

Effects of Different Proportions of Pennisetum Purpureum Silage and Natural Grass Hay on Feed Utilization, Milk Yield and Composition of Crossbred Dairy Cows Supplemented with Concentrate Diet

*Tesfaye Mediksa[1] Mengistu Urgie[2] Getachew Animut[2]
1. Bako Agricultural Research Center, P.O.Box 03, West Shoa, Bako, Ethiopia
2. School of Animal and Range Sciences, College of Agriculture and Environmental Sciences, Haramaya University, Dire Dawa, Ethiopia

Abstract
Effects of different proportions of *pennisetum purpureum* silage and natural grass hay on feed intake, digestibility, milk yield and milk composition of crossbred dairy cows were assessed at Bako Agricultural Research Center by using ten crossbred cows of similar milk yield (6.2-8.5 kg/d), body weight (307.99±8.53), age of lactation (early lactation), but differ in parities arranged in switch over 5*5 double single Latin square design; being started at November /2013 and finished at March /2014. Experimental animals were fed adlibitum of natural grass hay and *Pennisetum Purpureum* silage at proportion of (T1) Natural grass hay ad libitum + Concentrate mix (0.5 kg/l of milk), (T2) 75% Natural grass hay + 25% Napier grass silage + Concentrate mix (0.5 kg/l of milk), (T3) Natural grass hay + 50% Napier grass silage + Concentrate mix (0.5 kg/l of milk), (T4) 25 % Natural grass hay + 75% Napier grass silage + Concentrate mix (0.5 kg/l of milk) and (T5) Napier grass silage ad libitum + Concentrate mix (0.5 kg/l of milk), respectively. The concentrate mix is composed of 49.5% maize grain + 49.5% noug seed cake + 1% salt and supplemented with Concentrate mix at rate of (0.5 kg/l of milk). Results of chemical analysis and digestability studies of experimental feeds indicated that *Pennisetum Purpureum* silage (CP=13.85%, ME=10.22 ($MJKg^{-1}DM$)) had better nutritive value than natural grass hay (CP=11.72% and ME=7.98 ($MJKg^{-1}$ DM)). The daily DM, CP, and ME intake were highly significant ($P<0.001$) among the treatments with the highest intake observed when cows were fed sole *Pennisetum Purpureum* silage (T5). Apparent DM digestibility of T5 (66.1) was higher ($P<0.001$) than T1 (63.4), T2 (63.6), T3 (64.1) and T4 (64.9%). Daily milk yield was higher ($P<0.01$) for T4 (6.60) and T5 (6.89) as compared to T1 (6.28 l/d). Composition of all milk constituents were not significantly ($P>0.05$) different among dietary treatments. Economic analysis indicates that use of *Pennisetum Purpureum* silage as basal diet results in a better economic gain than when natural grass hay is used. Therefore, the results demonstrated that *Pennisetum Purpureum* silage had better feeding value as compared to the natural grass hay for crossbred lactating dairy cows and can be conserved and used especially in the dry season when conventional roughages are in short supply and low in CP content.
Keywords: Basal diet, Crossbred, Digestibility, Hay, Intake, and Napier grass silage.

1. Introduction

The inadequacy and fluctuations in feed supply is the major stumbling block affecting livestock production in Ethiopia (Legesse 2008). In the mixed crop-livestock production systems of the Ethiopian highlands, feed resources for livestock mainly come from marginal pasturelands, crop residues, and aftermath grazing (Bogale et al 2008). Nevertheless, forages from marginal pasturelands and crop residues are generally low quality. Thus, the nutritional requirements of dry pregnant and lactating cattle for milk production are not sufficiently met. Under such circumstances, cows in early lactation and high producing cows are typically in a negative energy balance. Factors associated with a negative energy balance have been suggested to have adverse implication on reproductive efficiency and milk production and body weight loss of animals (Hindrichsen et al 2004 and Emebet 2008). This is further aggravated by the fact that yield and nutritive value of tropical grasses decline sharply as dry season approaches (Babayemi et al 2009), leading to reduced feed intake, greater weight loss, and poor milk production from cattle raised in extensive production systems (Smith 2001). The situation may be reversed during the wet season when there is more forage than being used (Higashiyama and Hirata 2006) and opportunity to cultivate forage is high. Thus, surplus and cultivated quality forages should be conserved during the wet season for use during the dry season. To this effect, silage-making is a common means of preserving surplus forage which could be fed to livestock during periods of scarcity (Wong 2000). By conserving excess forage produced during the wet season to silage (Wong 2000), the low production and productivity of dairy animals during the dry season due to scarcity of forage can be ameliorated. For such purpose, Napier grass (Pennesitum purpureum) is a high yielding tropical grass with great potentials for making silage.

Napier grass (Pennisetum purpureum) is recommended as basal forage for intensive cattle production because of its high biomass fresh dry matter yield of 40 t/ha compared to other grasses (ILRI 2001). Napier grass is tall growing perennial grass which is indigenous to tropical and subtropical climates. Since Pennesitum purpureum (ILRI 14984), yields high biomass, it can be used for silage production which will ensure sufficient availability of feed on farm throughout the year. However, the potential of this forage as a quality roughage feed for dairy when made to silage is not well studied in Ethiopia. Its' supplementation with commercial protein supplements was not fully explored, although generally supplementing Napier grass with concentrate or leguminous forage plants was reported to improve animal performance (Solomon 2001). Moreover, the potential of Napier grass in improving the utilization of other grasses such as natural hay is not also well documented. To fill the existing information gap, evaluation of Pennesitum purpureum through animal feeding trials is important (Tessema and Baars 2004). Therefore, the objective of this study was to study the effects of feeding Napier grass silage with natural grass hay in varying proportions on voluntary feed intake, digestibility, and milk yield and composition of crossbred dairy cattle and its economic visibility.

