria milanjiana (Rendle) Stapf	Hiddoo	*Poaceae*	3.77	2.62	0.00	0.00
Indigofera volkensii Taub.	Gurbii hoolaa	*Fabaceae*	0.00	0.00	1.92	0.61
Justicia odora (Forssk.) Vahl	Agaggaroo harree	*Acanthaceae*	0.00	0.00	5.77	3.05
Athroism aboranense Cufod.	Gurbii	*Asteraceae*	7.55	21.83	3.85	1.22
Justicia odora (Forssk.) Vahl	Agaggaroo harree	*Acanthaceae*	0.00	0.00	1.92	0.61
Pupalia lappacea (L.) A. Juss.	Hanqarree	*Amaranthaceae*	7.55	8.30	0.00	0.00
Chlorophytum gallabatense Schweinf. ex Baker	Miirtuu	*Anthericaceae*	7.55	11.35	0.00	0.00

Effects of Cissus rotundifolia species on rangeland species richness, diversity and dry matter yield.

Cissus rotundifolia was climbing perennial succulent herb with thick, fleshy and broadly ovate to orbicular leaves and light green flowers. This species has mostly encroached in red soil type of degraded rangeland areas of study sites and had impacted on understory vegetation attributes. There was significant difference ($P < 0.05$) between encroached and non-encroached habitats of *Cissus rotundifolia* in terms of litter and basal cover (Figure 2). The result revealed that under canopy of *Cissus rotundifolia* encroached areas had a higher litter cover as compared with the non-encroached areas, with a mean of 33.67 %. This is due to effect of leaves drops in the encroached habitat while higher grazing pressures reduce the leaves drops from the non-encroached study sites.

No significant difference ($P > 0.05$) was found in basal cover, herbaceous richness, diversity and dry matter yield between encroached and non-encroached habitats of *Cissus rotundifolia* (Figure 2) due to effect of both canopy cover and heavy grazing pressure in encroached and non-encroached habitats, respectively, which implies that the grazing pressure and encroachment by *Cissus rotundifolia* reduce rangeland production. The thickest encroachment of *Cissus rotundifolia* reduce the growth of understory species due their shad and competition effect which made uniform circumstance with openly grazed area that reduce herbaceous production through damage photosynthesis part of plants. This result agreed with Sharma (2013), who reported that canopy cover had impacts on understory species through interference with amounts of sunlight availability and soil nutrient competition.

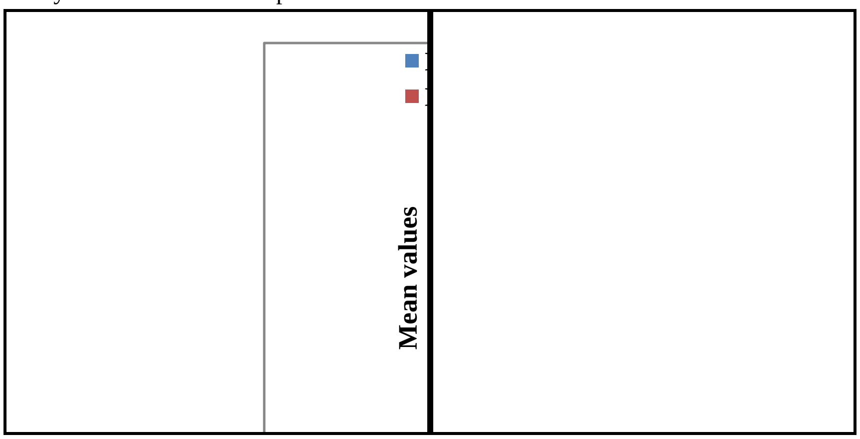


Figure 2: Mean and standard errors of basal and litter cover (%), herbaceous dry matter (t ha^{-1}), richness and diversity in the encroached and non-encroached habitats of Cissus rotundifolia.

[1] Only bars with asterisk (*) are significantly different at P< 0.05.

For instance, Gilliam (2014) suggested that the response of herbaceous layer under tree canopy led to decrease in species richness and diversity. Studies by Vockenhuber et al. (2011) in a forest also showed a negative response of species richness to increasing canopy cover.

Effects of Euphorbia nubica on rangeland species composition.

The effect of *Euphorbia nubica* on rangeland species composition, the relative density and frequency of herbaceous species of study site are presented in Table 3. From a total grass species recorded in the study site the most palatable, productive and perennial specie included *Cenchrus ciliaris* and *Digitaria naghellensis* were found in the non-encroached but these species declined in the encroached habotats of *Euphorbia nubica habitats*. The less desirable herb species such as *Solanum somalense* and *Pupalia lappacea* were found in the encroached than non-encroached habitats. This indicates that *Euphorbia nubica* has negative impacts on rangeland's palatable species due to its high competition and thick shade formation. This finding is in agreement with Angassa (2008) who reported that the disappearances of productive perennial grasses were due to bush encroachment.

Some palatable grass species such as *Chrysopogon aucheri*, *Pennisetum mezianum* and *Cynodon dactylon* and forbes species such as *Commelina Africana* were recorded in the encroached than in non-encroached habitat of *Euphorbia nubica* due to its protection from grazing but they had poor performance due to effect of *Euphorbia nubica* encroachment.

Chrysopogon aucheri was found to have the highest relative frequency, followed by *Pupalia lappacea* in the encroached areas of *Euphorbia nubica*; *Chrysopogon aucheri* had the highest relative frequency in the non-encroached habitat of *Euphorbia nubica* comparison to other species. *Pennisetum mezianum* species was found to have the highest relative density in both encroached and non-encroached sites of *Euphorbia nubica* relative to other species. This indicates that different species have different ability to withstand harsh circumstances i.e. impacts of encroaching species.

Table 3: The relative frequency and density (RF and RD, respectively) of herbaceous species in the encroached and non-encroached habitats of *Euphorbia nubica*

Scientific name	Vernacular name	Family name	Encroached		Non-Encroached	
			RF	RD	RF	RD
Cenchrus ciliaris L.	Mata guddeessa	*Poaceae*	0.00	0.00	2.04	0.75
Sporobolus pellucidus	Salaqoo	*Poaceae*	2.33	1.27	6.12	3.73
Indigofera spinosa	Qilxiphee gaalaa	*Fabaceae*	9.30	7.59	8.16	5.97
Volkensinia prostrate	Gurbii	*Amaranthaceae*	6.98	6.33	6.12	2.99
Cyperus species	Saattuu	*Poaceae*	0.00	0.00	8.16	13.43
Digitaria naghellensis	Ilmogorii	*Poaceae*	2.33	1.27	4.08	2.24
Endostemon kelleri	Urgoo	*Lamiaceae*	9.30	6.33	8.16	3.73
Cynodon dactylon (L.) Pers.	Sardoo	*Poaceae*	6.98	6.33	6.12	3.73
Justicia odora (Forssk.) Vahl	Agaggaroo harree	*Acanthaceae*	0.00	0.00	2.04	0.75
Pupalia lappacea (L.) A. Juss.	Hanqarree	*Amaranthaceae*	11.63	8.86	2.04	0.75
Chionothrix species		*Amaranthaceae*	6.98	6.33	8.16	4.48
Tagetes minuta L.	Suunkii	*Asteraceae*	4.65	6.33	0.00	0.00
Pennisetum mezianum	Ogoondhichoo	*Poaceae*	9.30	27.85	8.16	26.87
Ocimum urticifolium Roth.	Hancabbii	*Lamiaceae*	2.33	1.27	2.04	0.75
Solanum somalense F.	Hiddii gaagee	*Solanaceae*	2.33	2.53	0.00	0.00
Aristida kenyensis	Bilaa	*Poaceae*	2.33	2.53	8.16	9.70
Chrysopogon aucheri	Alaloo	*Poaceae*	16.28	7.59	14.29	14.18
Commelina africana	Qaayyoo	*Commelinaceae*	6.98	7.59	6.12	5.97

Effects of euphorbia nubica on rangeland species richness, diversity and dry matter yield.

Euphorbia nubica is a stem pale green with prominent leaf-scars and encroached in wide range in semi-arid area of study sites that had impacted rangeland productivity. This species propagates in different systems that enable it to easily spread on rangeland. There were significance difference ($P < 0.05$) in basal and litter cover between encroached of *Euphorbia nubica* (Figure 3). The basal and litter cover were higher in the encroached than the non-encroached sites. This is due to effect of leaves drops and less livestock grazing and trampling in the encroached than in non-encroached sites of *Euphorbia nubica*. Similarly, the remaining parameters like species richness, diversity and dry matter yield were not significantly different ($P > 0.05$) between encroached and non-encroached habitats of *Euphorbia nubica* (Figure 3).

Figure 3: Mean and standard errors of basal and litter cover (%), herbaceous dry matter (t ha^{-1}), richness and diversity in the encroached and non-encroached habitats of Euphorbia nubica. [1] *Only bars with asterisk (*) are significantly different at P< 0.05.*

The morphological feature of *Euphorbia nubica* has shading effect, which interferes with light penetration, and competes for nutrients with understory species and hence reduces herbaceous species attribute in the same way as openly grazed area. This result was in agreement with Sharma (2013), who reported that canopy cover had impacts on understory species through interference with amounts of sunlight availability and soil nutrient competition. In most studies plant species richness and diversity increased outside canopy than under canopy. Similarly, Gilliam (2014) confirmed that herbaceous layer under tree canopy led to decrease in species richness and diversity because increase in soil nitrogen input will lead to the loss of many nitrogen efficient species which brings about dominance of few high nitrogen-requiring species.

Effects of Ipomoea hildebrandtii on understory of rangeland species

The effect of *Ipomoea hildebrandtii* on rangeland species composition, the relative density and frequency of herbaceous species of study site is presented in Table 4. A total of 27 herbaceous plant species, belonging to 12 families was encountered in the study sites. Of these total herbaceous plant species recorded in the study sites, ten species were grass species and 12 species were non-grass species. From the total grass species recorded in the study site the most palatable, productive and perennial specie include *Chrysopogon aucheri* and *Cynodon dactylon,* which were found in the non-encroached habitat but these species declined in the encroached habitats of *Ipomoea hildebrandtii.* The less desirable herb species (i.e., *Pupalia lappacea*) were found more in the encroached than non-encroached habitat. This indicates that *Ipomoea hildebrandtii* species has negative impacts on palatable species of rangeland due to its high competition on nutrients/resources and shading effect due to microclimates of created by thick shade. The non-grass and annual species were more abundant in encroached than non-encroached habitats of *Ipomoea hildebrandtii* because less grazing and good moisture retain and lower light intensities under encroached area may provide suitable environment for growth of forb and annual species. This finding was confirmed with Angassa (2008) who report that bush encroachment can extinct the perennial grasses of Borana rangeland.

The result showed that *Sporobolus pellucidus* had the highest relative frequency, followed by *Pupalia lappacea* species in encroached habitat of *Ipomoea hildebrandtii*; however, *Chrysopogon aucheri* had the highest relative frequency in the non-encroached habitat of *Euphorbia nubica* species relative to other species. This showed that the encroachment of *Ipomoea hildebrandtii* had impacts on rangelands' herbaceous species production.

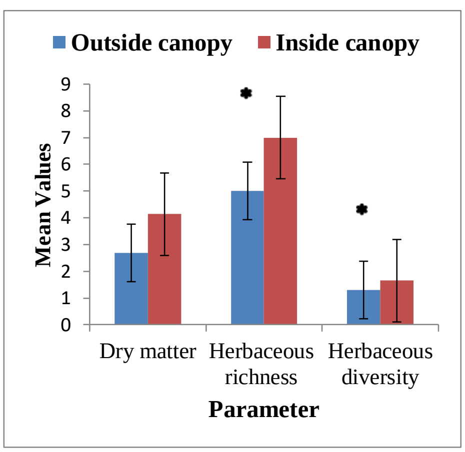
Table 4: The relative frequency and density (RF and RD, respectively) of herbaceous species in the encroached and non-encroached habitats of *Euphorbia nubica*

`Scientific name	**Vernacular name**	**Family name**	Encroached		Non-Encroached	
			RF	RD	RD	RD
Sporobolus pellucidus	Salaqoo	*Poaceae*	11.97	33.61	10.59	27.78
Indigofera spinosa	Qilxiphee	*Fabaceae*	5.98	3.86	10.59	9.83
Chionothrix tomentosa Rendle	Gurbii daalattii	*Amaranthaceae*	7.69	5.51	8.24	4.70
Cyperus bulbosus	Saattuu	*Poaceae*	5.13	4.68	12.94	17.95
Digitaria naghellensis	Ilmogorii	*Poaceae*	7.69	4.41	3.53	2.56
Endostemon kelleri	Urgoo	*Lamiaceae*	6.84	3.86	1.18	0.43
Justicia odora (Forssk.) Vahl	Agaggaroo harree	*Acanthaceae*	6.84	5.51	5.88	2.99
Pupalia lappacea (L.)	Hanqarree	*Amaranthaceae*	4.27	5.79	3.53	2.99
Oxygonum species		*Fabaceae*	0.85	0.28	0.00	0.00
Amaranthus thunbergii Moq.	Raafuu	*Amaranthaceae*	0.00	0.00	1.18	0.43
Hibiscus crassinervius	Bungaala	*Malvaceae*	1.71	1.38	2.35	1.28
Solanum somalense Franchet	Hiddii gaagee	*Solanaceae*	0.85	0.28	0.00	0.00
Digitaria milanjiana (Rendle) Stapf	Hiddoo	*Poaceae*	0.85	0.28	0.00	0.00
Indigofera volkensii Taub.	Gurbii hoolaa	*Fabaceae*	0.85	0.28	0.00	0.00
Heteropogon contortus	Seericha	*Poaceae*	0.85	0.55	0.00	0.00

Chlorophytum gallabatense Schweinf. ex Baker	Miirtuu	*Anthericaceae*	0.85	0.28	2.35	0.85
Aristida kenyensis	Bilaa	*Poaceae*	9.40	8.26	12.94	13.25
Chrysopogon aucheri	Alaloo	*Poaceae*	2.56	0.83	4.71	2.56
Commelina africana	Qaayyoo	*Commelinaceae*	7.69	9.09	5.88	4.70
Cynodon dactylon	Sardoo	*Poaceae*	0.00	0.00	2.35	0.85
Indigofera species		*Fabaceae*	0.85	0.28	0.00	0.00
Tagetes minuta L.	Suunkii	*Asteraceae*	1.71	0.55	1.18	0.43
Chenopodium opulifolium Schrad ex Koch. & Ziz.	Ononnuu	*Chenopodiaceae*	3.42	1.93	3.53	1.71
Oxygonum sinuatum (Meisn.) Dammer	Mogoree	*Fabaceae*	2.56	1.38	4.71	2.99
Dactiloctinium species		*Poaceae*	3.42	5.23	2.35	1.71
Chionothrix species		*Amaranthaceae*	0.85	0.28	0.00	0.00

Effects of Ipomoea hildebrandtii on understory species of rangeland.

