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Full Length Research Paper

The status of production, conservation and utilization of natural pasture hay for feeding dairy cattle in the greater Addis milkshed, central highlands of Ethiopia

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This study was conducted to assess the production status, conservation practices and contribution of natural pasture hay for feeding dairy cattle in greater Addis milksheds of the central highlands of Ethiopia. Data were collected from 147 smallholder dairy farmers (84.4% male headed and 15.6 female headed households) using a structured questionnaire, observations, and sampling and measurements of pasture productivity. The average cattle herd size per household in the study areas was 11.8 Tropical Livestock Units (TLU), and the number of total cows and lactating cows owned per household were 4.2 heads and 2.5 heads on an average, respectively with higher proportion of crossbreds than local cows especially at Sululta and G/Jarso. Natural pasture hay was the dominant feed produced and conserved for feeding dairy cattle in the study areas. Peri-urban dairy farmers in Sululta and Ejere produce hay both on their own land and by contracting standing hay, while the urban dairy producers in Fiche town (G/Jarso) produce hay by contracting standing hay mainly from the pasture grown within government compounds available in the vicinity of the town such as the military camp. Overall, 81.6% of all the respondents (96.7% in Sululta, 38.5% in G/Jarso and 97.9% in Ejere) produce hay on their own land and/or by renting standing hay. The total average area of pasture land used for hay making per household in a season was 1.10 ha (1.15 ha in Sululta, 1.76 ha in G/Jarso and 0.83 ha in Ejere), with an estimated average pasture productivity of 6.38 tones DM/ha. The total average quantity of hay produced per household in a season was estimated to be 6.85 tones in dry matter basis. It was also estimated that majority (77.5%) of the households do not apply any management technique to improve pasture productivity other than protecting from livestock for three to four months during the active growing period. Dairy cattle were fed with hay as the major source of basal diet for an average duration of 8 months per year (10.5 months in G/Jarso, 8.5 months in Sululta and 5.4 months in Ejere). Majority of the households conserve hay in loose form and in open air for the whole duration while feeding. Such practices may lead to the loss in hay quality as a result of exposure to adverse weather conditions (such as the combined effects of wetting and drying cycles); a process generally termed as "weathering" loss. Therefore, the changes in hay quality during storage and the corresponding animal performance should be further studied in order to design proper feeding scheme that ensures adequate supply of the required nutrients in hay based feeding system of dairy cattle in the highlands of Ethiopia

Key words: - natural pasture hay, productivity, storage system, dairy cattle, central highlands of Ethiopia

INTRODUCTION

Ethiopia has large cattle resource bases and suitable agro-ecological conditions for dairy production. However, the country is yet very far from being self sufficient in dairy products, and the per capita milk consumption (19 liters per annum) has been one of the least in the world (Zegeye, 2003; Azage et al., 2006; ELDMPS, 2007; Staal

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et al., 2008; FAOSTAT, 2010). Moreover, it is lower than the sub Saharan African average per capita consumption of about 27 liters per annum (FAO, 2009). Among the various factors responsible for low productivity of livestock in general and dairy cattle in particular, the inadequacy of feed in terms of both quantity and quality often imposes the major limitation (Tilahun et al., 2005; Azage et al., 2006; Belete et al., 2009). According to ELDMPS (2007), a deficit of 35% in feed supply is always common in any normal year and this figure rises to about 70% during drought years in the country. Dairy production is basically a function of genetics, feeding, health care and other general management practices. Evidences indicate that genetic improvement will lead to an improvement in milk productivity of cattle ranging from 60 to 300% in terms of 100% only if accompanied by better feeding regimes (McDermott et al., 2010). This could be further emphasized by the fact that feed accounts for 60-70% of the costs associated with dairy production. As dairying is a routine venture which requires continuous and adequate supply of the required nutrients, no improvement in dairy production is possible without adequate understanding and concomitant improvement in feed quantity and quality.