2. Materials and Methods

2.1. Study Area

Bako Agricultural Research Centre is located in Oromia Regional State West Shoa Zone at about 257 Km from the capital city Addis Ababa on the way to Nekemte town. The centre is located at 8 km from Bako town. The altitude of the research centre is 1650 masl and lies at about 09°6'N latitude and 37°09'E longitude. The area has a warm sub-humid climate with annual mean minimum and maximum temperature of 13°C and 29.9°C, respectively. Mean monthly minimum and maximum temperatures are about 10.4°C and 33.6°C, respectively, with an average monthly temperature of 21°C. The daily mean minimum and maximum temperatures are 9.4°C and 31.3°C, respectively. The relative humidity of the study area was 48.8% for the year 2013/14 cropping calendar during which the study was conducted. The area is known by Unimodal types of rainfall and receives annual rainfall of 1431 mm mainly from May to September with maximum precipitation in the month of June to August. Sixty percent of the soil is reddish brown in color, and clay-loam in texture (Wakene 2001).

2.2. Experimental Animals and Management

A total of ten crossbred cows (Horro x Holstein Fresian) were used for this experiment. Experimental cows with similar lactation performance, same early stage of lactation, similar body weight, but with different parities were selected. All cows were weighed and drenched with broad-spectrum anti-helminthics (Albendazole 500 mg) prior the commencement of the experiment. The calves were separated from their dams five days after parturition and reared according to the standard calf rearing procedures of the research centre. The cows were placed in an individual pen in a well-ventilated barn with concrete floor and appropriate drainage slope and gutters and stall-fed. The cows were hand-milked twice daily at approximately 12-hour intervals in milking room.

2.3. Feed Preparation and Feeding

Napier grass was harvested, chopped, ensiled and Natural pasture hay was harvested before it is matured, sun dried, chopped and stored under a hay shade and used as basal diet throughout the experimental period. The basal feed offer was adjusted daily by allowing 20% of refusal from previous day's intake. The quantity of concentrate mix offered daily was at the rate of 0.5 kg/l of milk produced by each cow and offered with equal portions at 5:00 am and 5:00 pm during the morning and evening milking time, respectively. Representative and composite samples of all experimental feeds were taken for laboratory analysis.

2.4. Experimental Design, Treatments, and Measurements

At the beginning of the experiment, ten cows were randomly assigned in a switch over 5X5 double Latin square design. There were five periods each consisting 30 days. During the first 15 days of each period, animals were acclimated to the experimental diet and the remaining 15 days were used to collect data. Hence, the experiments took 150 days; being started in November 2013 and finished in March 2014. The experimental animals were initially randomly allotted to one of the five dietary treatments given below. The concentrate mix is 49.5% maize grain + 49.5% noug seed cake + 1% salt). Treatments were:

T1 = Natural grass hay ad libitum + Concentrate mix (0.5 kg/l of milk)
T2 = 75% Natural grass hay + 25% Napier grass silage + Concentrate mix (0.5 kg/l of milk)
T3 = 50 % Natural grass hay + 50% Napier grass silage + Concentrate mix (0.5 kg/l of milk)
T4 = 25 % Natural grass hay + 75% Napier grass silage + Concentrate mix (0.5 kg/l of milk)
T5 = Napier grass silage ad libitum + Concentrate mix (0.5 kg/l of milk)

The basal feed was offered ad libitum at a 20% refusal rate and the offer was adjusted every four days. Treatment one and treatment five were fed ad libitum natural grass hay and *Pennisetum Purpureum* silage at a

20% refusal rate, respectively. For other treatments (T2, T3 and T4) that were offered the mixture of the two basal diets (natural grass hay and *Pennisetum Purpureum* silage), the proportion was determined from the measurements of the individual basal diets intake determined before the beginning of the actual experiment. This was done by feeding each cow with each basal diet for five days and determining the mean intake of each basal diet, which was then used to determine the amount of each basal diet in the mixture. The 20% refusal rate was also calculated based on the average intake. The amount of the roughages calculated for the day was measured and placed infront of the animal and was offered three times at 08:00, 14:00 and 20:00 hours each day. The quantity of concentrate mix offered daily was at the rate of 0.5 kg/l of milk produced by each cow and it was offered with equal portions at 05:00 and 17:00 hours 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. Feed offered and refused was measured and recorded for each cow to determine daily feed and nutrient intake and feed conversion ratio was calculated from total dry matter intake in kg divided by milk yield in kg and times by hundred. Water was available to the animal all the time throughout the experiment and 100 gram mineral mixtures composed of (Ca 280g, P 170g, Mg 120g, K 200g, Na105g, Cl 124g, Cu 95mg, Zn 278mg, Mn 277mg, Fe 350mg) was added for each cow daily into feed trough.

2.5. Diet Apparent Digestibility

Apparent digestibility of the diet used in each treatment was determined using total feacal collection methods for a period of 5 consecutive days. Farm personnel were assigned around the clock to scoop faeces into plastic buckets as soon as the animals defecated. Urine contamination was minimized by frequent washing of the concrete floor with high pressure running water using a plastic water tube. Individual cow's faeces were weighed every morning before 08:00 hours and before fresh feeds were given to the animals. After weighing, the faeces from each cow were thoroughly mixed and a sample taken and placed in polyethylene bag. Composite samples of about 1% of the daily collected fecal samples were mixed and stored as one sample in a deep freezer (-20 ^{o}C) until the end of the collection period. At the end of the collection period, the 5 days pooled samples were subsequently thawed and mixed thoroughly and two subsamples taken. One sample for estimating DM was oven dried at 105^{o}C for 24 hours, while the other sample was oven dried at 65^{o}C for 72 hours, ground to pass a 1mm sieve and stored in sample bottles at room temperature. Composite samples of the hay, Napier grass silage, concentrate mixture and faecal DM output were analyzed to determine DM, OM, N, NDF, and ADF digestibility.