There was significant difference ($P < 0.05$) in litter cover, herbaceous richness and diversity between encroached and non-encroached of *Ipomoea hildebrandtii* (Figure 4). The result revealed that the under canopy of *Ipomoea hildebrandtii* species had a higher litter cover, species richness and diversity as compared with non-encroached habitat. This is due to effect of leaves drops, more abundant annual species and lower accessibility of grazing under canopy cover than in the non-encroached sites of *Ipomoea hildebrandtii and hence* enhance these herbaceous attributes.



Dry matter	3.59	4.89
Herbaceou	4.75	5.92
Herbaceou	1.27	1.44

Figure 4: Mean and standard errors of basal and litter cover (%), herbaceous dry matter (t ha^{-1}), richness and diversity in the encroached and non-encroached habitats of Ipomoea hildebrandtii.

[1] *Only bars with asterisk (*) are significantly different at P< 0.05.*

There was no significant difference (P >0.05) observed in basal cover and herbaceous dry matter yield between encroached and non-encroached habitats of *Ipomoea hildebrandtii* (Figure 4) due to *Ipomoea hildebrandtii* has less canopy cover which has less effect on understory species. The morphological feature of *Ipomoea hildebrandtii* has able to retain moisture and provide shade that increase the number of annual species may herbaceous attributes under encroached area. Unlike, studies in a forest by Vockenhuber et al. (2011) reported that a negative response of species richness when trees canopy cover increases.

Effects of Sansevieria ehrenbergii on herbaceous species composition

The effect of *Sansevieria ehrenbergii* was analyzed based on herbaceous species relative density and frequency (Table 5). A total of sixteen herbaceous plant species, belonging to eight families, was encountered in the study sites. Of these total herbaceous plant species recorded in the study sites, eight species were grass species and seven species were forb species. From a total grass species recorded in the study site the most productive specie such as *Cenchrus ciliaris, Chrysopogon aucheri* and *Pennisetum mezianum* were found in the non-encroached while less desirable species such as *Solanaceae* families and *Pupalia lappacea* were found in the encroached habitat (Table 5), which revealed that Sansevieria *ehrenbergii* can change species composition and reduce production function especially rangeland feed resources.

Generally, the result showed that *Sporobolus pellucidus* was found to have the highest relative frequency and density, followed by *Commelina africana* in the encroached habitat of *Sansevieria ehrenbergii* while *Cyperus* species, followed by *Sporobolus pellucidus* had the highest relative frequency and density in the non-encroached habitat of *Sansevieria ehrenbergii*.

High amount of grass species were present in the non-encroached than encroached sites of *Sansevieria ehrenbergii*. In contrast, due to lower temperature and light intensities in the encroached habitat forb and annual species were more abundant under canopy than outside canopy of *Sansevieria ehrenbergii* species. This shows that encroachment of the *Sansevieria ehrenbergii* species on rangeland areas would likely decrease the presence of productive grass species.

Table 5: The relative frequency and density (RF and RD, respectively) of herbaceous species in the encroached and non-encroached habitats of *Sansevieria ehrenbergii*

`Scientific name	Vernacular name	Family name	Encroached		Non-Encroached	
			RF	RD	RF	RD
Cenchrus ciliaris L.	Mata guddeessa	*Poaceae*	2.82	1.27	5.08	2.65
Sporobolus pellucidus	Salaqoo	*Poaceae*	14.08	25.42	15.25	16.81
Indigofera spinosa	Qilxiphee gaalaa	*Fabaceae*	8.45	8.05	5.08	1.77

Volkensinia prostrate	Gurbii	*Amaranthaceae*	4.23	1.69	0.00	0.00
Cyperus species	Saattuu	*Poaceae*	5.63	10.59	18.64	36.28
Digitaria naghellensis	Ilmogorii	*Poaceae*	2.82	1.27	1.69	0.44
Endostemon kelleri	Urgoo	*Lamiaceae*	1.41	0.85	3.39	1.33
Chrysopogon aucheri	Alaloo	*Poaceae*	7.04	8.05	8.47	7.52
Pupalia lappacea	Hanqarree	*Amaranthaceae*	1.41	0.42	0.00	0.00
Chlorophytum gallabatense	Miirtuu	*Anthericaceae*	2.82	1.27	1.69	0.88
Aristida kenyensis	Bilaa	*Poaceae*	5.63	6.36	10.17	10.18
Justicia odora	Agaggaroo harree	*Acanthaceae*	8.45	5.51	5.08	1.77
Chrysopogon aucheri	Alaloo	*Poaceae*	7.04	8.05	8.47	7.52
Commelina Africana	Qaayyoo	*Commelinaceae*	12.68	16.53	6.78	12.83
Tephrosia pentaphylla	Darguu	*Fabaceae*	4.23	1.69	3.39	1.33
Pennisetum mezianum	Ogoondhichoo	*Poaceae*	5.63	5.93	6.78	4.87
Cissus aphyllantha Gilg.	Cophii soodduu	*Vitaceae*	1.41	0.42	6.78	0.00
Cloris roxbargana		*Poaceae*	4.23	2.12	1.69	1.33
Hibiscus boranensis cufod	Bungaalaa	*Malvaceae*	2.82	1.27	0.00	0.00
Ocimum urticifolium Roth.	Hancabbii	*Lamiaceae*	1.41	0.42	0.00	0.00
Solanum somalense Franchet	Hiddii gaagee	*Solanaceae*	1.41	0.42	0.00	0.00
Solanum species	Bosoqqee	*Solanaceae*	1.41	0.42	0.00	0.00

Effects of Sansevieria ehrenbergii in understory species of rangeland

Sansevieria Ehrenbergii was significantly different ($P < 0.05$) in litter cover between encroached areas of *Sansevieria ehrenbergii* and non-encroached areas (Figure 5). The result revealed that encroached areas with *Sansevieria ehrenbergii* had a higher litter cover compared with the non-encroached areas, with a mean of 33.67 % and 8.33 %, respectively. This is due to leaves drops and light grazing pressures in the encroached areas of *Sansevieria ehrenbergii*. However, there were no significant difference ($P > 0.05$) in basal cover, species richness, diversity and dry matter yield between encroached and non-encroached areas of *Sansevieria ehrenbergii* (Figure 5) due to effect of canopy cover in the encroached sites and presence of heavy grazing pressure in the non-encroached areas that reduced the basal cover of herbaceous species. The tufts growth behavior of *Sansevieria ehrenbergii* has negative impact on understory species while their growths of spine prevent livestock grazing than non-encroached areas

Dry matter	3.59	4.89
Herbaceou	4.75	5.92
Herbaceou	1.27	1.44

Figure 5: Mean and standard errors of basal and litter cover (%), herbaceous dry matter (t ha^{-1}), richness and diversity in the encroached and non-encroached habitats of Sansevieria ehrenbergii; [1] Only bars with asterisk (*) are significantly different at P< 0.05.

The tufts growth behavior of *Sansevieria ehrenbergii* has negative impact on understory species while their growths of spine prevent livestock grazing than non-encroached areas. This result is in agreement with Sharma (2013), who reported that canopy cover had impacts on understory species through interference with amounts of sunlight availability and soil nutrient competition; Tesemma et al. (2011) also stated that intensive grazing did reduce herbaceous dry matter yield per hector (kg ha $^{-1}$). Similarly, some studies suggested that the response of herbaceous layer under tree canopy led to decrease in species richness and diversity (Gilliam, 2014).

Conclusion and Recommendation

Beside Vachellia and Senegalia species, cissus, euphorbia, sansevieria and ipomoea species have adversely affected rangeland condition and its productivity. The four main encroaching species were used to examining the impacts of *cissus, euphorbia, sansevieria and ipomoea* species on rangeland herbaceous species. Based on pastoralists' perceptions most of these species are less important due to their easily spread as well as shrinkage of grazing areas of rangeland due to their encroachment. These encroaching *(cissus, euphorbia, sansevieria and ipomoea)* species have negative impacts on rangeland ecosystem because they alter the species composition through displacement of productive grass species and increasing less desirable species. The result showed significant difference (P < 0.05) in litter cover between encroached and non-encroached habitats of all encroaching *(cissus, euphorbia, sansevieria and ipomoea)* species but not for dry matter yield. Except *Ipomoea hildebrandtii*, all the remaining encroaching *(cissus, euphorbia, sansevieria and ipomoea)* species were not significantly different (P < 0.05) in herbaceous richness and diversity between encroached and non-encroached habitats. Generally, encroachment reduces desirable herbaceous species and increase less desirable and annual herbaceous species.

Prevention and controlling of non-woody species is the main important rangeland management practices in order to reduce the impact of non-woody species encroachment on rangeland production.

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Causes and Effects of Rangeland Degradation in the Lowland Districts of the Bale Eco-Region, Southeast Ethiopia

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Abstract

This study was carried out in Bale Eco-Region (BER) which is located in Southeastern Ethiopia, with the objective of addressing the causes and effects of rangeland degradation particularly rangeland degradation. Both purposive and stratified random sampling approaches were used to select households (HH). Individual interview, key informants and Focus *Group Discussions (FGD)* were the main data sources for this study. T*he livelihood activity in BER lowland area before 1965 was pastoralism and it was based on highly productive, vast and free rangeland with unlimited movement of the pastoralists. In the lowland of BER mobility has a destination, pattern and objective to meet. These destinations are source of mineral, a breeding site, feed and water. Mobility was used as strong seasonal disease prevention mechanism as well as water and feed shortage escaping mechanism. However, this community has currently changed to agro-pastoral and even some of them to crop production due to different disturbances. The change was mainly aggravated by expansion of agricultural investment, high population growth, illegal settlement and cultivation and banning of mobility to forest areas. Utilization of rangeland is communal and rangeland around homestead and watering points are overgrazed and resulted in bare land and encroached by unpalatable and thorny species. The vegetation cleaning and cultivation of drought prone area under rain feed regimes has accelerated bare land expansion and unpalatable vegetation encroachment. The overall rangeland condition is deteriorated and the livelihoods were jeopardized. Consequently, when people get in trouble, they move from degraded to protected area and moist source of forest land in Bale Mountain National Park, causing serious deforestation.*

Key Words**:** *Eco-region, Pastoralism, Rangeland, crop encroachment, Livelihood*

INTRODUCTION

Livestock population has reached more than 88 million in Ethiopia which is the largest in Africa (MoA, 2010). African Intergovernmental Authority on Development (IGAD) estimated that pastoralist livestock population makes up 30% of the nation's cattle, 70% of the goats and sheep and all camels in the country (IGAD, 2010). In Ethiopia, despite a strong subsistence orientation, pastoralists contribute about 90% of live animals to the legal livestock exports in, and 20% of the draught animals to the highlands (Sandford and Habtu, 2000) for traction.

Rangelands in Ethiopia occupy about 61% of the national land mass and largely dominate the lowland areas (Coppock, 1994). Of the total land mass of the country, about 12-15% and 12% are pastoral and agro-pastoral, respectively. Bale eco-region comprises 12 and 2 districts of Bale and West Arsi zones of the Oromia regional state, respectively. According to Bale zone finance and economic development office (BZFEDO, 2001), out of the total area of Bale zone 63.5% is included under lowland and 39.1% is under rangeland. These areas are characterized by arid and semi-arid environments, diversified vegetation types, livestock and wild animal species as well as untapped mineral resources.

Rangelands in Ethiopia are in danger of becoming seriously degraded owing to natural and human-induced factors (Coppock, 1994; Amaha *et al.*, 2008). In Ethiopia, about 20, 24 and 51% of the rangelands are in good, medium and poor condition classes, respectively, implying a steady decrease in rangeland production and productivity. As a result, dry matter feed production is between 1.0 and 0.53 tons/ha/annum, with carrying capacity varying from 8 to 15 ha per Tropical livestock Unit (Amaha *et al.*, 2008). Different studies and reports indicated that rangeland degradation has increasingly become a threat to the pastoral production systems and has resulted in substantial declines in rangeland condition. Water potential, soil status, and animal performance decline in livestock holding at the household level which in turn leads to food insecurity and widespread poverty to the extent of food aid and the need for alternative means of livelihood as income diversification. Nowadays the Bale lowland eco-region has led to low livestock productivity, leading to declined number of livestock holding per house hold, severe livestock death during dry periods, increasing of cultivated land, increasing of number of people vulnerable to food insecurity and considerably higher reliance on food aid.