Natural pasture constitutes the major source of basal feed for dairy cattle in the central highlands of Ethiopia. The area of natural pasture lands in the highland mixed farming systems is limited due to expansion of cropping, urbanization and industrial development by displacing a considerable area of pasture land. According to Abera (2006), the natural pasture available in the highlands of the country does not exceed 6 million hectares, the majority of which is concentrated in the central part (mainly parts of North and West Shewa zones of the Oromia Regional State) where fodder conservation in the form of hay is a common practice. Moreover, available pasture lands are highly fragmented and limited to areas where conditions are adverse for cropping due to topographic, edaphic and climatic limitations in the highlands. Mainly, the slope of hills and the seasonally waterlogged areas are left for grazing and/or seasonal hay making. Smallholder market oriented dairy farmers in the central highlands mainly rely on the hay produced from the aforementioned pasture lands. The urban and peri-urban dairy feedlots and small scale fattening operations also depend on the hay produced in these areas as a source of roughage feed. According to Berhanu et al., (2009), about 1 million bales (1 bale □ 13-16 kg) of hay is annually produced in Sululta area alone, North Shewa Zone of Oromia Region and the majority of the hay is supplied to urban and peri-urban dairy producers on sale.

This shows that hay is not only the major source of feed for dairy production, but also is an important source of cash income for smallholder farmers. During the last few years price per kg of native hay has dramatically increased and appears to be more than most agro-industrial by-products (Dawit et al., 2012). As hay is produced only once a year following the main rainy season, its extended utilization as dairy feed depends on pasture productivity, proper harvesting, collection, and conservation systems. Understanding the dynamics in the production status, conservation practices and utilization of native hay would help in designing appropriate strategies to improve the supply, quality and its contribution at a reasonable cost. Therefore, the objective of this study was to assess the production status, conservation practices and contribution of natural pasture hay for feeding dairy cattle in three selected dairy shed areas within the greater Addis milkshed in the central highlands of Ethiopia.

MATERIALS AND METHODS

The study areas

The study was conducted between March to November 2012 to assess the production, conservation systems and utilization of natural pasture hay for feeding dairy cattle in three selected milkshed districts (woredas) in the central highlands of Ethiopia. The three woredas included in the study were Sululta and Girar Jarso woredas from North Shewa zone, and Ejere woreda from West Shewa zone, all located in the Oromia Regional State. Girar Jarso is located between 9°38'47"N to 9°59'49"N and 38°34'17"E to 38°49'41"E and the zonal town Fiche, is situated 113 km northwest of Addis Ababa. Sululta is located between 9°4'30"N to 9°30'59"N and 38°31'26"E to 38°58'49"E and the woreda town Chancho, is situated 40 km northwest of Addis Ababa. Although it is geographically located in North Shewa zone of the Oromia Regional State, Sululta woreda has been administratively placed under the Oromia Special Zone Surrounding Finfinne since 2007. Ejere is located between 8°51'16"N to 9°14'53"N and 38°15'2"E to 38°28'45"E and about 40 km west of Addis Ababa. Both Sululta and Girar Jarso specifically the study sites are located at an altitude of above 2500 m above sea level (a.s.l), while Ejere is located at an altitude of 2400 m above sea level (a.s.l). Figure 1 indicates the maps of the woredas and specific study sites within the woredas.

Girar Jarso (with Fiche - the capital town of North Shewa zone as focal study site) was selected to represent urban dairy production where dairying is practiced to support family income in addition to other non-agricultural activities. The dairy production in this system is relatively intensive and mainly based on stall-feeding using purchased roughages and concentrates. Moreover, the exotic blood level in the herd could be high, but very few cows are kept per farm (house-hold). Both Sululta and Ejere woredas represented peri-urban dairy production system where crop and livestock production are closely integrated, and agricultural