2.6. Invitro Organic Matter Digestibility

The two stage rumen inoculums-pepsin method of Tilley and Terry (1963) were used to determine IVOMD. Rumen liquor was collected from ruminally festulated steers and transported to the laboratory using thermos flasks that had been pre-warmed to 39 ^{0}C. Rumen liquor was taken in the morning before animals are offered feed. A duplicate sample of 0.5 g of each were incubated with 30 ml of rumen liquor and a buffer in 100 ml test tube in water bath at 39 ^{0}C for a period of 48 hour for microbial digestion followed by another 48 hour for enzyme digestion with acid pepsin solution. Blank samples containing buffered rumen fluid were incubated in duplicates for adjustment.

$$\text{In vitro OM/ DOMD} = \frac{\text{OM in the feed- (OM in residue – blank) x 100}}{\text{OM in the feed}}$$

Where OM = 100 - Ash (measured after incineration of feed or residue)

Metabolisable energy contents of the feeds were estimated from in vitro organic matter digestibility (IVOMD) as described by McDonald et al (2002) as: ME (MJ/kg) = 0.016 IVOMD.

2.7. 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 (concentrate) and the two basal diets, and considering milk sales price and labour cost incurred during the entire experimentation process. The milk price was fixed based on the milk price paid to farmers by the Dairy Development Cooperatives (DDC) in the study area. The prices of the natural grass hay, *Pennisetum Purpureum* silage and ingredients used to form concentrate mix were obtained from the current market price during the experimental period. Partial budget analysis by using marginal analysis was employed to compute total cost of production /cow/day, mean milk yield/cow/day, price of milk/cow/day, cost of production/litre of milk, return/cow/day, net return/cow/day and MRR return/cow/day. Calculations employed were;

Net returen (NR) = Total revenue (TR) – Total variable cost (TVC)

$\Delta NR = \Delta TR - \Delta TVC$

$$\text{Margina rate of return (MRR \%)} = \frac{\Delta NR}{\Delta TVC} \times 100$$

ΔNR = Change in net returen
ΔTVC = Change in total variable cost
ΔTR Change in total revenue

2.8. Chemical Analysis

All samples of feed offered and refusals and faeces were analyzed for DM, ash, N (Kjeldahl-N) according to AOAC (1990). Organic matter (OM) was determined as 100-ash. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined by the methods of Van Soest and Robertson (1985). Invitro organic matter digestibility of feed offered and refusal was determined using the procedures outlined by Tilley and Terry (1963). The milk samples were used to determine percentage fat, protein and solid not fat (SNF) by Ultrasonic Ekomilk Analyzer (30 w Bulteh 2000, Bulgaria), which have the capacity to measure 20 – 25 samples per hour. Total milk solids (TS) were calculated as TS = SNF+Fat. Calcium and phosphorous content of the offered feeds were analyzed by atomic absorption spectrophotometry and colorimetry (AOAC 1995) respectively.

2.9. Statistical Analysis

Voluntary DM and nutrient intakes, live weight change, milk yield and compositions, and digestibility were subjected to GLM procedure for double 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:

$Y_{ijk} = \mu + C_i + P_j + T_k + E_{ijk}$,

Where; μ = Overall mean; C_i = Cow effect (parity); P_j = Period effect; T_k = Treatment effect; E_{ijk} = Experimental error

3. Results and Discussion

3.1. Chemical Composition of Experimental Feeds

The NDF, ADF, and ADL contents of natural grass hay used in this study were higher than that of *Pennisetum Purpureum* Silage. The CP contents were high in *Pennisetum Purpureum* Silage than natural grass hay, but OM was almost similar. The CP content of concentrate was higher than that of *Pennisetum Purpureum* Silage and their combination with natural grass hay. The natural grass hay contained 7.49% and 32.30% more NDF than *Pennisetum Purpureum* Silage and concentrate mix, respectively. The same trend was observed for ADF and ADL contents of the feeds. The level of ADL concentration observed for natural grass hay and *Pennisetum Purpureum* Silage was much higher and almost 3.1 and 2.67 times greater than that observed for the concentrate mix. The CP content of maize grain was 9.9%. These indicates that crushed maize grain is a good source of protein, which could be used as a supplement when animals feed is based on native grass hay, pasture grazing or crop residues.

Table 1: Chemical composition, in-vitro organic matter digestibility and metabolizable energy content of experimental feeds (% for DM and %DM for other chemical composition values)

Feeds offered	DM	Ash	OM	CP	NDF	ADF	ADL	ME (MJ Kg^{-1} DM)	IVOMD
NGH	92.62	11.16	88.4	11.72	72.46	48.68	6.32	7.98	49.90
NGH:PPS 75:25	77.00	11.47	88.21	12.25	70.59	47.39	6.14	8.46	52.91
NGH:PPS 50:50	61.37	11.77	88.01	12.79	68.72	46.09	5.96	9.11	56.91
NGH:PPS 25:75	45.75	12.08	87.82	13.32	66.84	44.80	5.78	9.67	60.41
PPS	30.12	12.38	87.62	13.85	64.97	43.50	5.60	10.22	63.91
Maize grain	89.2	1.70	98.3	8.4	5.6	2.40	-	15.6	97.50
NSC	92.00	11.0	89.00	31.7	32.3	29.8	10	11.1	69.20
Concentrate	92.74	5.15	94.85	25.27	32.67	17.13	2.10	12.2	70.18
Refusal									
NGH	92.16	9.9	90.10	11.20	73.82	52.48	6.62	7.3	45.74
NGH:PPS 75:25	60.30	9.36	90.65	10.18	69.04	50.04	8.93	7.5	47.01
NGH:PPS 50:50	61.67	9.4	90.6	9.93	69.66	49.23	9.10	8.2	51.23
NGH:PPS 25:75	60.345	9.735	90.27	10.61	69.40	50	9.06	8.3	52.15
PPS	30.07	10.67	89.33	12.79	65.54	43.87	6.5	9.2	57.23