However; detail causes and effects of the declining rangeland condition, which resulted in pastoralists to change their livelihood activity and put pressure on conserved Bale eco-region, is not yet studied. Therefore; this study was carried out in Collaboration with Bale zone Pastoral Area Development Office to address the causes and effects of rangeland degradation, which is currently affecting the whole system in the Bale lowland eco-region, south eastern Ethiopia.

MATERIAL AND METHODS

Description of the study area

This study was carried out in Bale Eco-Region (BER) located in the Bale administrative zone of the Oromia regional state of Ethiopia some 400km south east of the national capital, Addis Ababa. The Eco-Region lies between 05˚22' - 08˚08'N and 38˚41 - 40˚44'E. Three lowland districts located in Bale eco region, namely, Dalo Mana, Mada Wolabu and Harana Buluk, were included in this study. The rainfall pattern in the study area is bimodal, with rains from March to June, called "*Gana*" and from September to November called "*Hagaya*", the latter with erratic distribution. In the district, pastoralism and agro-pastoralism are the main production systems. Description of the study area is indicated in Table 1.

Table 1: Descriptions of the study area

District	human Population	Altitude (masl.)	Temperature (^oC)		Rainfall (mm)		District area (km^2)	Forest and woodland (%)	Rangeland (%)	Cultivated land (%)	Arable land (%)	Degraded land (%)	Other (%)
			Min	Max.	Min.	Max							
Dalo Mana	114,742	1200-500	21	38	628	775	4,834	43	21	3	7	23	3
Mada Wolabu	122,277	500–500	20	40	400	800	8,871	38	15	3.24	3.12	36.23	4.41
Harana Buluk	102,872	1500-3000	13	23	900	1,000	1,934	64	12	5	1.5	15.45	2.05
	Cattle	**Goats**	**Sheep**		**Camels**		**Donkeys**	**Horses**	**Mules**				
Dalo Mana	322,626	90,902	14,912		44,672		13,994	1,275	2,511				
Mada Wolabu	213,962	233,020	11,901		19,446		7,873	1,541	4,775				
Harana Buluk	156,975	47,135	7,782		750		8,706	5,753	5,277				

Source: BZFEO (2000) and BZPADO (2016)

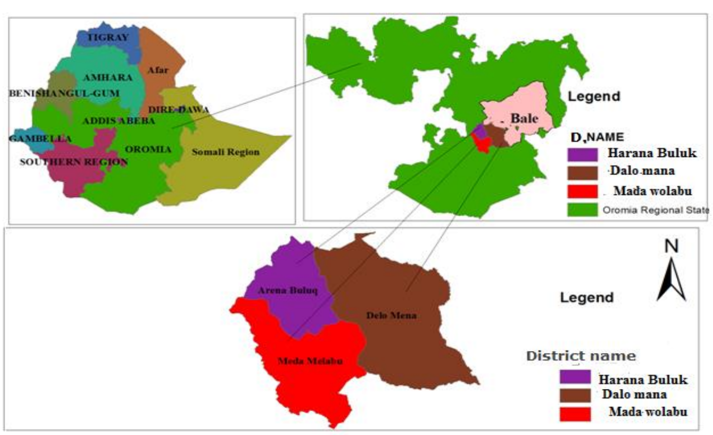

Fig. 9: Map of the study area

Data collection

The study was based on primary and secondary data. Primary data related to the socio-economic characteristics of the pastoralists such as educational level, land size, livestock ownership, and livelihood activities were collected using semi-structured questionnaires. The data on cause and effects of rangeland degradation, perception of communities on rangeland condition trend and overall livelihood activity was collected using Focus Group Discussion (FGD) and key informants, respectively. Secondary data about livestock development activities and information on rangeland management and utilization was collected from respective organizations. The status of rangeland condition was judged using field observation, targeting major rangeland and types of grazing, using easily understandable methods such as resource mapping and constraint listing by the local communities.

Sampling Method

In this study both purposive and stratified random sampling approaches were used to identify study subjects and collect primary data. In the first stage, out of nine lowland districts found in the lowland of Bale eco region three s (Mada Wolabu, Harana Buluk and Dalo Mana) were purposively selected. The main criteria used to select the three Districts were livelihood activity (pastoral and agro pastoral), proximity to Bale highland forest, representativeness of the districts to major land use/land cover types, land management practices, trends in land use and land management interventions, natural resources use interdependence and inter-links, environmental degradations and local livelihoods. In the second stage, the sample size in each livelihood activity (of the three Districts selected) was determined by adopting rule of thumb sampling approach of Green (1991), as**:**

$$N \geq 50 + 8M$$

Where: N=the sample size from each Livelihood activity and

M=the number of key research variables of the study for the livelihood activity *(Xi), m=1, 2…n*.

The sample size from the agro-pastoral area where a total of 3(three) key variables were assessed for the three research topics covered were determined as:

$$N \geq 50 + 8M;\ N \geq 50 + 8\ (3),\ N = 148\ HHs$$

In the third stage, 2 representatives of village association (VAs) (one for each livelihood activity) from each district, accounting to a total of 6 VAs from the 3 districts were purposively selected by adopting the criteria used to select the study districts above. The aim was to distribute the sample size determined for each livelihood activity to the respective districts selected in the livelihood activity and cascade the sample size determined to the 6 VAs selected. The probability proportional sample size distribution technique was used to allocate the sample size determined for each agro-ecology to the respective districts and VAs proportional to the total HHs size of each district and VA (Village Association) selected, respectively (Table 2).

In the fourth stage, stratified-random sampling technique was used to select sample HHs in each VA proportional to the sample size determined for each VA above. The listing of the total number of the HHs in each VA was carried out with the help of VA administrators and local experts. Finally, random selection of sample HHs from each respondent category was carried out in each study VA, through random lottery method and data collection and field assessment was carried out at household farm level through applying various data collection methods and tools.

Table 2. Summary of study VAs and sampled households by Livelihood activity

No	Livelihood Activity	Study District	Sample Vas	No of sample HHs		Total
				Male	Female	
1	Pastoral	Dalo Mana	Barak	18	1	19
		Haran Buluk	Melka Arba	21	4	25
		Mada Wolabu	Hora kore	28	2	30
		Sub-total		67	7	74
2	Agro. Pastoral	Dalo Mana	Haya Oda	22	3	25
		Harana Buluk	Shawe	24	0	24
		Mada Wolabu	Karjul	23	2	25
		Sub-total		69	5	74
		Overall sample size		136	12	148

Household (HH) survey, Key Informants Interview (KII) ***and Focus Group Discussions (FGD)***

Survey of a total of 148 agro-pastoral HH units was carried out to collect primary data in the 6 study VAs. To that effect, a semi-structured questionnaire was prepared for all the research topics separately and translated into local language (Afan Oromo). The questionnaire was first tested in one VA during the reconnaissance survey, modified and administered to the sampled respondents.

In-depth interview with key informants from Bale zone and districts pastoral community area development offices and livestock and fisher resource development office, local elders, administrators and experts was carried out to supplement and enrich the data collected from the HH survey. The representative individuals of different government organizations, experts and local elders (24 males and 1 female) were also interviewed on issues of cause and effects of rangeland degradation of Bale Eco-Region BER (Table 3).

Table 3. List of participant stakeholders in the study

S/N	VA/Organization	Informants		
		Male	Female	Total
1.	Districts & VA administrations	6	1	7
2.	District Land resource management office experts	3	0	3
3.	District Investment offices	2	0	2
4.	Local Elders in three districts & VA administrations	7	0	7
5.	Distract Range land development experts	3	0	3
6.	Rang land experts	3	0	3
	Total	24	1	25

In this study, Focus Group Discussion (FGD) was particularly important to bring together pastoralists and other individuals to debate mainly on cause of rangeland degradation and its effects on overall ecosystems in the area. In each study districts, 2 FGDs were conducted with selected participants from the community (Table 4 and Fig 2).

Table 4. Pastoral and Agro-pastoral FGD Participants

No	Livelihood Activity	Study District	Sample VAs	No of sample households		Total
				Male	Female	
1	Pastoral	Dalo Mana	Barak	12	3	15
		Haran Buluk	Melka Arba	14	2	16
		Mada Wolabu	Hora kore	15	3	18
		Sub-total		41	8	49
2	Agro. Pastoral	Dalo Mana	Haya Oda	16	2	18
		Haran Buluk	Shawe	17	2	19
		Mada Wolabu	Karjul	12	4	16
		Sub-total		45	8	53
		Over all sample size		86	16	102

As much as possible efforts were made to form homogenous groups for each FGD. Females' representation in the FGDs was low because it was hardly possible to balance the number of males and females house hold heads.

Shawe

Barak

Hora kore

Karjul

Fig 2. Photos during FGD in selected VA

Data analysis

Descriptive statistics was used to analyze data collected using Statistical Package Software for Social Sciences (SPSS) Computer software program. Data collected from FGD and key informants was summarized using prioritization matrix and response percentage of the participants.

RESULTS AND DISCUSSION

Household Characteristics

Household characteristics of the respondents in the study area are presented in Table 5. There was no a significant difference ($P>0.05$) with respect to sex, educational status and age of the respondents across the study area. Out of the total households involved in the study, 8.1%were headed by females. Concerning educational status, more than 60.8% of the respondents' had completed primary education while about 32.4% were illiterates. More than 46.0% of the respondents were aged greater than 40 years, while 17 to 25 years aged participants were less than 4.1%. Out of the total participants 70.3% of them are using both livestock and Crop production as income source.

Table 5. Household characteristics of the respondents in the study area

Sources of variation		Districts of the study								P-Value
		Mada wolabu		Dalo Mana		Harana Bulul		Total		
		N	N %	N	N %	N	N %	N	N %	
Production system	Pastoral	25	48.1%	15	35.7%	26	48.1%	66	44.6%	>0.392^{ns}
	Agro. Pastora	27	51.9%	27	64.3%	28	51.9%	82	55.4%	
Household head age	17-25	2	3.8%	3	7.1%	1	1.9%	6	4.1%	>0.113^{ns}
	25-31	8	15.4%	11	26.2%	8	14.8%	27	18.2%	
	32-40	21	40.4%	15	35.7%	11	20.4%	47	31.8%	
	41-48	11	21.2%	7	16.7%	16	29.6%	34	23.0%	
	49-56	4	7.7%	0	0.0%	6	11.1%	10	6.8%	
	>56	6	11.5%	6	14.3%	12	22.2%	24	16.2%	
Participant sex	Male	49	94.2%	38	90.5%	49	90.7%	136	91.9%	>0.744^{ns}
	Female	3	5.8%	4	9.5%	5	9.3%	12	8.1%	
Educational Status	Illiterate	18	34.6%	12	28.6%	18	33.3%	48	32.4%	>0.814^{ns}
	Primary	31	59.6%	27	64.3%	32	59.3%	90	60.8%	
	Secondary	2	3.8%	3	7.1%	2	3.7%	7	4.7%	
	College	0	0.0%	0	0.0%	0	0.0%	0	0.0%	
	Religious	1	1.9%	0	0.0%	2	3.7%	3	2.0%	
Income sources of household	crop production	8	15.4%	7	16.7%	5	9.3%	20	13.5%	<0.017**
	Livestock production	15	28.8%	5	11.9%	3	5.6%	23	15.5%	
	Both	29	55.8%	30	71.4%	45	83.3%	104	70.3%	
	Others	0	0.0%	0	0.0%	1	1.9%	1	0.7%	
	Total	**52**	**100.0%**	**42**	**100.0%**	**54**	**100.0%**	**148**	**100.0%**	

** Frequency variation is significant at 1% probability level while ^{ns} is non-significant,

Causes of ecological change and trends of livelihood

1. Responses of households on causes of ecological change

Ecological disturbance is one of the strongest challenges that have been scientists and all human beings worried about. In this study, participants were highly concerned about ecological degradation around their area. Based on their experience and their current personal observation population growth (26%), climate change (50%) and land use policy (24%) was listed as the main causes of range land degradation in the area (fig. 3).