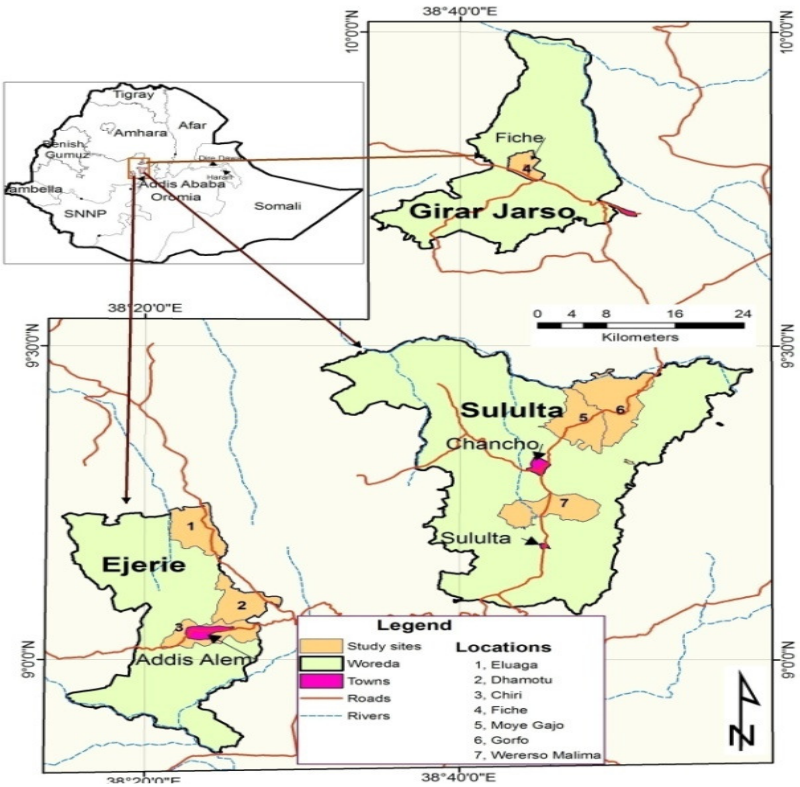

Figure 1: Map of the study areas

activities other than milk production form additional source of income. The major difference between Sululta and Ejere is that in Sululta, cropping is mainly subsistent and livestock production particularly dairying is the major source of livelihood. Hence, it was selected to represent intensified dairy/crop livestock sub-system where some form of intensive dairy production is practiced and the farmers have had experiences with different dairy development projects which have influenced the production system (Azage et al., 2005). Ejere is characterized by intensive cropping where both crops and livestock production have comparable contributions to livelihoods. Hence, it was selected to represent intensified crop/livestock (dairy) production sub-system where the cropping system is more intensive, particularly with a frequent use of fertilizers. Therefore, the three woredas were assumed to represent three segments of market-oriented smallholder dairy production systems/sub-systems viz. urban (Girar Jarso-Fiche), peri-urban intensified dairy/crop-livestock sub-system (Sululta) and peri-urban intensified crop/crop livestock sub-system (Ejere).

Sampling procedures and data collection

In the first step,a quick survey was made and discussions were held with agricultural extension offices and available dairy cooperatives/unions in the three districts (woredas). First hand information was gathered regarding the overall picture of dairy production, feed resources and other related issues. The information obtained from the respective woreda offices of agriculture was used to select focal villages (Kebele administrations) and individual farmers in a sort of multi-stage purposive sampling technique. Two to three villages were selected from each woreda on the basis of dairy production potential, linkage to milk market, experience in hay production/utilization and accessibility. Subsequently, a total of 147 dairy farmers (60 from Sululta, 39 from Girar Jarso and 48 from Ejere) were selected with the help of village development agents. A pre-tested structured questionnaire was used to collect data by interviewing individual farmers at their farm gates.

The questionnaire covered various topics including general household characteristics, livestock and dairy cows herd size and composition, land holding, land area used for hay production, pasture management and productivity, hay storage systems, and contribution for feeding dairy cattle in terms of the duration of feeding period of hay in a year. As the survey was conducted by a team of researchers with expertise in animal production, and feeds and nutrition, it was easier to countercheck the farmers` responses with own personal

Table 1: Demographic characteristics of the responding households

Variable	Sululta (N=60)	G/Jarso (N=39)	Ejere (N=48)	Overall (N=147)
Sex				
Male (%)	95.0	64.0	87.5	84.4
Female (%)	5.0	36.0	12.5	15.6
Total (%)	**100**	**100**	**100**	**100**
Age (years)	43.1 (22-76)*	46.8 (20-70)	45.0 (28-60)	45.0 (20-76)
Family size	7.08 (2-13)	6.19 (1-11)	7.21 (4-12)	6.83 (1-13)
Educational status				
Unable to read & write (%)	16.7	18.0	14.6	16.4
Read & write only (%)	15.0	2.5	10.4	9.3
Attended formal education (%)	68.3	79.5	75.0	74.3
Total (%)	**100**	**100**	**100**	**100**
Level of formal education attended				
Primary school (1-4), %	15.0	5.1	18.8	13.0
Junior secondary school (5-8), %	26.6	15.4	33.3	25.1
High school (9-12), %	25.0	41.0	22.9	29.6
Graduate/certificate, %	1.7	18.0	-	6.6
Total (%)	**68.3**	**79.5**	**75.0**	**74.3**

Figures in the brackets indicate ranges

observations of the realities on the ground. The conversion factors suggested by Gryseels (1988) for indigenous breeds and by Bekele (1991) for crossbreds were adopted to convert the livestock numbers into Tropical Livestock Units (TLU) which is equivalent to a live weight of 250 kg.