ME= metabolisable energy (0.016*DOMDM); NGH=natural grass hay; NSC = noug seed cake; PPS= *Pennisetum Purpureum* silage; HC= hemi-cellulose; C=cellulose; ADF= acid detergent fiber; ADL= acid detergent lignin; CP= crude protein; DM= dry matter; NDF= neutral detergent fiber; OM= organic matter; IVOMD=Invitro organic matter digestibilty; EE= etheter extract; CF=crude fiber; Ca=calcium; P = phosphorus.

3.2. Dry Matter and Nutrients Intakes

There was no significant difference (P>0.001) between T1 and T2 in daily DM intake, but values were lower than T4 and T3. The difference could be attributed to the high rumen degradable protein content of the *Pennisetum Purpureum* Silage compared to natural grass hay, which might have enhanced the efficiency of rumen microorganisms that increase fiber degradability and digestibility thereby improving feed intake (McDonald et al 2002). The low CP and high fiber contents of the natural grass hay likely depressed both feed intake and digestibility since NDF is negatively correlated with feed intake and its content above 55% can limit DM intake (Van Soest 1967; Arelovich et al 2008). Animals consuming feeds containing better protein will eat more than those given less protein containg diets (Steinshamn 2010).

In this study, cows fed with sole *Pennisetum Purpureum* Silage (T5) as a basal diet consumed 0.56, 0.86, 1.43, and 1.62 kg/d more basal diet than T4, T3, T2, and T1, respectively. The intake of DM (% BW) was highly significant (P<0. 01) among the treatments. This result was comparable with the 3.1% BW intake reported by Olorunnisomo and Ibhaze (2013) and higher than the values (2.2 – 2.3%) reported by Gwayumba et al (2002). Daily DM intake of 3.32 kg/d for urea treated rice straw supplemented with Verano stylo (Suriyajantratong and Wiliapon 1985) and 2.46 kg/100 kg BW for treated rice straw were reported by Rai et al (1989). The total DM intake (g/kg $W^{0.75}$) was highly significant (P<0.001) among the treatments and this result was comparable with that reported by Purushothaman et al (2008) who noted 147 g/kg $W^{0.75}$ for lactating crossbred cows fed rations containing calcium salts of palm oil fatty acids (bypass fat). As well 113.2 and 122.1 of DM intake (g/kg $W^{0.75}$) was reported by Dey et al (2014). The observed variations among the studies emanated from the differences in the quality of the feed used, animal factors (age, physiological status of the animals and breed), rumen fill, rate of passage of particulate matter and rates of degradation of experimental feeds used. Increased organic matter intake (P<0.001) when cows were fed with basal diet consisting *Pennisetum Purpureum* Silage might be due to the increased total DM and CP intake.

Intake of feed by ruminant can be improved through concentrate supplementation (Gatenby 2002). Addition of CP supplement may stimulate efficient rumen fermentation, more passage rate and intake (Kempton and Leng 1979). This implies the presence of direct relationship between CP content of feeds and feed intake (Tesfaye 2007). Earlier report (Mulu 2005) showed improvement in the daily total DM intake due to supplementation. This may be attributed to the ability of the supplements to provide nitrogen and energy for the cellulolytic microbes upon degradation in the rumen (Wambui et al 2006) and increases 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 (Ranjhan 1997). When the rate of breakdown of digesta increases, feed intake is accordingly increased (Van Soest 1982). Grovum and Williams (1977) reported that if the ingested feed is retained longer in the rumen, it is expected that the animal would consume less feed, because of the occupied space or 'gut fill'. The highest (p<0.001) DM intake obtained for T5 might have arisen from the more balanced intakes of both CP and ME that have led to a more efficient utilization of the fibre in the total diet, which is in agreement with other studies (Osuji and Odenyo 1997; Mpairwe 1998).

Table 2**:** Means of dry matter and nutrient intake of lactating crossbred dairy cows fed different proportions of natural grass hay and Napier grass silage and supplemented with concentrate mix

Parameters	Treatments							
	T1	T2	T3	T4	T5	SEM	Prob.	SL
Dry matter intake								
Basal feed (kg/d)	5.27^{d}	5.46^{d}	6.03^{c}	6.33^{b}	6.89^{a}	0.09	<.0001	***
Concentrate (kg/d)	3.40	3.47	3.49	3.51	3.42	0.05	0.5028	ns
Total DM (kg/d)	8.67^{e}	8.93^{d}	9.53^{c}	9.84^{b}	10.31^{a}	0.08	<.0001	***
DMI (% BW)	2.81^{c}	2.94^{bc}	3.15^{b}	3.18^{ab}	3.44^{a}	0.099	<.0001	**
DMI (g/kg $W^{0.75}$)	117.60^{d}	122.65^{cd}	131.34^{bc}	133.26^{b}	143.04^{a}	3.2	<.0001	***
Nutrient intake								
OM (kg/d)	7.90^{d}	8.38^{c}	8.69^{b}	8.98^{b}	9.40^{a}	0.12	<.0001	***
CP (kg/d)	1.48^{e}	1.58^{d}	1.65^{c}	1.73^{b}	1.82^{a}	0.02	<.0001	***
ME (MJ/d)	83.06^{e}	85.94^{d}	91.97^{c}	95.49^{b}	101.50^{a}	1.16	<.0001	***
NDF (kg/d)	4.93^{d}	5.15^{dc}	5.27^{bc}	5.38^{ab}	5.59^{a}	0.08	<.0001	**
ADF (kg/d)	3.15^{c}	3.30^{bc}	3.38^{b}	3.44^{ab}	3.58^{a}	0.05	<.0001	***
ADL (kg/d)	0.40^{c}	0.42^{bc}	0.43^{b}	0.44^{ab}	0.46^{a}	0.01	0.047	*