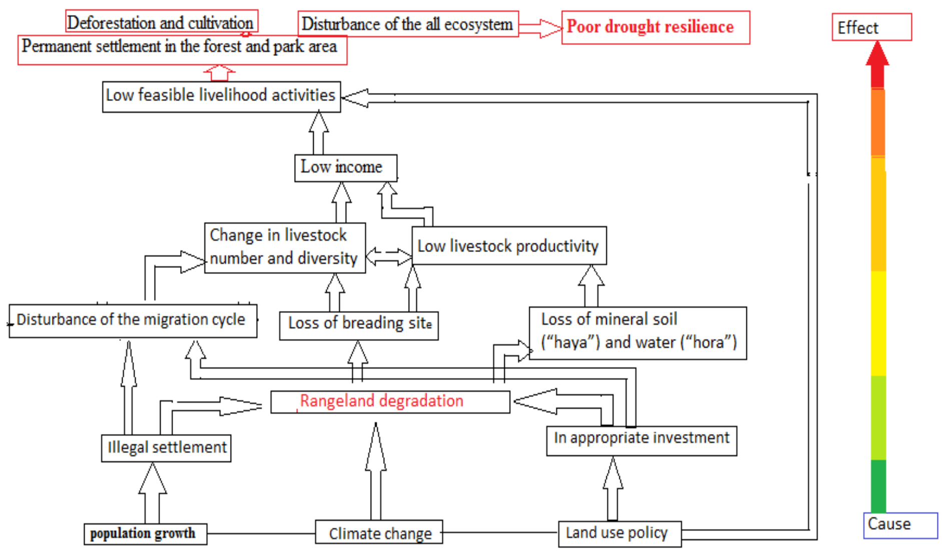

Figure 3: Responses of households on Causes and effects of range land degradation in Bale Eco region (BER)

Population growth, described as illegal settlement and internal growth, is one of the main contributors of the rangeland degradation in the area. This illegal settlement was highly related with migrants from highland area and other settlers from nearby borders of Somali region. Related to climate change, 52% of the respondents related rangeland degradation with the God. Their personal observation was apparent on decreasing and change in rainfall pattern. In addition, increasing of average temperature and range of its fluctuation was highly bolded by the participants.

The idea of inappropriate agricultural investments was supported by all respondents as the main cause of rangeland degradation disturbed the ecosystem. Participants related inappropriate agricultural investments to the push of pastoralists by the government to produce food crops by expansion of the inappropriate agricultural investments in potential rangeland areas, for instance, Barak rangeland.

The aggregate effects of rangeland degradation were disturbance of the mobility cycle, loss of breeding site and loss of mineral sources for animals. These effects significantly reduced livestock number, and diversity as well as rangeland productivity, which resulted in highly limited household income that forced them to participate in inappropriate livelihood activities, such crop production in drought prone areas.

The households that are unable to tolerate this problem were forced to migrate to protected forest and national parks, such as Harena forest and Bale mountain national park. This was finally disturbed the roof of the ecosystem through deforestation and cultivation for food crops. As such, the current overall ecosystem disturbance was become a challenge and the household in the area were exposed to poor drought resilience.

2. Trends of livelihood activity in the study area

Agro-pastoralists have lost income from livestock due to many factors, which are affecting livestock production. This loss has been exacerbated by the reluctance of state entities to acknowledge and respect pastoralists' rights to land and disregard to pastoralism. Pastoralists also mentioned that banning of mobility to forest during dry season and expansion of crop production in the name of investments has damaged huge rangeland areas, particularly in Berak PA of Dalo Mana, which has highly disturbed pastoralism.

In this study the number of livestock per HH has decreased dramatically in the last four decades (Fig. 4). The respondents have tried to relate this issue with climate change, high human population and conflict over conversion of rangeland to cropland and inequitable investment expenditure.

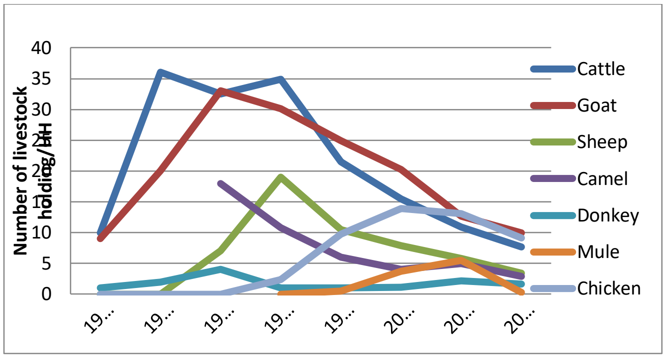

Fig. 4: Responses of the participants on Trend of livestock holding per household

The participants of FGD mainly stressed that the decline in rangeland productivity and livestock number were mainly aggravated by grabbing of vast area of rangeland by investors and smallholders. In Bale Eco-Region pastoral movement had been following grass and water availability through the year, which helps them to keep moving the normal activity of pastoralism, and hence, has to be maintained without interference of any livelihood activity that affects it. In this study all respondents has indicated that vast rangeland areas like Barak and Harana forest areas play a crucial role in reproduction and productivity of livestock particularly cattle.

In the low land eco-region of Bale Eco-Region mobility has a pattern, destination and objectives. Barak Rangeland and Harana Forest are the main mobility destinations targeted during different seasons. During wet season (from April to June) pastoralists of the study area migrate to Barak rangeland from more than 12 districts. This migration sites are the places where livestock get mineral water "*Hora*", mineral soil "*Haya*" and mineral soil dissolved in water "*Duba*". In addition, it is the most important cattle breeding site and the place to share bull with good production traits.

After wet season was passed Barak is highly affected by high feed and water shortage and serious livestock disease. To escape this scenario pastoralists migrate to Harana forest, which is another breeding place and calving place for those conceived at Barak during wet time (July to September). In addition, Harana forest is endowed with mineral spring waters, "Hora" that contributes a lot to cattle production and reproduction. At the end of the dry season in the Harana forest the pastoralists must live the forest immediately and go to Barak rangeland to escape the season of Tsetse fly bite and different disease outbreak. This season (from October to November) has short rain and hence, feed resources in the area are limited. After staying for a maximum of two months, mobility resumes back to Harana forest and stays for a maximum of three months (from December to February) and then leave the forest immediately to escape disease outbreak. To finish full mobility cycle of the year pastoralists stay at least for one month, i.e., March, some were in between Harana forest and Barak rangeland and move back again to Barak rangeland afterwards.

In Bale Eco-region this cycle of mobility has important contribution to livestock production and livelihood of the community, but has disturbed by expansion of cultivated land, agricultural investments and banning of forest mobility. The present results are in line with previous studies such as Abate *et al.* (2011) and Mohammed *et al.* (2017), who reported that demographic expansion and consequent agricultural expansion are the major driving factors of land use/cover changes. This was caused serious loss of livestock numbers and forced pastoralists to partially shift their livelihood activity to crop production. For instance, in response to this in recent years sesame (*Azadirachta indica*) has been popularized as one of the most important cash crops in Bale Eco-Region. However, all participants of this study has indicated that the yield from this crop was severely affected by disease and short rainy period and currently replaced by another cash crop Mung bean (*Vigna radiate L)*. The response of the participants indicated that the area of cultivated land for other crops production is slightly decreasing except some highly demanded cash crops such as Mung bean, Haricot bean and Khat (*Catha edulis*) (Fig. 5).

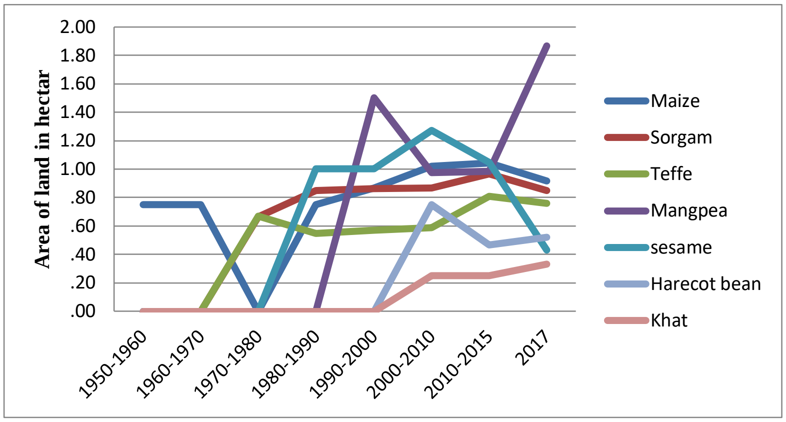

Fig. 5: *Responses of the participants on Trends of average of land used to produce different crops/ha in Bale low land eco-region*

Constraints of livestock production

Based on the result of the group discussion and responses of the sampled individual households, inadequate quantity and quality of feed resources are ranked as the primary constraint to livestock production followed by livestock health, shortage of water and poor livestock breed (Table 6).

Table 6. Major constraints of livestock production ranked by pastoralists and agro-pastoralists

Constraints	Number of respondents		Rank
	N	N%	
Feed	98	66.22	1
Disease	20	13.51	2
Water	10	6.76	3
Breed	8	5.41	4
Market	6	4.05	5
Theft	4	2.70	6
Conflicts	2	1.35	7

Low rangeland productivity is attributed to recurrent drought, bush encroachment and expansion of cultivation that resulted in inadequate availability of feed resource in the study area. The incidence of disease and parasites and poor genetic potential of the indigenous cattle are also among the major constraint that contributes to the low production and productivity. It is clear that Barak rangeland was the main breeding site for livestock, particularly cattle. Because of this the site was visited by thousands of cattle from other districts surrounding this rangeland and from nearby districts of Somali regional state; and the flow of genetic material was created as good opportunity for breed improvement. Currently, the previous pastoralists practice and opportunity to select good breeding animal was halted do to decrease in the number of cattle and their diversity coming to that traditional breeding ground (Fig.6).

Fig. 6: Flow of livestock genetic material (GM) related to seasonal mobility in rangelands of Bale lowland BER districts

In addition to livestock breeding improvement, the most important contribution of seasonal mobility ("*Godansa*") is rangeland improvement due to addition of the organic matter through their feces, remained litter and soil structure improvement through animal trampling. Currently the number of livestock, coming to this area is limited due to agricultural investment and sedentarization and in flow of farmers from other areas.

1. Feed resources and feeding practices

Crop residues is the major feed resource in Haya Oda VA of Dalo Mana district where as grazing of natural pasture is the main form of feed utilization at the rest VAs of the study area. At Karjul VA of Mada Wolabu distirict, 69.2% of the respondents indicated that, crop residue was the major feed resource followed by rangeland. Crop residues such as maize and sorghum stover and teff straw were fed mainly during the dry season. Utilization of rangeland is mostly communal and its use is continuous grazing throughout the year. Communal rangeland around homestead and watering point is usually overgrazed and resulted in bare land and mostly dominated by unpalatable species. Hence, (agro) pastoralists usually move their animals far from homestead. In some areas of the selected districts, rangelands are reserved for grazing by draught animals where cultivation is a primary means of livelihood. These lands are protected from animals during the wet season, mainly from July to November, to allow rejuvenation of the existing grass and are opened for grazing at the end of rainy season. In areas where more of the land was covered with woody vegetation, trees and shrubs were important sources of livestock feed throughout the year.

Agro-pastoralists in Dalo Mena districts also utilize weeds from crop field to feed lactating cows and draught oxen. During the dry period standing hay is also used as an important feed resource. All the households responded that there was a critical feed shortage during the dry seasons. To cope with feed shortages, mobility and use of feed sources like browse trees, enclosures and crop residue are used as alternative. In Dalo Mana town 15-20 kg of teff *(Eragrostis tef*) straw is sold at about 30 - 45 birr (1.1 - 1.67 USD) and a bell of straw of 24 kg is sold at about 55 - 60 birr (2.02-2.2 USD). Agro-industrial by-products were not adequately available and known in the area.

On the other hand, forage crops were not widely cultivated because of scarcity of forage seeds, lack of knowledge of production and feeding techniques and poor extension services in the area. Only 2.1% of the respondents at Shawe VA of Harana Buluk district are producing improved forage crops mainly Elephant grass.

Table 7. Major feed resources used by pastoralists and agro-pastoralist

Parameters	**Percent Respondent**		
	Meda wolabu	**Delomena**	**Harana Buluk**
Crop residues	69.2	18.3	19.3
Rangeland	13.3	55	57.8
Haymaking	2.2	0	2.2
Stubble grazing	6.4	16	12.4
Fodder trees (indigenous)	4.4	11.1	8.2
Cultivated forage crops	0	0	2.1

Feeding systems in the study area was based on the purpose of livestock rearing. In most cases animals of different species irrespective of their age and sex are allowed to graze together. However, lactating animals especially cattle receive special attention. Cattle in the VAs such as Barak, Malkarba and Kerjul are spending extra time and energy looking for drinking water especially during the dry season when there is no surface water.

Pastoralists and agro-pastoralists in the study area, previously supplement livestock with mineral soil called locally *'Haya'* and Mineral soil dissolved in water called "*Duba*". *Haya,* a black or gray colored soil is usually fed during the wet season to all class of livestock, particularly to cattle. This activity is currently limited due to more of these mineral soil places were controlled by private individuals. The most serious problem currently increasing in the area is the heavy influx of settlers in almost every area previously considered as communal rangeland in both pastoral and Agro pastoral area. Mineral water locally called "*Hora*" is the most important livestock mineral supplement previously used in the area. Though the potential of minerals on livestock productivity is indisputable nowadays its supply to their animals is limited. A number of "*Hora*" i.e., mineral springs, are located in the forest where the movement of pastoralists are constrained because the area is privatized by local individuals. Many different scientific articles have explained that minerals are important for good production and reproductive performance of animals as deficiency limits their performances. Proper herd management should be designed to optimize the production of the highest quality product, while minimizing any adverse effects on the health and welfare of the animals as well as the rangeland. Adequate and balances of major and minor trace mineral plays important roles in health as well as reproductive efficiency. Therefore, pocket areas with these minerals should be protected and the accessibility by pastoral communities should be ensured.