Estimation of hay production from natural pasture

Sampling for pasture herbage yield determination was made in all the study areas during the peak hay harvesting period (Mid – Late October, 2012). Three to five representative pasture fields were selected in each of the villages included in the study in both Sululta and Ejere woredas. But in Girar Jarso, sampling was made from pastures grown in government compounds like the military camp and Farmers` Training Centers (FTC`s) found around Fiche town as these compounds were reported to be the major sources of hay for the urban dairy farmers in Fiche town. Sampling was made by placing a 0.5m^2 quadrate at five randomly selected plots within the pasture field. After measuring the fresh weight of the biomass harvested from the five 0.5m^2 plots, a sample of 350g was taken using a sensitive field balance for further DM determination through oven drying in the laboratory. The quantity of hay produced per household was estimated by multiplying the average DM yield per hectare with the corresponding areas of pasture land reported to be used for hay production by the households.

Data analysis

The three woredas (representing the three dairy production systems/sub-systems) were used as fixed factors for the various dependent variables assessed in the study. The survey data was coded and analyzed using the statistical package for social sciences (SPSS version 16, 2007) for windows. Where applicable, the significance of differences in mean values of the quantitative variables between the woredas were tested using Duncan`s Multiple Range Test (Duncan, 1955) at a probability level of 0.05. Qualitative variables were also described using the descriptive statistics of SPSS.

RESULTS AND DISCUSSIONS

Household characteristics

The major household characteristics of the respondents are shown in Table 1. On average, the majority (84.4%) of the total respondents were male headed households and the rest 15.6% were female headed households. The proportion of female households was higher in G/Jarso (urban based dairy production) than in the other two woredas peri-urban crop-livestock mixed farms. Similar studies in Addis Ababa have indicated that female households constitute 33% of dairy farmers (Azage, 2004). This indicates the importance of dairying in supporting livelihoods of female headed households in urban areas. The overall average age of the respondents was 45 years and ranged from 20–76 years. There was no significant difference in average ages of the respondents in the three woredas and most of the respondents were within the range of productive age (20-60 years).

The overall average family size of the responding households in all the study areas was 6.83 persons, and ranged from 1-13 persons. It was also observed that 67%

of all the responding households had family sizes of greater than or equal to 6 persons. The average family size in this study was much closer to the figures reported earlier in Selale area (Kelay, 2002) and in milkshed areas around Bahir Dar and Gondar in North western Ethiopia (Yitaye, 2008), but was lower than the figure (8.9) reported in Debre Birhan, Sebeta, Jimma and Ziway areas (Zewdie, 2010). Large family size is considered as an asset and a factor which guarantees social security within the household in agriculture based livelihoods. This could be the major reason for the comparatively higher average family size per household in Ejere and Sululta woredas (peri-urban production system) than the urban based dairy production in G/Jarso.

The educational level of the respondents ranged from totally illiterate to those with university education. Overall, 16.4% of the respondents were illiterate, 9.3% were able to read and write through informal means such as adult education, and 74.3% had attended different levels of formal education (Table 1). In all the study areas, more than 50% of the respondents had attended formal education (79.5% in G/Jarso, 75% in Ejere, and 68.3% in Sululta). However, there were considerable differences in the levels of formal education attended by the respondents in the three woredas. In Sululta and Ejere, the majority of respondents had attended primary and junior secondary schools, while about 41% of the respondents had attended high school and 18% were graduates/certificate holders who were government employees and carry out dairying as supplementary source of income in G/Jarso. The proportion of households possessing higher education in G/Jarso in this study was comparable to the figure (19.6%) reported in milkshed areas of North western Ethiopia (Yitaye, 2008), but was lower than the 24% reported in the Harar milkshed (Mohammed, 2003). In general, the level of education of dairy farmers is an important factor determining the managerial capacity, adoption of new technologies and the overall intensification of smallholder dairy production.