$^{a-,e}$means within rows having different superscript are significantly different at *** = P<0.001; ** = P<0.01; * = P<0.05; SL = Significance level; SEM = Standard error of mean; DMI = Dry matter intake; CP = Crude protein; ME = Metabolisable energy; NDF= Nutral detergent fiber; ADF=Acid detergent fiber intake; ADL= Acid detergent lignin; BW=Body weight; $W^{0.75}$=Metabolic body weight; T1= ad libitum Hay + Concentrate mix (0.5 kg/l of milk); T2= 75% Hay + 25% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T3=50% Hay + 50% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T4=25 % Hay + 75% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T5= ad libitum Napier Grass Silage + Concentrate mix (0.5 kg/l of milk), Concentrate =49.5% maize grain + 49.5% noug seed cake + 1% salt

The CP intake was 17.1, 17.2, 17.3, 17.6 and 17.7% of the total DM intake for T1, T2, T3, T4 and T5, respectively and its intake has shown an increase (P<0.001) with increasing level of *Pennisetum Purpureum* Silage in the mixtures due to the relatively higher CP content of *Pennisetum Purpureum* Silage than NHG and their mixture. As far as protein requirements concerned, the CP intake in all treatments of the present study was higher than the estimated daily CP (866.5 g/d) requirement of lactating cows producing 8-10 kg of milk per day with 4.5% butter fat (ARC 1990). This was due to almost similar milk production, hence amount of concentrate supplement offered to the experimental animals in all treatment groups during the entire feeding period. Moreover, protein supplementation brings about increase in the protein content of the feeds and this eventually leads to increase in protein intake (Arigbede et al 2006).

The intake of NDF and ADF tend to increase as the proportion of *Pennisetum Purpureum* Silage in the basal diet increases and it was higher (p<0.001) in T5 than T1, T2, and T3. The ADL intake also showed a similar trend and was higher (P<0.05) in T5 than other treatments. Higher fibre intake when cows consumed higher proportion of *Pennisetum Purpureum* Silage was obviously attributed to the high total DM intake. Metabolisable energy intake among the treatments was highly significant (P<0.001). Higher ME intake was observed in T5 compared to T1, T2, and T3; and T4 has similar ME with T5 and higher as compared to T1. The positive association observed between *Pennisetum Purpureum* Silage and the concentrate mix was typically higher for T5 which can be explained by higher total DM intakes (Table 3). According to Lonsdale (1989), feeds that have < 9, 9 - 12 and >12 MJ ME/kg DM are classified as low, medium and high energy sources, respectively. The highest ME intake (101.5 MJ/head/day) obtained for 100% of *Pennisetum Purpureum* Silage and concentrate mix (T5) is above the estimated daily ME (97.6 MJ/head/day) requirement of lactating cows weighing 400 kg and producing 8-10 kg milk of 4.5% butter fat (ARC 1990). According to the ARC (1990), estimation of energy balance from this study showed a deficit of -14.54, -11.66. -5.63 and -2.11 MJ/d for T1, T2, T3 and T4, respectively, while a positive energy balances of +3.9 MJ/d was obtained for T5. The finding from this study was supported by Preston and Leng (1986) who noted that molasses or alkali treated straw based diets are more digestible, but they support little improvement in animal productivity unless they are supplemented with by-pass nutrients.

3.3. Apparent Dry Matter and Nutrient Digestibility

When cows fed T5 diet, the DM digestibility was higher by 2.72, 2.54, 2.05, and 1.23% as compared to T1, T2, T3, and T4, respectively. The diet that consist higher *Pennisetum Purpureum* Silage compared to 25% Hay + 75% Napier grass silage (T4) has also higher DM digestibility than T1 and T2 demonstrating that increased *Pennisetum Purpureum* Silage proportion in the basal diet improved DM digestibility. The improved DM digestibility at high level of *Pennisetum Purpureum* Silage in the basal diet might be associated with the nutrient contents of *Pennisetum Purpureum* Silage. Therefore, sole *Pennisetum Purpureum* Silage as basal diet can fairly be a better basal diet for crossbred dairy cows for good milk production when it is supplemented by concentrate diet at the rate of 0.5 kg/l of milk yield. The DM digestibililty coefficient of treatment feeds in the current study was higher than 55.3% and 48.6% reported by Singh et al (1992) and Pathak (2005), respectively. However, similar level of digestibility as in the present study was obtained by Varvikko and Khalili (1993), Getu (2006), and Tesfaye (2011) who reported a value of 61.4, 60.7, and 63.3%, respectively.

The apparent OM digestibility (P<0.01) was significantly different among treatments. There were no significance difference (P>0.01) among T1, T2 and T3; and among T2, T3 and T4 in OM digestibility. Cows in T5 had shown higher OM digestibility compared to Cows in T1, T2, T3 and T4, which might be due to the higher CP intake in T5 (Table 3) that have created a better environment by providing more N for rumen microorganisms. In support of the present finding, Lapenga et al (2009) noted that supplementation of Mubende goats fed Napier grass with different protein and energy sources increased DM and OM digestibility. Likewise, supplementation of sheep fed maize stover with Desmodium intortum hay resulted in improved digestibility of the diet as a result of increased microbial N supply and rumen fermentation (Adugna and Sundstøl 2000).