Trends of government policies and their effects on Range land Degradation

Table 8. Major policy issues, events and their effects on rangeland in lowlands of Bale eco-region

No.	Year/ regime	Main events on rangeland and pastoralism	Effects on rangeland and local community	Response to the effects by community, NGO's and gov't
1	Haile Selassie (1928-1974)	• Vast area of land Locally called "Gofare" was used for grazing • Free grazing and pastoralism was implemented • Ample amount of river and shallow hole water ("Eela") source were available • Burning of rangeland was not restricted • Number of livestock owned per HH was very high as compared to current • Bale mountain • tain National park was established	• Any pastoralist who wants to utilize the grazing land can use it by only paying a few payment called "Gofare payment" • Rangeland was well managed	• Development and food aid programs like today was not common
2	Provisional Military Administrative Council (PMAC) "Derg" (1974-1991)	• Villagezation was launched • Vast area of grazing land used by herders during dry season in mid and high altitude area was controlled by crop producers and state farmer • Few small scale irrigation was established	• The place where to migrate during dry season was lost/limited and conflict was frequent • High number of herders evacuated from mid and highland area for state farm establishment was migrated to lowland areas and introduced different crop cultivation activities in low land area • Over utilization of biodiversity was started	• Few small scale irrigation was established
3	EPRDF (1991 to date)	• High issues of conflicts on watering point and grazing land was emerged • Little care for natural resource	• Fencing locally called "Kalo" for grazing and crop land was started • The previous communal range land was shared by local pastoralists and the	• A number of Food aid delivering activities by government and NGOS was started

		were come out particularly on communal grazing land • crop producing investors and privet farmers • None feasible Agricultural investment has taken a large area of rangeland	remained fragile land was seriously degraded • Mobility and free grazing was halted and conflicts was increased • Drought resilience of the community was seriously affected and high food aid dependency was developed • Serous pesticide application was started and bee keeping activity was highly decreased • A large area of potential grazing land covered by woody plants savanna was cleared for crop production and this was disturbed normal mobilty cycle in the area	• Watershade development programs such as work for food was started

Perceptions of pastoralists and agro pastoralists on rangeland degradation indicators and the current status of low land BER

Pastoral communities' indigenous ecological knowledge and its outcomes can make an important contribution to the development of local policies. Comparison and ranking of the rangeland degradation indices from pastoral and agro-pastoral viewpoints is crucial. Pastoralists and herders often have different perceptions on the rangelands degradation problems compared to the scholars and the experts (Reed and Dougill, 2002).

Table. 9: Perception of the participants on indicators of rangeland degradation

No.	Criteria	Indices	Perception of the participants (5-point Likert scale)		
			Pastoral N=74	Agro pastoral N=74	Combined N=148
1.	Vegetation	Reduction of plant production	3.00	3.05	3.0
		Loss of biodiversity	4.00	3.72	3.9
		Loss of palatable plants	2.99	2.83	2.9
		Increasing of number of non-palatable and poisonous plants	3.76	3.53	3.6
		Reduction of shrubs and perennials	3.47	3.29	3.4
		Reduction of annual plants and forbs	2.33	2.4	2.4
		Reduction of vegetation cover	2.33	4.23	3.3
		Increasing of plants intervals	3.33	3.42	3.4
		Loss of litter	3.23	3.25	3.2
2.	Soil	Soil salination	2.21	2.95	2.6
		Reduction of soil infiltration	2.68	3.42	3.1
		Increase of bare soil	3.13	2.76	2.9
		Clayey soil	3.06	3.14	3.1
		Loss of soil darkness	3.78	3.22	3.5
		The sandiness of the soil	1.2	1.2	1.2
3.	Climate	Reduction of rain fall	2.68	3.46	3.1
		High and low temperatures	3.14	3.62	3.4
		Reduction of water resources	3.67	5.00	4.3
3.	Others	Increase of water resources spacing	4.50	5.26	4.9
		Increased risk of wildfires	2.30	2.12	2.2
		Increased risk of pest damage (such as rats and grasshoppers)	1.25	1.35	1.3
		Overall average	2.82	3.06	2.9

Variation in perception between experts and rangeland users leads to restrictions on the successful implementation of range management plans.

Due to a long history and experience, pastoralists have a comprehensive and accurate body of knowledge about their own pastoral systems and rangelands' conditions. Therefore, it is recommended that sustainable range management systems are based on a combination of indigenous ecological knowledge of local Communities and scientific knowledge to prevent degradation of rangelands (Khwarae, 2006). In this regard, pastoralists and herders have better and unique knowledge on the trends of their rangeland. Based on the pastoralists' indigenous knowledge of rangeland degradation estimation (5-point Likert scale) it is possible to estimate and talk about the rangeland degradation trend and their effort made to improve it so far (Table 9). In this study, the rangeland users were highly considered loss of biodiversity and "reduction in plant production as well as limitation of water resource potential as priorities for assessing rangeland degradation. Study by Ahmad *et al* (2012) confirmed that the rangeland degradation indicators vary from region to region, but reduction of plants production is one of the main symptoms of rangeland degradation. Using these main symptoms as indicators, 93% of the respondents have indicated that their rangeland is under severe risk in both pastoral and agro-pastoral areas.

CONCLUSION AND RECOMMENDATION

Before three decades the livelihood activities of the local communities in this area was totally pastoralism and the potential of this ecosystem was tremendous, with high biodiversity, good water resources and sufficient grasses and browses. In addition to livestock production only few activities like bee keeping and maize cultivation for family consumption had been practiced. During that time the community was stable and income from Pastoralism activity was sufficient for family need in the area despite the unexpected conflicts between government and clans that frequently occurred in the area.

However, the recent deforestation, expansion of cultivated land and settlement, conflict on water, grazing land and border dispute and administration change has brought a lot of negative change in the area. Herding patterns were seriously affected by expansion of crop production, high human population growth and establishment of the Bale Mountains National Park. Due to these factors different destination with high sources of mineral water and soil, grazing area for different season and good breeding niche for livestock was lost. In addition this pressure was also hindered pastoralists mobility.

The rangeland ecosystem in the area was disturbed and pastoralism is replaced by drought susceptible livelihood activities such as crop farming. This in turn caused severe livestock losses due to shortages of feed, water, mineral licks and disturbed animal breeding niche. The overall disturbance of ecosystem was highly influenced livelihood of the communities and poor resilience after drought in the area has exposed residents to frequent food aid.

Therefore, to limit the current crises of BER in particular and south east Ethiopian rangelands in general the following points have to be considered by community and all stakeholders:

- The feasibility of investment activities planned in lowland areas has to be seriously considered in relation to social and environmental feasibility.

- In lowland of BER the influx of settlers and illegal settlement and expansion agricultural land is the main bottle necks to rangeland rehabilitation. Hence, there must be a clear policy of land uses and livestock development in pastoral areas.
- The current running soil and water conservation activities by the government lacks coordination or involvement of stakeholders, skilled human power and lacks integration of biological materials in the developed conservation structure.
- Mobility is a purposive movement, which supports pastoralists to fulfill the requirement of their livestock through the year. In numerous VAs of BER currently mobility of pastoralists is hindered by influx of settlers, expansion of crop land, expansion of private enclosure "*kalo*". A number of Mineral water and Mineral soil places are now controlled by private individuals and National parks. This has hindered the activity of mineral supplementation of pastoralists to their animals. Lack of micro-minerals in animal feeds affects the production and reproductive activity of livestock in many ways. To fill this gap the exact minerals that pastoralists had been utilizing has to be identified and the way to supply these minerals has to be devised.
- During this study the elders have indicated that a number of native grass species, forage trees, shrubs and herbaceous legumes have endangered. To sustain the existence of these materials and further collection of the material has to be carried out and tested on experiment sites to for continued utilization of the materials.

ACKNOWLEDGEMENT

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Fishery Research Results

Establishment of medium scale spirulina farm and Determination of Growth rate

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Abstract

The pilot scale cultivation of Spirulina isolates was evaluated on station at Batu fish and other aquatic life Research Center.The evaluation was in a raceway pond (10.0 m long×3.0 m wide×0.50 m high), with a surface area of 37.10 m^2. The raceway pond was cement lined and covered by a greenhouse structure constructed from transparent polyethylene film.The mean water temperature was 29ºC, ranging from 24-35ºC during the day time.The pH of the raceway culture was adjusted to over 10.0 for the initial culture, using Na_2CO_3 to minimize or delete any contaminant organisms. Thereafter, the pH increased to 10.94 ± 0.15 and the fluctuation was minimal.The algal inoculum was started at 0.79 µg/L and increased to 224 µg/L by day 13. The chlorophyll a concentration increased linearly from day 5 to reach 224 µg/l on day 13, and then decreased sharply to 198 µg/l by day 16, yet no decreases were found, except for those during the initial days of culture. Therefore, this pilot scale can be scaled for production.

Keywords:outdoor cultivation, raceway culture, *Spirulina platensis*, underground water

Introduction

Increase in world population and the forecast of insufficient protein supply have spurred research into alternative food sources (Spolaore et al., 2006) and many studies have investigated the potential of microbial protein for use in human and animal foodstuffs. Spirulina is 60-70% protein by weight and contains a rich source of vitamins, especially vitamin B12 and provitamin A (β-carotene), and minerals, especially iron. One of the few sources of dietary γ-linolenic acid (GLA), it also contains a host of other phytochemicals that have potential health benefits (Belay, 2002).

Pre-clinical and clinical studies suggest that the consumption of Spirulina biomass has therapeutic effects such as reducing blood cholesterol, protecting against some cancers, reducing drug and heavy metal nephrotoxicity, hyperlipidemia and obesity (Becker, 1986). Hirahashi et al. (2002) reported that aqueous extracts of Spirulina platensis partially inhibited the replication of HIV-1 in human cells.

Spirulina platensis (Gom.) Geitl., renamed as *Arthrospira fusiformis* (Voronich.) (Kebede, 1997), is a filamentous, helicoidal cyanophyte, and cosmopolitan in distribution.Spirulina, has the ability to grow under autotrophic, mixotrophic and heterotrophic condition (Kim et al., 2007; Ogbonda et al., 2007). Outdoor production of spirulina is influenced by solar radiance in the photosynthetically active range, pH, presence of contaminants, temperature, dissolved oxygen concentration, salinity, mixing and nutrient availability (Vonshak, 1997). Commercial production involves cultivation of Spirulina in open pond raceways. The outdoor cultivation of Spirulina has limitations mainly due to lack of control over key growth parameters including light intensity, temperature and dissolved oxygen concentration (Chaumount, 1993). Owing to its ability to grow under fairly high alkaline conditions, it can be cultivated in open-air cultures and can remain largely free from contamination by other microorganisms (Chaumount, 1993).

Despite the presence of spirulina in Ethiopian rift valley lakes, the growth rate and production potential of the algae has not been studied in open ponds in Ethiopia. The objective of the research was to evaluate the feasibility of the pilot scale constant-volume semi continuous production of biomass from Spirulina strain isolated from Lake Chitu in Ethiopian Rift valley using ground water supplemented Zarrouk Medium.

Materials and Methods

The experiment was developed in several phases. The first phase involved production of large volumes of the inoculum in the laboratory. This required scaling-up the volumes from 20 ml to 20 l. Spirulina strain was maintained and cultivated in the Zarrouk medium described by Costa et al. (2004), which contained (g L^{-1}) the following: $NaHCO_3$ (16.80), $NaNO_3$ (2.50), NaCl (1.00), K_2HPO_4 (0.50), K_2SO_4 (1.00), $MgSO_4{\cdot}7H_2O$ (0.20), $CaCl_2$ (0.04), $FeSO_4{\cdot}7H_2O$ (0.01), and EDTA (0.08). Agitation of the cultures were performed either by orbital shaking in water bath or by bubbling air (only for culture volumes >2 L). light was provided continuously by fluorescent lamps.The second phase was performed outdoors using a raceway pond. Inoculation of the raceways followed the scaling-up sequence described by Borowitzka and Borowitzka (1989).
The pilot plant for production of Spirulina is located at Batu Fish and other Aquatic Life Research Center, the production pond (**Fig 1**.) is a raceway pond (10.0 m long×3.0 m wide×0.50 m high), with a surface area of 37.10 m^2. The raceway pond was cement lined and covered by a greenhouse structure constructed from transparent polyethylene film. The raceway was agitated by a paddle wheel rotating at 20 rpm 12 h per day. The experiment was carried out from June 2018 to August 2018 when the water temperature ranged from 23.9 °C to 33.7 °C

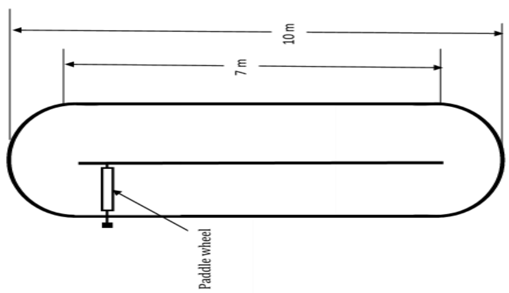

Fig 1 Pilot scale raceway pond at Batu Fish and Other Aquatic Life Research Center

The volume of culture media was maintained by the periodic addition of filtered ground water supplemented by 20% Zarrouk Media to compensate for evaporation, over the course of the experiment.

Chl-a was determined spectro photometrically using 90% acetone as an extraction solvent. 200mL culture was filtered through 47 mm diameter Whatman filter papers (GF/F) with the help of an electrically operated suction pump. To extract Chl-a, the filters were left overnight in the dark after the addition of a small volume of 90% acetone. The filter was then ground using a tissue grinder and the extract was subsequently centrifuged at 3000 rpm for10 min. The optical density (absorbance) of the extract was measured at 665 and 750 nm with UV-Vis spectrophotometer and Chl-a concentration, uncorrected for degradation products, was determined according to Talling and Driver (1963).Biomass production (B, mg L^{-1}) was calculated as the change in biomass per volume of sample filtered (Colla et al. 2007).