Livestock and dairy cows herd size and structure

The general livestock and dairy cattle ownership status of the surveyed households are presented in Table 2. Cattle are the dominant species raised by 100% of the responding households in all the study areas. The overall average cattle herd size per household was 11.8 TLU and accounted for about 85% of the total livestock herd owned by the households. Average cattle herd sizes per household were significantly higher ($p<0.05$) in Sululta and Ejere woredas (peri-urban areas) and lower by more than half in G/Jarso (urban based production). This agrees with the findings of Yitaye (2008) and Zewdie et al., (2011) who reported higher cattle herd size per household in peri-urban crop-livestock farms than in urban dairy production systems. The variations could be attributed to differences in production objectives between urban and peri-urban farmers, and also the lack of sufficient space to accommodate large herd size in urban centers. Yitaye (2008) indicated that lack of space was the major problem in urban dairying and that dairy cattle were kept in confined places of the same compound where the family members are living. Similar scenario was observed in this study and such a practice may bear some hygienic risks mainly associated with waste disposal which is often problematic in urban livestock production. Waste disposal is more problematic during the wet season as weather conditions are not conducive for making and drying dung cakes to use as fuel wood.

The lack of drainage system and waste disposal facilities were the major problems faced by urban dairy producers. The mean cattle herd sizes per household especially in Sululta and Ejere woredas in the present study were higher than the figures earlier reported in Sululta and Degem (Kelay, 2002), and comparable to the figures reported in Debre Birhan, Sebeta and Jimma areas (Zewdie, et al., 2011). The average cattle herd size per household in Sululta has been found to increase from 8.13 TLU (Kelay, 2002) to 14.4 TLU in the present study indicating an increase of about 77% within 10 years time. This shows the increased importance of cattle especially dairying to the livelihoods of farmers in the area. But in G/Jarso (Fiche town), the average cattle herd size per household in this study was lower than the figure (6.8) previously reported by Fikre (2007). Sheep, donkey, horse and chicken were the other important livestock species raised by large proportion of households in the study areas. Goats were also raised by considerable proportion of households (43.8%) in Ejere woreda.

99.3% of the total respondents owned dairy cows ranging from 1-35 heads, with an overall average of 4.2 heads per household (Table 2). This was higher than the figures previously reported in Sululta and Degem woredas (Kelay, 2002) and in milkshed areas around Bahir Dar and Gondar in North western Ethiopia (Yitaye, 2008), but was comparable to the recent figures reported in Debre Birhan, Sebeta and Jimma (Zewdie, 2010). The average number of cows owned per household was significantly higher ($p<0.05$) in Sululta (5.2 heads) followed by Ejere (4.4 heads) and lower in G/Jarso (2.5 heads). Generally, 78% of the respondents in Sululta, 100% of the respondents in G/Jarso, 87.5% of the respondents in Ejere, and 87% of all the respondents in the three woredas owned 1-6 heads of mature dairy cows. With regard to breed composition, crossbred cows account for about 55-60% of the total cows owned per household in Sululta, more than 95% in G/Jarso, and about 45-50% in Ejere. Overall, 97.9 and 55.5% of the respondents

Table 2: Livestock and dairy cattle herd size and composition per household in the study areas