Apparent ADF digestibility differed among treatments (P<0.05). Neverthles, NDF and CP digestibility were similar (P>0.05) among treatments. Apparent ADF digestibility was higher (P<0.05) in T4 and T5 as compared to T1. Absence of significant difference among treatments for NDF digestibility in the present study is also supported by previous research results (Ash and Norto, 1987; Kaitho et al 1998; Matiwos et al 2008) who reported that supplementation with dietary protein had no significant effect on NDF digestibility. The value of NDF digestibility in the present study is comparable with that reported (63.3%) earlier by Varvikko and Khalili (1993) for low quality native hay supplemented with graded levels of tagasaste replacing a concentrate mix in

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the daily ration of lactating crossbred cows. Ndlovu (1992) reported high content of NDF and lignin fractions to be responsible for lower fibre degradation. The lack of response to fibre apparent digestibility was in agreement with that reported by Adu et al (1992). The reason may be due to the higher NDF and ADF content in the basal diet as a result their intakes, which might have detrimental effect on the digestion of fibre. The observed disparity in the digestibility of feeds and nutrients between different experiments might be related with the differences in the nature of CP found in the treatment diets (Milis and Liamadis 2007), breed and condition of the animals (Chantiratikul et al 2009).

Table 3**:** The mean apparent DM and nutrients digestibility coefficients of lactating cross bred dairy cows fed different proportions of natural grass hay and Napier grass silage and supplemented with concentrate mix

Apparent digestibility (%)	Treatments							
	T1	T2	T3	T4	T5	SEM	Prob.	SL
DM	63.40^{c}	63.58^{c}	64.07^{bc}	64.89^{b}	66.12^{a}	0.33	<.0001	***
CP	74.27	74.55	75.13	76.00	76.82	0.99	0.3565	Ns
OM	65.67^{c}	66.67^{bc}	66.49^{bc}	67.09^{b}	68.37^{a}	0.44	0.0025	**
NDF	57.46	57.14	56.64	58.55	56.51	2.46	0.9792	ns
ADF	49.16^{b}	51.15^{ab}	51.70^{ab}	52.79^{a}	53.95^{a}	1.14	0.05	*

$^{a-c}$means within rows having different superscript are significantly different at *** = P<0.001; ** = P<0.01; * = P<0.05; ns = non significant; T1= ad libitum Hay + Concentrate mix (0.5 kg/l of milk); T2 = 75%Hay + 25% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T3=50 %Hay + 50% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T4=25 % Hay + 75% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T5= ad libitum Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); Concentrate mix = 49.5% maize grain + 49.5% noug seed cake + 1% salt; DM = dry matter; CP = crude protein; OM = organic matter; NDF = neutral detergent fibre; ADF = Acid detergent fibre.

The CP digestibility was expected to follow the differences in CP intake observed among treatments. It has been reported that increasing CP in the diet increased the digestibility of CP (Hirut 2008). The CP digestibility observed in the present study could safely be compared to the mean CP digestibility of 71.5% reported by Mpairwe (1998) for crossbred cows fed low quality basal diets and supplemented with graded levels of lablab hay and wheat bran. Likewise, Getu (2006) and Tesfaye (2011) reported CP digestibility of 67.9% and 72.7%, respectively in crossbred dairy cows, which is similar to the present value. In contrast to the present study 48.6% digestibility have also been reported by Pathak (2005) for 3% urea treated wheat straw supplemented with a concentrates plus some green forage legume for local cows.

3.4. Milk Yield and Composition

Daily milk yield was significantly different among treatments (P<0.01) and was higher in T4 and T5 as compared to T1. Cows fed with sole *Pennisetum Purpureum* Silage (T5) produced more milk than those in T2 and T3 basal diets. The difference in milk yield among treatment groups is attributed to the differences in crude protein and energy contents in the diets (Steinshamn 2010). Adebabay et al (2009) indicated that supplemented cows produced significantly more milk than those grazed on natural pasture alone. Milk protein, milk fat, solid not fat (SNF) and total solid (TS) contents were not significantly (P>0.05) different among treatments. Results of the present study of milk composition agreed with Promma et al (1994) who reported that feeding lactating Holstein cows with either ammonium sulphate neutralised rice straw or non neutralised rice straw for increased CP intakes did not change milk composition. However, Adebabay et al (2009) and Nega et al (2006) noted differences in milk composition under different concentrate supplementation regimes. The observed lack of differences in milk composition is due to the similar type and same amount per kg milk of concentrate supplementation across the treatments.

Table 4. Effects of different proportions of natural grass hay and Napier grass silage on milk yield and composition of crossbred dairy cows supplemented with concentrate mix

Parameters	Treatments							
	T1	T2	T3	T4	T5	SEM	Prob.	SL
Milk yield (kg/d)	6.28^{c}	6.31^{bc}	6.43^{bc}	6.60^{ab}	6.89^{a}	0.11	0.0019	**
Milk fat (%)	4.75	4.50	4.97	4.40	4.51	0.25	0.5176	Ns
Milk Protein (%)	3.54	3.63	3.63	3.57	3.62	0.05	0.5598	Ns
SNF (%)	8.49	8.79	8.74	8.61	8.77	0.13	0.4326	Ns
TS (%)	13.92	13.68	14.45	13.68	13.6 2	0.35	0.4397	Ns
FCR (TDMI/MY)	1.39^{c}	1.42^{bc}	1.49^{ab}	1.49^{ab}	1.5^{a}	0.03	0.0108	*

$^{a-c}$means within rows having different superscript are significantly different at; (**)= P<0.01; (*)= P<0.05; SL =

significance level; SEM = standard error of mean; ns = not significant; T1= ad libitum Hay + Concentrate mix (0.5 kg/l of milk); T2=75%Hay + 25% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T3=50 %Hay + 50% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T4=25 % Hay + 75% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T5= ad libitum Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); Concentrate mix = 49.5% maize grain + 49.5% noug seed cake + 1% salt; SNF=solid not fat; TS = total solid; FCR = feed conversion ratio; TDMI=total dry matter intake ; MY =milk yield.