The biomass concentration values in the production tanks were used to calculate the maximum biomass dry weight (Xmax, g L^{-1}) and the maximum biomass productivity (Pmax, g m^{-2} d^{-1}) was calculated as Pmax =(Xt−Xo)·(t−to)$^{-1}$, where Xo is the initial biomass concentration (g L^{-1}) at time to (d) and Xt is the biomass concentration (g L^{-1}) at any time t (d) subsequent to to (d) (Schmidell et al., 2001). The mean productivity (P, g m^{-2} d^{-1}) was calculated as the mean of the productivity's values (Bailey and Ollis, 1986).

The μmax was calculated by applying linear regression to the logarithmic growth rate of each culture, obtained from a plot of ln X (g L^{-1}) versus t (d). The doubling time (Dt) was determined in the exponential growth phase for each culture by using the equation Dt = ln2/μmax.

Results and discussion

During the raceway cultivation of *S. platensis*, the mean water temperature was 29ºC, ranging from 24-35ºC during the day time (Fig. 2). This was low, considering that S. platensis favors a high-water temperature, ranging from 30 to 38ºC for optimal growth (Belay 1997). However, the optimum temperature range for the growth of *S. platensis* is variable and strains can differ both in their optimal growth temperature and their extreme temperature ranges (Vonshak, 1997). For example, Richmond (1990) reported that during outdoor cultivation the minimal temperature for the growth of S. platensis was around 18 °C and that cultures deteriorated quickly when the maximum day-time temperature was below 12 °C. However, other lower temperature limits can exist for different Spirulina species or strains, with Jimenez et al. (2003) having reported that cultures of Spirulina grew in the Spanish city of Malaga at temperatures ranging from 9 °C to 28 °C.

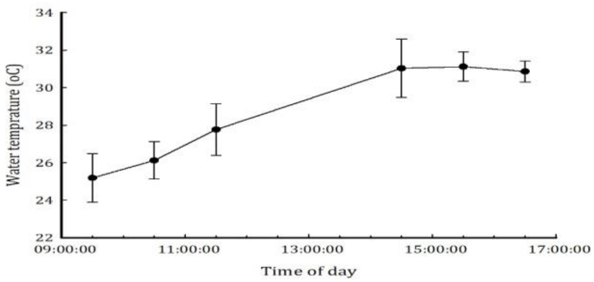

Fig 2 Durnial temperature fluctuation during culturing

The pH of the raceway culture was adjusted to over 10.0 for the initial culture, using Na_2CO_3 to minimize or delete any contaminant organisms. Thereafter, the pH increased to 10.94 ±0.15 and the fluctuation was minimal. According to Vonshak (1997) the pH optimum for Spirulina ranges from pH 9.5 to pH 10.5, with a reduction in cell numbers occurring at pH 8.0 and below. Jimenez et al. (2003) report that pH 9.5 and above is ideal for pilot scale cultivation of Spirulina, with their Spirulina cultures in Spain having pH values of pH 9.0 to 10.9, similar to the pH 10.9 seen in our raceway tank.

Outdoor cultivation is usually influenced by bacterial contamination (Hoffman et al., 2008). These microorganisms influence negatively the microalgal growth and the quality of the product (Richmond, 2000), being most significant in intensive outdoor mass cultures, where the microorganisms can compete for nutrients, and graze upon the microalgae, reducing drastically the commercial production (Ugwu et al., 2008).

The algal inoculum was started at 0.79 µg/L and increased to 224 µg/L by day 13 (Fig. 3). The chlorophyll a concentration increased linearly from day 5 to reach 224 µg/l on day 13, and then decreased sharply to 198 µg/l by day 16, yet no decreases were found, except for those during the initial days of culture (Fig. 3).

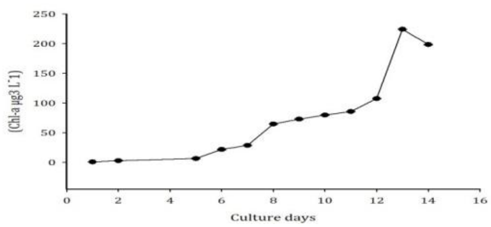

Fig 3.Mean growth (n=3) curve based on chlorophyll a of Spirulina platensisin raceway pond

In the raceway tanks Spirulina isolates from Lake chitu presented a maximum biomass of 1.44 g L−1 a maximum productivity (Pmax) of 74.18 g m^{-2} d^{-1} and mean biomass productivity (P) of 27.58 g m^{-2} d^{-1}, although the productivity decreased with time.

Conclusion

The pilot scale cultivation of Spirulina strain from lake Chitu was cultivated for three months in central Ethiopian rift valley in south of days and indicates that this strain is resistant to fluctuations in environmental conditions such as temperature, which varied between 23 °C and 30 °C. The pH was maintained at 10.7. The ground water used to indicate that supplementing Spirulina culture with Zarrouk medium is helpful in algal growth. Commercial microalgal culture is a well-established industry. Most of the culture systems in use today are open air and relatively unsophisticated. However, over the last 50 years great advances have been made in our understanding of the biology of the algae and in the engineering requirements of large-scale algae culture systems. This study being the first out door culture in the country refinement work is needed to optimize growth and medium.

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Growth performance of common carp (Cyprinus carpio) at different agro ecologies

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Abstract

Common carp (Cyprinus carpio) is one of the promising aquaculture fish species next to Nile tilapia being cultured at farmers level in all agro-ecologies within Oromia with a number of challenges. Water temperature which varies with varying altitude of land in Ethiopia is among the major growth factor for fish. The current experiment was aimed to evaluate the growth performance of common carp at different altitudes having different agro-ecological characteristics. Fish ponds found at three different agro-ecologies namely lowland represented by Gidara at altitude of 1000 m a.s.l., mid-altitude represented by Wonchi/Walga at altitude of 2050 m a.s.l. and highland represented by Debre Tsige/Wakene at altitude of 2600 m a.s.l. The carps were stocked at average total weight of 4.8 - 6.1 gm with stocking densities of 1.7 to 1.8 carp per m^2in November 2016. The fish were fed with mixture of wheat bran and noug cake at feeding rate of 3% of their body weight twice a day. Water temperature, transparency and fish weight data were collected duringsixexperimental months. Water temperature and transparency were found to differ in ponds of different agro-ecologies. Growth of fish in terms of monthly mean weight increment was analyzed against the prevailing growth factors' levels at the agro-ecologies. Growth of carp was limited by higher water turbidity, shallower than 12 cm secchi transparency at lowland; lower water temperature of below 16 ºC and higher secchi transparency at highland pondsin months of November-February, while both lower water temperature and higher water transparency limited growth at mid-altitude. Hence, growth of carp at highland and mid-altitude agro-ecologies can be enhanced by using dipper ponds to maintain water temperature in preferable range during the cold months and fertilizing ponds to enhance water turbidity. Higher water turbidity at lowland is better minimized by minimizing water disturbances by animals and using filter and sediment pond before filling the fish pond.

Key words*: Agro-ecology, Cyprinus carpio, growth, transparency, water temperature*

Introduction

Agriculture is a backbone of Ethiopia's economy with about 80% of the population involved in the business. However, productivity of the traditional farming system is poor at farmers' level, leading to nutritional insecurity and foodself-insufficiency in some parts of the country.Productivity and sustainability of traditional rain fed agriculture at smallscale farmers level has been challenged by recurrent drought in some parts of Ethiopia,affecting the food and nutritional security goal of the country.To mitigate the problems, increasing productivity of the farms through intensification by applying technologies in one hand and diversifying agricultural products on the other hand are better approaches. With this regard, development of aquaculture in the country is a potential but not utilized sector to enhance protein food supplyfor the society (Mulugeta Wakjira*et al.*, 2013).

Aquaculture activity was started in Ethiopia some sixty-three years ago in 1955 when ponds were constructed around Bishoftu and Akaki, for fish growth observation (FAO SFE, 2009). Later in the 2008, extension of fish pond culture started in Oromia mainly in West Shoa Zone at farmers plot by the assistance of Oromia Livestock development, health and marketing agency, Sebeta National Fisheries Research Center and Ziway Fisheries Resources Research Center where Nile tilapia and tilapia Zilli were stocked to the ponds in 2008 (DabaTugie, 2010).Since then, fish pond culture has been expanding in all zones of Oromia region with a lot of productivity challenges in relation to fish genetics, management and adaptability to environmental conditions (feed and water quality) as experts and farmers complain at different districts.

Common carp (*Cyprinus carpio*), next to *Oreochromis niloticus* and *Clarias gariepinus*, is a candidate fish species in the development of Ethiopian aquaculture, which has been started at extensive farming level in earthen ponds among farmers (Megerssa Endebu *et al.*, 2016). In pond culture, growth performance of fish is determined by many factors, of which water temperature (Oyugi *et al*., 2012) is among the major ones. Though Carps prefer low temperature for spawning, higher temperature is desirable for good growth (Sapkale and Singh, 2013).

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Water temperature in Ethiopia is affected by altitude, agro-ecologies where by the ambient temperature decreases along with the altitude. With respect to the expansion of carp pond culture at different agro ecologies, though difficult to compare different culture conditions, it was observed that growth rate varied with the varying altitude. Growth at higher altitude (at Debre Tsige) under monoculture without integration was very slow (Daba Tugie and Tokuma Negisho, 2011) while the growth rate of the common carp under poly culture with tilapia and integrated with poultry at Metehara, lower altitude was faster (Megerssa Endebu *et al.*, 2013). Growth performance of the fish under similar culture condition in different agro ecology was not determined for carp. Thereforethe aim of the current experiment was to determine the growth performance of common carp in pond culture at different altitudes, and to identify the factors limiting growth of fish at different agro-ecologies.

Materials and methods

Study area

Three sites (table 1) representing three altitude based agro-ecologicalcategorise namely lowland (*Gammoojjii*) in East Shoa zone, mid-altitude (*Badda-daree*) in South west Shoa zone and highland (*Baddaa*) in North Shoa zonewere selected as experimental sites. The experimental sites were Fentale (Gidara) at altitude of 1090 m.a.s.l. in the low land,Wonchi (Walga) at altitude of 2050m.a.s.l. in the mid-altitude range and Debre Lebanos (Wakene FTC) at altitude of 2600m.a.s.l. in highland ago-ecology range.

Existing fish ponds (figure 1) of pond area 100 - 160 m^2 were used for the experiments; these ponds were in standard pond size range (Kumar *et al*., 2014) though they were below the minimum production pond sizerecommended for family ponds (FAO, 2005).

Figure 1. Experimental ponds at Gidara, Walga and Wakene FTC.

The fish

Juveniles of carp (*Cyprinus carpio*) were collected from Koka reservoir by hauling seine net in a shore area, in November 2016. The carps were then transported to the experimental sites, in oxygenated plastic bags and stocked into the prepared ponds. Average size at stocking was 5.2 g, 4.8 g to 6.1 gm total weight (table 1, size not significantly different at stocking), with stocking densities of 1.7 to 1.8 carp per m^2(Kumar, 2014). The fish were fed with mixture of wheat bran and noug-cake at feeding rate of 3% of their body weight twice a day throughout the experimental period.

Table 1. Summary information on the experimental sites

Agro-ecology	**Lowland (*Gammoojji*)**	**Mid-altitude (*Baddadare*)**	**Highland (*Badda*)**
Zone, District	East Showa, Fentale	S/West Showa, Wonchi	DebreLibanos, North Showa
Experimental Site	Gidara	Walga	Wakene FTC
Altitude (m.a.s.l.)	1090	2050	2600
Pond area m^2	120	160	100
Water source to ponds	Modern irrigation canal diverted from Awash river	Traditional irrigation canal diverted from Walga river	Spring developed near the pond
Source of fish	Koka reservoir	Koka reservoir	Koka reservoir
Size at stocking	5.20 ± 1.66g/fish	4.80±1.76 g/fish	6.10 ± 1.77 g/fish
Stocking density	1.8 carp/m^2	1.7 carp/m^2	1.8 carp/m^2

Data collection

Water quality parameters in the fish ponds were measured monthly during the seven months of experimental period.

Fish growth parameters such as weight (to 0.1 cm) were recorded monthly by sampling at least 30% of the fish in the pondsup to six months. Simultaneously, water transparency and water temperature were also measured along with the fish data.

Data Analysis

Descriptive statistics was used to analyse the water quality parameters at the ponds during experimental months. Monthly growth of the carps in terms of mean weight at different altitude was described in tables.The difference in mean weight of carps at each month during the experimental period was analysed by one-way-ANOVA and monthly mean weight differenceswere identified by Tukey HSD post Hoc Test at statistical significance level of 0.05 in SPSS software.

Results and discussion

Water temperature

Water sources for the experimental ponds varied at the three experimental sites. The pond at Gidara (lowland) received water from irrigation canal diverted from Awash river (turbid water), the pond at Walga (mid-altitude) received water from irrigation canal diverted from Walaga river (clear water coming from Wonchi Lake) while the pond at Wakene FTC (highland) was a spring near to the pond.