Variable	Sululta (N=60)		G/Jarso (N=39)		Ejere (N=48)		Overall (N=147)	
	%	Mean±SE	%	Mean±SE	%	Mean±SE	%	Mean±SE
Livestock herd size and structure (TLU)								
Cattle	100	14.4±1.6[a]	100	5.9±0.4[b]	100	13.4±0.9[a]	100	11.8±0.8
Sheep	83.3	1.4±0.2[a]	61.5	0.5±0.08[b]	58.3	0.7±0.1[b]	69.4	1.0±0.1
Goats	5.0	0.9±0.4	-	-	43.8	0.8±0.2	16.3	0.8±0.2
Horse	26.7	1.0±0.1	-	-	47.9	1.8±0.2	26.5	1.5±0.2
Donkey	88.3	1.1±0.1[a]	20.5	1.2±0.3[a]	85.4	1.1±0.1[a]	69.4	1.1±0.1
Mule	8.3	0.7±0.0	-	-	2.1	0.7	4.1	0.7±0.0
Chicken	80.0	0.1±0.01[a]	43.6	0.05±0.01[b]	81.3	0.1±0.01[a]	70.0	0.1±0.01
Total	**100**	**17.0±1.8[a]**	**100**	**6.5±0.5[b]**	**100**	**16.1±1.1[a]**	**100**	**13.9±0.9**
Dairy cows herd size and structure (heads)	%	Mean	%	Mean	%	Mean	%	Mean
Total cows	98.3	5.2[a] (1-35)*	100	2.5[b] (1-6)	100	4.4[a] (1-18)	99.3	4.2 (1-35)
Crossbred cows	98.3	3.3 (1-35)	100	2.5 (1-6)	95.8	2.2 (1-6)	97.9	2.7 (1-35)
Local cows	74.6	2.6 (1-6)	2.6	1.0	75.0	3.1 (1-13)	55.5	2.8 (1-13)
Total lactation cows	94.9	3.1[a] (1-17)	92.3	2.0[b] (1-4)	97.9	2.3[ab] (1-6)	95.2	2.5 (1-17)
Lactating crossbred cows	96.4	2.2 (1-17)	100	2.0 (1-4)	78.7	1.7 (1-4)	91.4	2.0 (1-17)
Lactating local cows	51.8	1.9 (1-4)	2.8	1.0	59.6	1.6 (1-3)	41.7	1.7 (1-4)

[a-b] Means with different superscripts within a row differ significantly (P<0.05)
*Figures in the brackets indicate the ranges in number of dairy cows owned per household
1 TLU = 0.91 local oxen/bull, 0.52 crossbred oxen/bull, 1.25 local cows, 0.56 crossbred cows, 2 local heifers, 1.43 crossbred heifers, 5 local calves, 2.5 crossbred calves, 10 sheep/goats, 1.25 horses, 2 donkeys (Gryseels, 1988; Bekele, 1991)

reported to own crossbred and local cows, respectively. Similar trends have been reported in Debre Birhan, Sebeta and Jimma peri-urban production systems (Zewdie, 2010). However, this is referring to market-oriented dairy producers and should not be interpreted to the whole farming households in the study areas.

The overall average number of crossbred cows owned per household was 2.7 heads (ranging from 1-35 heads). The average figure indicate that majority of the households own 1-3 heads of crossbred cows. The average number of crossbred cows owned per household was higher in Sululta (3.3 heads) followed by G/Jarso (2.5 heads) and Ejere (2.2 heads). On the other hand, the average number of local cows owned per household was higher in Ejere (3.1 heads) followed by Sululta (2.6 heads), while local cows were rarely reared in the urban based dairy production in G/Jarso. An overall average of 2.8 (ranging from 1-13) heads of local cows were owned per household, and according to the respondents, the major reason for keeping local cows is to produce replacement oxen for draught power in the peri-urban crop-livestock farms.

Over 95% of the respondents owned lactating cows ranging from 1-17 heads with an overall average of 2.5 heads per household (3.1 heads in Sululta, 2 heads in G/Jarso and 2.3 heads in Ejere). Belete et al., (2010) also reported comparable figures in Fogera woreda of Amhara region. The average number of lactating cows per household in this study was greater than the figure reported for smallholder dairy farmers (1.29), but lower than the figure reported for medium farms (6.43) in Bishoftu, Ethiopia (Mulisa et al., 2011). The majority (91.4%) of the total respondents owned lactating crossbred cows ranging from 1-17 heads (average 2 heads), while only 41.7% of the respondents owned lactating local cows ranging from 1-4 heads (average 1.7 heads). The higher proportion of lactating crossbred cows owned per household indicates the increased tendency of market orientation by the producers as crossbred cows are primarily reared to generate income from sale of milk.

Hay production

The prevailing aspects of natural pasture hay production in the study areas are presented in Tables 3-5. Table 3 indicates the area of land used for seasonal hay production per household,

Table 3: Land area used for seasonal hay production per household, its proportion in relation to the total land and estimated pasture productivity in the study areas