Generally, both the CP and ME intake were sufficient to meet requirement for the observed milk yield (6.5 kg/d). The mean daily milk yield obtained from the present trial was almost comparable to the values of 6.5, 6.7 and 5.6 kg d^{-1} reported by Getu (2006), Khalilli et al (1992) and Reherahie (2001) for crossbred lactating cows fed urea treated teff straw basal diet and supplemented with oats-vetch hay with a concentrate at the rate of 2.5 kg/day and barely straws supplemented with concentrate mix, respectively. The feed conversion ratio was significantly (P <0.05) different and increased from T1 to T5, but it is lower than the value reported by Olorunnisomo and Ibhaze (2013) who noted that the DM intake, milk yield and feed conversion ratio of Sokoto Gudali cows fed Napier grass-cassava peel silage were 13.93 kg/d, 6.7 kg/d and 2.08 DMI/ kg milk yield, respectively. The variation between different reports might be due to the differences in metabolizable energy intake and intrinsic factors like level of production, parity, stage of lactation, external factors like environmental stress, and unequal intervals between milking and changes in feeding.

3.5. Daily Live Weight Change

The result of mean daily live weight loss was not significantly (P>0.05) different. The presence of marked differences in DM digestibility and nutrient intake among the dietary treatments did not bring a significant effect in weight change of the cows, which may be due to the utilization of additional nutrients consumed for milk production and weight gain. During the early lactation (60-90 days after calving) all cows lost body weight, with a declining trend with advance in lactation. The loss in body weight despite the increased CP intake (Table 3) above the requirement might suggest that energy was the most limiting factor in all treatments, except in T5 (Table 3). In natural grass hay based diet, the proportion of acetate as rumen fermentation end product predominates. The consequence of this is low proportion of propionic acid, which is glycogenic (Leng 1982), is reduction in the effectiveness of N retention and reduced weight gain (Yilala and Bryant, 1985). Total ME intakes were lower compared to requirements (ARC 1990) and hence during early lactation it has been utilized for increased milk yield by depleting body weight reserves and thus the cows lost more body weight during this stage of lactation (calving to 60 days).

Table 5: Effects of different proportions of natural grass hay and Napier grass silage on mean live weight change of lactating crossbred dairy cows supplemented with concentrate diet

Parameters	Treatments							
	T1	T2	T3	T4	T5	SEM	Prob.	SL
Live weight change (g/day)	-117.20	-108.87	-107.16	-104.13	-97.50	11.51	0.8160	Ns

SL= significance level; SEM = standard error of mean; ns = not significant; T1= ad libitum Hay + Concentrate mix (0.5 kg/l of milk); T2= 75%Hay + 25% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T3=50 %Hay + 50% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T4=25 % Hay + 75% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T5= ad libitum Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); Concentrate mix = 49.5% maize grain + 49.5% noug seed cake + 1% salt

Similar amount of body weight lose of 120 g/day with the present study was reported for lactating crossbred cows by Getu (2006). But, body weight loss of cows (60-90 days) in the present study is higher than that reported by Muinga et al (1992, 1995). Muinga et al (1992) reported body weight loss of 20 to 90 kg for the entire lactation period for lactating crossbred cows fed ad libitum Napier grass fodder and supplemented with 0.4 or 8 kg/d of fresh leucaena forage. However, positive weight changes for dairy cows fed urea treated and untreated low basal feeds (teff and barley straw, maize stover and oats- vetch mixture) supplemented with either conventional concentrate or forage legumes have also been documented by different workers (Lemma et al 1990; Mpairwe 1998; Reherahie 2001). The variation in live weight change between the different studies could be explained by the difference in the stage of lactation and genetic potential of the animals used in the experiments, the quality of the basal feeds used and the quality and quantity of supplements used in the studies. Garnsworthy (1997) noted that cows in early lactation and those of higher genetic merits partition energy towards milk production at the expense of body fat reserve. This author further noted that cows normally lose 0.5-1.0 kg of body weight each day for the first eight weeks of lactation. Therefore, increased energy intake at this stage of lactation is expected to result in further increases in milk yield, if the cow's genetic potential has not been reached and/or a reduction in the daily amount of body fat mobilized. Cows on all dietary treatments in the present study were losing body weight progressively during the first period of the lactation cycle (Figure 4), which can be solely attributed to peak lactation. Cows were still losing body weight after the first period of the lactation cycle, but with a generally declining trend.

However, improvements in body weight condition of cows have also been observed for all dietary treatments during the last period of the experiment. This could probably be associated with more diversion of the available nutrients to body tissue accretion or the decreased milk yield during this period.