Water quality parameters such as temperature, secchi depth; and zoo and phytoplankton abundance were assessed in this experiment as these parameters influence the fish growth. The results recorded during the growth period were given in graph (figure 2 & 3).Average water temperature was driven from temperatures measured at 8:00-10:00 am and 2:00 to 4:00 pm at depth of 25-30 cm. Lowest average water temperature recorded during the culture period was in January while the highest was in May for all the three agro-ecologies. The lowest water temperatures were 18.5^0C, 15.5^0Cand 13.0^0C while the highest average water temperatures were 26^0C, 21^0C and 17 ^{0}C at lowland, mid-altitude and highland ponds respectively.

The water temperature decreased as the altitude increases in all the culture months (figure 2) like the ambient temperature does.

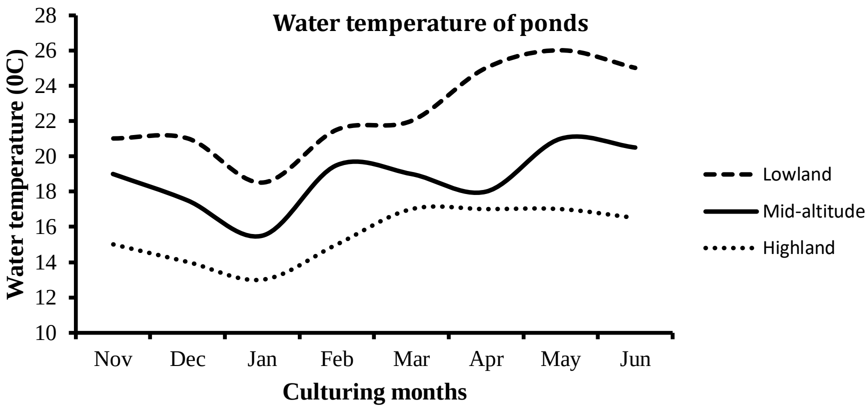

Figure 2. Average water temperature measured from 8:00 to 10:00 in the morning and 2:00 to 4:00 pm in the afternoon at depth of 5-15

Carps normally can survive in temp range of 2ºC– 40ºC, prefer a temperature range of 15ºC-32^{0}C (Edwards and Twomey, 1982), and the optimum requirement in wild is from 20ºC–28ºC(FAO, 2005)

Water transparency as measured by secchi depth in ponds at three different agro-ecologies

Source of water at Gidara, the lowland was Awash river which was diverted for irrigation purpose. The water at Gidara was relatively turbid by its nature and the turbidity aggravated by disturbance of animals and irrigation users in the upstream, effect reflected with lower transparency in the fish pond (figure, 3).

Similarly, source water at Walga site, the mid-altitude was an irrigation water diverted from Walga, a river running downhill from Lake Wonchi (a crater lake at altitude of 2,887 m a.s.l.) and tributaries in its surrounding. The experimental site has a wetland nature that the inlet water coming to the experimental pond was mechanically and biologically filtered by wetland vegetations in the canal and periphery of ponds.

Pond water at Debre-Tsige had higher transparency, except during rainy days when the pond water turned turbid because of flood effects like in the 6th month of culture period (figure 3). The source of water at Debre-Tsige/Wakene FTC was pure spring water from immediate distance and contributed for the water clarity. Furthermore, a mat of spirogyra algae flourishing in water canal and in the pond helped filtering the turbidity.

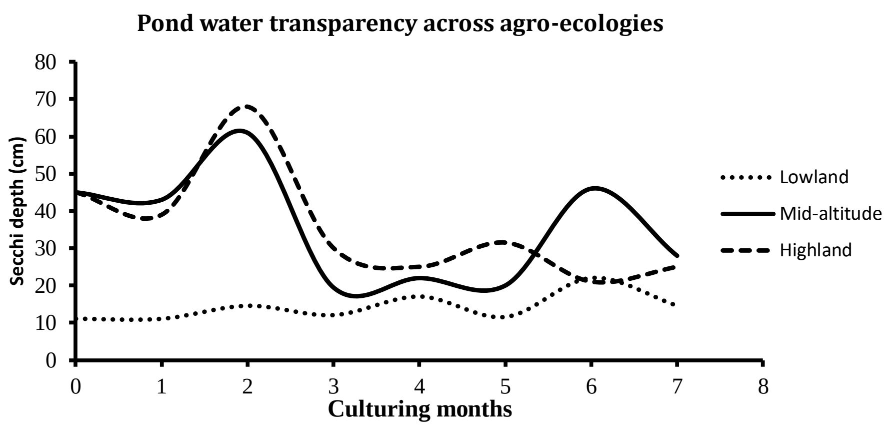

Figure 3. Water transparency as measured by secchi depth (cm).

Measured in secchi depth, water transparency range from 30-80 cm is good for fish health; 15-40 cm is good for intensive culture system and < 12 cm causes stress to fish (Bhatnagar *et al.*2004).

Plankton

Plankton abundance and diversity in water samples taken from the fish ponds were analysed in the laboratory of Batu Fishery Research Center. Higher phytoplankton species diversity was observed in the fish pond at lowland while it was less in mid-altitude and highland pond (table 2). Filamentous algae, the spirogyra, was very invasive and colonized the pond at highland. Zoo planktons were found in fish ponds at all the three experimental sites. The oligochite and gastro-tricha larvae found in ponds at the highland were possible live foods for the carps to support their growth. Insect larvae were found at all the three sites but not quantified during this experiment.However, the planktons have lower importance in diet of the common carps as compared to detritus, insects and macrophytes food categories in natural environment (Elias Dadebo*et al.*, 2015). Hence, the difference in plankton diversity and abundance in fish ponds at the three experimental sites may not significantly affect the growth of carps as supplementary feed given to the carps at all the three experimental sites were similar, and the amount of food supplemented to the fish adjustedmonthly based on the average fish size in the ponds measured every month.

Table 2. Plankton diversity and abundance in the fish ponds at the three experimental sites

	Gidara (Lowland)	**Walga(mid-altitude)**	**Wakene FTC (highland)**
Algae	Mycrocystine,	Volvox	Desmids

	chlorophyceae, scenedesmus, desmids, Relatively higher diversity but not abundant	Diatoms Filamentous algae Poor diversity and abundance	Filamentous algae (dominant in pond) Poor algal diversity
Zoo plankton	Paramcium Rotifer	Paramecium Euglena Daphnia	Rotifer Gastrotricha larvae and oligochite

Growth performance in total weight of common carp across agro-ecologies

The carps average weight was recorded monthly and given in table (table 3). Though average sizes of the carps at stocking was nearly similar at the three experimental sites, the growth change in size (weight, g) was not similar. Monthly growth rate of the carps differed from site to site irregularly (table 3) with the highest mean weight of 77.16±21.89 g/fish at highland and lowest of 47.69±21.19 at mid-altitude. These irregularity in growth of the carps across the culture period at the three experimental sites were perhaps attributed to the differences in growth factors at the sites.

Table 3. Carp growth in weight (g), monthly mean ± S.D. at the three experimental sites

Culturing month	Lowland (Gidara)	Mid-altitude (Walga)	Highland (Wakene FTC)
November	5.20 ± 1.66	4.80±1.76	6.10±1.77
December	11.24 ± 3.85	7.77±2.71	9.86±1.91
January	14.47 ± 3.17	8.39±2.72	10.36±2.35
February	26.64±5.46	11.38±3.45	14.10±3.51
March	38.76±5.11	23.11±5.56	20.79±4.82
April	42.71±8.30	31.10±14.97	33.43±11.40
May	52.75±10.77	34.25±15.8	55.00±19.49
June	62.07±11.75	47.69±21.19	77.16±21.89

It is important to analyze the growth performance of the carps at the three agro-ecologies in relation to the prevailing growth factors at the sites monthly.

Carp growth, water temperature, transparency and fish growth at the three agro-ecologies

In order to critically identify whether growth exists each month in the experimental ponds, mean comparison was made for each month in one-way-ANOVA in SPSS software. The one-way-ANOVA showed that there was significant (p=0.00) difference between monthly mean weight during the six months of culture period at all the three agro ecologies. The difference in mean weight (g) at each consecutive month was then further identified by Post Hoc Test using Tukey HSD multiple comparison test at significance level of 0.05. The ANOVA result was then compared against the factors' level in the ponds during those months (table 4).

In low land agro-ecology, at Gidara, there was no significant ($p>0.05$) growth of carp between months of November & December, December & January and March & April while significant ($p=0.00$) change in mean weight observed between months January & February, February and March, April & May and May & June (table 4). The average water temperature at Gidara ranged between 18.5 ^{0}C and 26.0 ^{0}C while the water transparency measured in secchi depth ranged between 11cm and 22 cm during the experimental period. The temperature was within the preferable range for the carps, however, the water transparency as measured in secchi depth was below12 cm, which causes stress to fish (Bhatnagar *et al.*2004), in months of November, December and April during when the mean carp weight increment recorded wasnot significant (table 4).At the lowland agro-ecology, growth of carp was mainly affected by water turbidity.

In the mid-altitude agro-ecology, at Walga experimental site, significant ($p < 0.05$) growth in terms of mean weight increament between consecutive months was observed between months February & March, March & April and May & June when the water temperature and water transparency were within preferable range (Table 4). Growth of carp at mid-altitude was retarded by lower water temperature and/or higher water transparency (low pond productivity) during some months.

At highland agro-ecology, water temperature ranged between 13.0^{o}Cand 17.0^{o}Cwhile the water transparency measured in secchi depth ranged between 21 cm and 68 cm. The growth of carps was not significant ($p> 0.05$) between the consecutive months fromNovember to March when the water temperature was below 16^{o}Cand water transparency above 40 cm secchi depth (table 4). When the water temperature improved to above 16^{o}C, transparency (productivity) became within the optimum range and growth rate of the carp increased with significant average weight differences between months March to June.

Table 4. P-value (mean fish weight difference between consecutive months), average water temperature (^{o}C) and secchi depth transparency (cm) at mid month.

(I) - (J)	**Lowland**			**Mid-altitude**			**Highland**		
Experimental months	P-value, mean fish weight	T^{0}C	Secchi (cm)	P-val	T^{0}C	Secchi (cm)	p-val	T^{0}C	Secchi (cm)
Mid-November		21.0	11.0		19.0	45.0		15	45
Nov- December	0.31	21.0	11.0	0.99	17.5	43.0	0.97	14.0	46.0
Dec - January	0.59	18.5	14.5	1.00	15.5	61.0	1.00	13.0	68.0
Jan - February	0.00*	21.5	12.0	0.95	19.5	19.5	0.78	15.0	30.0
Feb - March	0.00*	22.0	17.0	0.01*	19.0	22.0	0.13	17.0	25.0
Mar - April	0.44	25.0	11.5	0.03*	18.0	20.0	0.00*	17.0	31.5
April - May	0.00*	26.0	22.0	0.90	21.0	46.0	0.00*	17.0	21.0
May - June	0.00*	25.0	14.5	0.00*	20.5	28.0	0.00*	16.5	25.0

* $p<0.05$ at alpha 0.05

Conclusions and Recommendations

Growth of carps was affected significantly by water temperature and water transparency. Mean weight increment observed at water temperature above 16^{0}C and water transparency between 15-40 cm secchi depth. The two factors differ in ponds of different agro-ecologies. Water temperature drops below 16 ^{0}C at highland in months of November, December, Januaryand February while water transparency was higher than the recommended range in similar months.Similarly, at mid-altitude, water temperature were below 16 ^{o}C in early January and water transparency became high above 40 cm in November, December and Januaryduring when the growth of carps was not significant in weight increment. Higher water turbidity in fish ponds, sourced from disturbed irrigation canal,deposited in pond bottom, limited the growth of carp at lowland,regardless of temperature being in a preferred range.

Hence, inorder to improve growth of carp at highland areas during cold moths of November-February, it is better to use deep ponds (about 2 m depth) to maintain temperature and improve pond productivity through fertilization using poultry manure, cattle manure or urea. Within the optimum range of temperature at lowland and mid-altitude, maintaining water quality (within secchi depth transparency of 15-40 cm) by controlling quality of inlet water and pond fertilization improves fish growth.

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Evaluation of recycle plastic bottles as a fishing boat in Lake Ziway

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Abstract

The increasing numbers of waste plastic bottles over the years has created environment issue across the world in general and in the study area in particular. While, the recycled bottled for different purpose shows not an increasing rate and the recycled rate is far less behind the wasted rate. A study was made to assess the speed of the waste plastic bottle boat that swift km/hour and the cost of the boat as compared to the traditional wooden boat."Selam" brand of plastic mineral water bottle was the most preferred around the study area and suitable to make the fishing boat due to its shape.2290 pcs of Polyethylene Terephthalate (PET) mineral bottles having the capacities of two litters and white thin cord of 0.5 mm diameter were used to construct the boat. The result indicates the boat that made up of plastic bottle traveled with on average (4.51 ± 0.11 km/h) as compare to wooden boat (4.04 ± 0.12 km/h). The cost of plastic bottle was kept as zero against the average cost of timber that needs 4,000 ETB to make one boat according to present market rate. However, additional estimation also needed to further refine with respect to durability and other related issues.

Key words: Boat, coast, polyethylene terephthalate mineral water bottle, speed.

1. Introduction

In the world, 40 million of waste plastic bottle are throwing away a day (Alma *et al*., 2016). This plastic bottle wastes poses serious environmental pollutions and health problems in humans and animals. Burning plastics releases toxic and potentially cancer-causing chemicals into the air during burning. The smoke and ash can irritate eyes and lungs, which is especially bad for people with asthma or heart disease. However, with the increasing trend in the use of bottled water instead of tap water by consumers of around rift valley area at work and recreation centers regardless of due care on environmental effect of the plastic package of the bottled water after use. Besides, there is growing social pressure for organizations to reduce their rates of consumption of nonrenewable natural resources and in parallel, to also reduce the release of post-production and post consumption waste to landfills, water bodies and air, thereby causing damage to the environment. To respond to the pressure, it is necessary that organizations' operations prioritize the "3R" goals: Reduce, Reuse and Recycle (Correa H. and Xavier L., 2013).

Since, the waste plastic bottle has a trend of increasing over the year in Ethiopia. While, the bottles recycled for different purpose show not an increasing trend, the recycle rate is far less behind the wasted rate.

Two alternative solutions against the plastic bottle disposal are recycling and reusing process. Recycling needs additional energy to treat the materials for producing something usable. Moreover, the recycling process produces wastewater and air pollutants. So, the best solution is reusing for which no additional energy is required and does not contribute to pollution. It is focused on not only the financial aspect but also the environmental aspect.

In addition, the boat that made from the timber is noticed to have high possibility to crack at the different side of the boat and the consequence is the boat sink and fails to act as a fishing boat. To overcome this problem, there is an idea to design and test the boat that made up of polyethylene terephthalate mineral water bottle as fishing boat.

Fig. 1**:**Polyethylene Terephthalate mineral water bottles that collected after used

On the other hand, there is a shortage of timber for making wooden boat in the area as well as in the country in general and there were two factors that prevent aboriginal people from making their own fishing boat that are high cost of constructing materials and labor for construction. One of the solutions for this problem can be use of affordable recycled materials. As indicated in figure 1, such plastic bottles are dropped by users after drinking the liquid parts and in the long run may impacts on the environment. Hence, recycling of such materials for different purposes, like for boat is economically and environmentally important. Therefore, the objective of this paper is to investigate the cost of the boats as compared to the traditional wooden boat used by the fishermen and to evaluate the speed of the boat that swift km/hour.

2. Materials and Methods

2.1. Materials

Recycled materials of 2290 pcs of Polyethylene Terephthalate (PET) mineral bottles "Selam"brand of 2 litter capacities were collected to make the fishing boat from Battu town (Figure 2). This material donot react with oxygen and carbon dioxide and there is no risk of pollution to the water of the lake.

Fig.2: “Selam” plastic bottle

White thin cord of 0.5 mm in diameter was used to tight the plastic bottles together; and flat timbers were also used for make the floor of the boat.

2.2. The design of fishing boat

The design of the boat was described in figure 3 and 4.

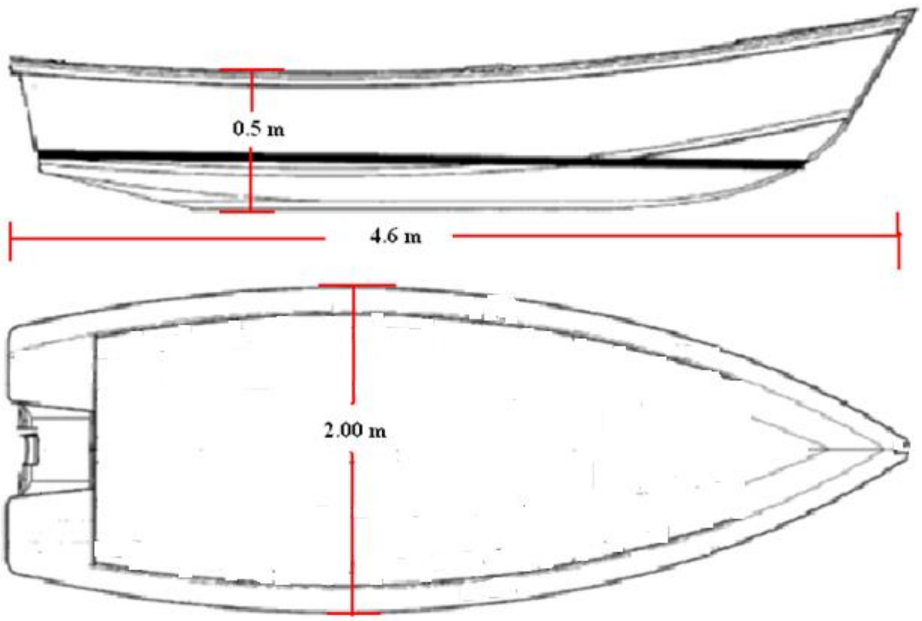

Fig.3: The design of the boat

Fig.4: The boat that is made up of west plastic bottle

The boat design was inspired by Archimedes Principle and the Archimedes principle indicates that “the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces”(Faturachman *et al.,* 2012). The weight of the waste bottles arrangement acts horizontally (Figure 4), and the buoyant force provided by the displaced fluid acts upward. If these two forces are equal, the plastic bottle boat floats. Density is defined as weight per volume. If the density of an object exceeds the density of water, the objects will sink (Faturachman *et al.,* 2012). The boat buoyancy was tested in Lake Ziway with different level of wave action.

2.3. Questionnaire survey

The type of questioner that was conducted in the study area was semi-structured questionnaire. The content of the questionnaire prepared to interview the respondent includes, general questions related to packed water that used with brand,drink preference of bottled water and area used to disposal the plastic bottle.

2.4. Site selection

Before starting to test and drive the plastic bottle boat in the lake, Global Positioning System (GPS) was taken to demarcate the locations of the area, which is presented in Table 1.

Table 1. Some characteristics of the site

Location of the study site		**Relative location**
Latitude	Longitude	

$07^{0}54.79'$ N	$038^{0}144.111'$E	South-west part of the lake

The site was located in the South- western part of the lake (Table 1 and Fig.2.) and the area relatively characterized by high wind pressure and water current/wave. The average depth of the site was between 1.5 to 2meterswithin 0.5 to 1.5 km distance of offshore of the lake.

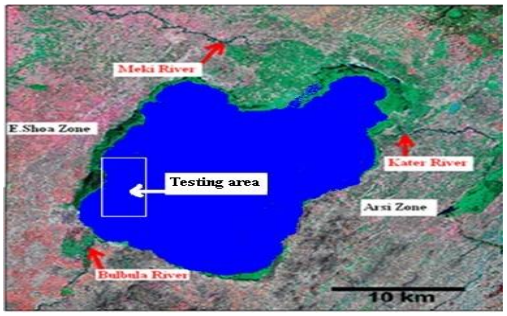

Fig.5. Lake Ziway with satellite image and the test area of the boat.

2.5. Data analysis: The data were analyzed using General Linear Model of Statistical Analysis system.

3. Results and Discussions

3.1. Packed water used with brand in the study area

Respondents were asked to identify their preference among the bottled water brands sold in Battu town. Table 2demonstrate that the respondents supposed “Selam” product was preferred about 79% and “Yes” (11%) then followed by“Edan”**(**8%). From this empirical fact it is safe to conclude that “Selam” bottled water brand holds the lion’s share of Battu town market in particular and in mid rift valley area of the country in general and known to be the popular brand of bottled water in the study area today. Also, this brand is appropriate for making fishing boat due to the design of the bottle as shown on figure 3 and 5.

Table 2: Frequency of packed water with brand in the area

Brand	**Frequency in %**
“Yes”	11
“Aqua Addis”	1
“Selam”	79
“Abyssinia spring”	1
“Edan”	8

Total	100

Tables 3 portray the inquiry with regard to where consumers utilized bottled water in the study area. Accordingly, 100% of the respondents utilized around working and chewing chat area; 98% replied around hotel and restaurant areas. This indicates that people in the town were using bottled water as any commodity to be purchased and used in their day to day life style, at work or in restaurant/hotel.

Table 3: Drink Preference of bottled water in the study area

Place	Frequency in %
Home	10
Hotel and restaurant	98
Work (Meeting area)	100
Chat area	100

From this survey it can be observed that not significant portion only 10%of the respondents used bottled water for drinking at home. This may imply that there is a huge shift of life style in regard to economy.

3.2. Area used to disposal the plastic bottle

Critical question was raised to respondents as displayed in table 4, with regard to the disposal of bottled water after use in Battu town. Based on this,49% of the respondents replied they put in rubbish container after use of bottled water; 51% of the respondents responded that they disposed the empty bottle any where after use it and no one practiced as a recycled material like a plastic bottle and the like in the study area.

Table 4: Disposal of empty bottle

Items	Frequency in %
Put in rubbish container	49
Disposed any were	51
Recycled	0

Hence, table 4 demonstrated that there was indeed shocking implying how the consumers in Batu town were environmentally unconscious. The fact that zero percent of the respondents said they give the empty plastic bottles to recyclers imply a lot of possible problems. Perhaps the people were grossly ignorant of the issues at stake pertaining to saving the planet to the next generation by way of conserving the environment.

3.3. The speed of the waste plastic bottle and wooden boat

Both fishing boat landed on the lake and drive with the operators having almost similar age, body weight and height table 5.

Table 5: General description of the operator

Operator ID	High (m)	Weight (Kg)	Sex	Age (Year)	Health status
A	1.72	82	M	38	Healthy
B	1.73	83	M	39	Healthy

Conclusively, the fishing boat acts downward, and the buoyant force provided by the displaced fluid acts upward. Faturachman *et al.* (2012) also confirmed that with the same manner. Hence, with this study the two forces were found equal and the waste plastic bottle boat on the lake traveled with on average (4.51 ± 0.11 km/h) as compare to wooden boat (4.04 ± 0.12 km/h) (Table 6).Hence, waste plastic bottle boat was found to be swift better than wooden boat and stable at different wave action (Figure 6).

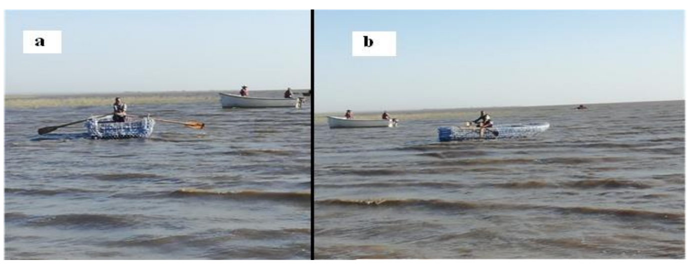

Fig. 6: Waste plastic bottle boat that swift against to wave action (a) and horizontal to wave action (b)

Table 6: Speed of plastic bottle boat and wooden boat

Operator	**Waste plastic bottle boat**		**Wooden boat**	
	Average speed (km/hour)	Maximum speed (km/hour)	Average speed (km/hour)	Maximum speed (km/hour)
A	4.24 ± 0.34	4.51 ±0.51	3.93 ±0.82	4.31±0.65
B	4.92± 0.19	5.84± 0.27	4.21± 0.22	5.22± 0.33
Average	**4.51 ± 0.11**	**5.23 ± 0.32**	**4.04 ± 0.12**	**4.71 ± 0.12**

It was also tried to test the plastic boat that can accommodate on average of six people, while wooden boat four. Hence, the density of the boat and required number of two or three person for fishing was much better advantageous to prevent it from sinking.

3.4. Cost benefits of the fishing boats

This study was also carried out to estimate the cost of a single boat using waste plastic bottle in place of timber. Hence, the cost of plastic bottle was kept as zero against the average cost of timber that needs 4,000 ETB to make one boat according to present market rate. Following the rules and guidelines on permissible boat builder to make a single timber boat required 3,000 ETB and 80% (4,600 ETB) reduction of total cost as compare to plastic bottle boat (2,400 ETB)(Table 7). The estimation also needs further refined with an aim to durability and other related issues.

Table 7. Coast benefits of the fishing boats

Boat type	**Materials used**	**Total price (ETB)**	**Cost difference (ETB)**
Fishing boat	Wooden	7000	4,600
	Waste plastic bottle	2400	

Moreover, use of building materials such as rope for binding one plastic bottle to another and some timbers for plastering of the floor was again significant reduction of cost as compared to conventional construction provided for boat that made up of timber.

It is evident from the study; plastic bottle has the potential to be used in construction and reduces the total cost of construction by at least 25-35% depending on the availability of resources and type of labor exploited. With Swach Bharat Mission in effect, it is arguably possible to expect more efficient collection and segregation of plastic bottles in hand which would help in building more dwelling units (Dibya *et al.*, 2016).

4. Conclusions and Recommendations

Based on the respondents bottled mineral water user's favorite 'Selam' product and significant number of consumers of bottled water in the study area prefers to use bottled water for drinking at work or hotel places as compared to utilized at home. The disposal of empty bottles by bottled water users any where on the streets of the town was environmentally unfriendly as all of the packaging of the bottled water is plastic.

In conclusion, the boat made of Polyethylene Terephthalate (PET) mineral bottles plastic bottles traveled on average (4.51 ± 0.11 km/h) as compare to wooden boat (4.04 ± 0.12 km/h). In addition the budget that spent to waste plastic bottle boat was 2400 ETB and it is much better and cost effective than wooden boat (7000 ETB). Hence, it is recommended that this prototype waste plastic bottle fishing boat needs to be adopted in the study area as well as other area that fishing was practiced. The government bodies also must take initiatives to include this practice in utilization of solid waste, mainly plastic bottle in various aspects like fishing boat, to reduce environmental pollutions. Finally, the boat also needs additional refinement with an aim to durability and other related issues.

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