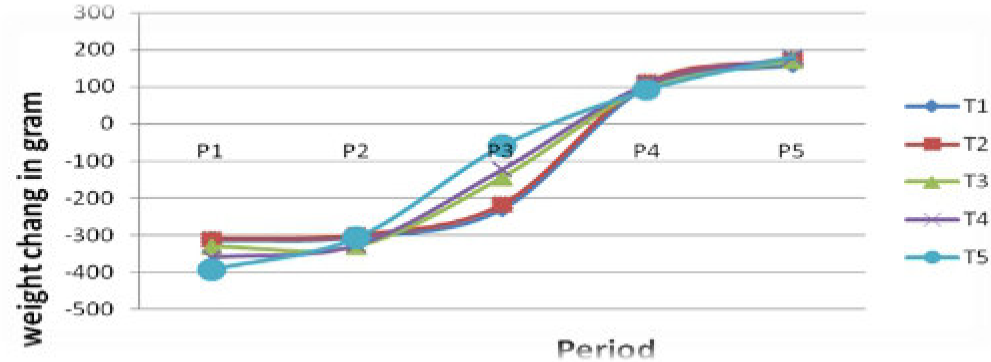

Fig. 1. Periodic live weight change of lactating crossbred cows fed different proportions of natural grass hay and Napier grass silage basal diet and supplemented with concentrate mix (0.5 kg/kg milk).
T1= ad libitum Hay + Concentrate mix (0.5 kg/l of milk); T2= 75% Hay + 25% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T3=50% Hay + 50% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T4=25 % Hay + 75% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T5= ad libitum Napier Grass Silage + Concentrate mix (0.5 kg/l of milk), p1=period one, p2=period two, p3=period three, p4=period four and p5=period five

3.6. Partial Budget Analysis

The economic feasibility of this study was analyzed using partial budget and marginal analysis approaches (Table 7). According to this analysis, Cows in T5 gave the highest net benefit (Birr 17.07 per cow/day), while Cows in T1 gave the lowest benefit (Birr 7.24 per cow/day) (Table 7). The minimum rate of return acceptable by the dairy farmer was assumed to be 50% (CIMMYT 1985). This implies that the dairy farmer expects a minimum rate of return of 50% if he is to adopt a new practice as compared to the practice he used to do.

Table 6**:** Partial budget analysis for lactating crossbred dairy cows fed different proportions of natural grass hay and Napier grass silage basal diet and supplemented with concentrate mix (0.5 kg/kg milk)

Variable	Treatments				
	T1	T2	T3	T4	T5
Milk yield (kg/cow/d)	6.28	6.31	6.43	6.60	6.89
Gross field benefit (ETB /cow/d)	75.36	75.72	77.16	79.2	82.68
Cost of NGH (ETB/ kg /cow/d)	30.98	24.09	17.74	9.31	-
Cost of PPS (ETB/ kg /cow/d)	-	6.67	12.43	17.53	28.38
Cost for Concentrate mix (ETB/kg/cow/d)	16.99	17.33	17.47	17.54	17.08
Cost of Tablet, Mineral and labour (ETB /cow/d)	20.15	20.15	20.15	20.15	20.15
Total variable cost (ETB /cow/d)	68.12	68.24	67.79	64.53	65.61
Gross income, ETB/head	75.36	75.72	77.16	79.2	82.68
Net benefit (ETB cow/d)	7.24	7.48	9.38	14.68	17.07
Change in net income	0	0.24	2.14	7.44	9.83
Change in total variable cost	0	0.97	1.19	3.77	4.1
MRR, %	0	0.25	1.8	1.96	2.4

ETB = Ethiopian Birr; MRR = Marginal rate of return; T1= ad libitum Hay + Concentrate mix (0.5 kg/l of milk); T2=75%Hay + 25% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T3=50 %Hay + 50% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T4=25 % Hay + 75% Napier Grass Silage + Concentrate mix (0.5 kg/l of milk); T5= ad libitum Napier Grass Silage + Concentrate mix (0.5 kg/l of milk), Concentrate mix = 49.5% maize grain + 49.5% noug seed cake + 1% salt.

In the present study, the net benefits obtained from the treatments increased from T1 to T5. Marginal rate of return indicates what farmers can expect to gain on the average in return from their investment when they decide to change from one practice to another. Among the treatments, the largest change in cost that varies was birr 4.1 per day and the change in net benefits was birr 9.83 per day resulting in 240% marginal rate of return was recored for T5. So for each birr invested in input for a cow, the farmer would recover birr 1(one) and an additional birr 2.40 at a given prices. Therefore, on the basis of MRR the technology is highly recommended for increasing milk productivity of cows. The result of MRR of the present study was comparable with 158% and 131.85% reported by Shah et al (2009) who worked on an on-farm trial of urea mineral molasses blocks fed to milking cows and buffaloes, respectively.

A rational dairy farmer has to make a compromised decision so that he could opt for a more sustainable milk yield and reasonable profit throughout the entire lactation period, although, this study emphasises the importance of additional observations to see the likelihood of lactation curve for all dietary treatments in the remaining part of the lactation cycle for conclusive economic decision. Generally, those cows fed basal diet of sole *Pennisetum Purpureum* Silage with recommended concentrate mix optimise both biological and economic benefits as compared to cows consumed other treatment rations. However, since the cost for most inputs are variable over time, it cannot be taken for granted that the net benefit obtained from this study would be sustainable over years or locations. The increased net benefit obtained for cows in T4 and T5 was generally due to the low cost of *Pennisetum Purpureum* Silage production. This implies that whether response to feeding basal diet of *Pennisetum Purpureum* Silage is beneficial in economic terms depends on the cost of growing and biomass yield of the forage. The net profit obtained in the present study was comparable with birr 2.84 and 3.00 reported by Getu (2006) and Reherahie (2001) who did feeding trial on dairy cows. In general, it can be understood from the present trial that if farmers establish and use *Pennisetum Purpureum* Silage, milk yield from dairy cows can be improved economically

4. Conclusion

In general, it can be understood from the present study that if farmers establish and use Napier grass silage, milk yield from crossbred dairy cows can be improved economically. Therefore, considering milk yield and economic return in this study, it can be concluded that cows fed basal diet of sole Napier grass silage with recommended concentrate mix (0.5 kg/l of milk yield) optimise both biological and economic benefits as compared to cows consumed other basal diets.There is a need for further study to determine effect of such dietary treatments over the entire lactation period for conclusive economic decision. In order to verify the importance of the present study at farmer’s level, undertaking on-farm trials using the treatments used in the current study is worthwhile

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