Variable	Category of the land	Sululta (N=60)		G/Jarso (N=39)		Ejere (N=48)		Overall (N=147)	
		%	Mean	%	Mean	%	Mean	%	Mean
Land owned (ha)	Own land	96.6	3.11[a] (0.25-7.13)*	12.8	1.50[b] (0.25-3.25)	95.8	3.53[a] (0.01-9.28)	88.5	3.22 (0.01-9.28)
	Rented land	83.1	1.72 (0.13-14.00)	38.5	1.59 (0.11-4.00)	81.2	1.59 (0.13-7.00)	84.4	1.65 (0.11-14.00)
	Total	**98.3**	**4.43[a] (1.50-14.00)**	**38.5**	**2.14[b] (0.11-4.00)**	**100**	**4.68 (0.50-11.25)**	**83.0**	**4.25 (0.11-14.00)**
Land used for seasonal hay production (ha)	Own land	66.7	0.62 (0.25-1.50)	7.7	0.83 (0.50-1.50)	58.3	0.57 (0.13-1.00)	48.3	0.61 (0.13-1.50)
	Rented land	70.0	1.00[b] (0.13-4.00)	38.5	1.59[a] (0.11-4.00)	75.0	0.64[b] (0.13-2.00)	63.3	0.96 (0.10-4.00)
	Total	**96.7**	**1.15[b] (0.25-4.00)**	**38.5**	**1.76[a] (0.11-4.00)**	**97.9**	**0.83[b] (0.13-2.00)**	**81.6**	**1.10 (0.11-4.00)**
Proportion of land used for seasonal hay production (%)	From own land		19.94		55.33		16.15		18.94
	From rented land		58.14		100		40.25		58.18
	From total land		25.96		82.24		17.73		25.88
Pasture productivity (tone DM/ha)			5.63[c]		7.97[a]		6.04[b]		6.38
Estimated amount of hay produced per HH in a season (tone DM)			6.48[b] (1.41-22.52)[@]		14.01[a] (0.88-31.88)		5.01[b] (0.76-12.08)		6.85 (0.76-31.88)

[a-b]Means having different superscripts for each category of land in a column differ significantly ($p<0.05$)
*indicate the ranges in the areas of land owned, contracted and used for hay production per household
[@]indicate total ranges in the amount of hay (tones) estimated to be produced per household in a season

proportion of the total land used for hay production and estimated pasture productivity in the study areas. Dairy farmers in the study areas produce hay on their own pasture land and/or by contracting standing hay. The majority of the respondents in Sululta (66.7%) and Ejere (58.3%) produce hay on their own land. The average size of own land used for hay production per household was 0.62 ha (ranging from 0.25-1.50 ha) in Sululta and 0.57 ha (ranging from 0.13-1.00 ha) in Ejere. In G/Jarso (urban based dairy production), only 3 respondents (7.7% of the total respondents) own land for hay production (average 0.83 ha, ranging from 0.50-1.50 ha). Overall, 48.3% of the total respondents produce hay on their own land with an average area of 0.61 ha (ranging from 0.13-1.50 ha) per household. Similarly, 70% of the respondents in Sululta, 38.5% of the respondents in G/Jarso, 75% of the respondents in Ejere, and 63.3% of all the respondents produce hay by contracting/renting pasture land. The overall average area of contracted land for hay production was 0.96 ha (ranging from 0.11-4.00 ha) per household. The average area of contracted standing hay per household was significantly higher in G/Jarso (1.59 ha, $p<0.05$) followed by Sululta (1.00 ha) and Ejere (0.64 ha). Overall, 96.7% of the respondents in Sululta, 38.5% of the respondents in G/Jarso, 97.9% of the respondents in Ejere, and 81.6% of all the respondents produce hay on their own land and/or by renting standing hay. The total average area of pasture land used for hay production per household ranged from 0.11-4.00 ha with an overall mean of 1.10 ha (1.15 ha in Sululta, 1.76 ha in G/Jarso and 0.83 ha in Ejere).

From the study, it has been understood that considerable proportion of land is devoted to hay production in the study areas. The overall average proportion of own held land used for seasonal hay production was 18.94% (19.94% in Sululta, 55.33% in G/Jarso and 16.15% in Ejere). Moreover, higher proportion (58.18%) of the contracted land was reported to be used for hay production (58.14% in Sululta, 100% in G/Jarso and 40.25% in Ejere). Overall, 25.88% of the total land available per household in a season whether own held and/or contracted is devoted to hay production. The average pasture land sizes used for hay production per household in this study were greater than the earlier figures reported in Selale (Kelay, 2002) and in Debre Birhan area (Zewdie, 2010). In all the study areas, the dairy farmers seem to produce more hay by contracting standing hay and this indicates the better access and well established culture of renting pasture land in the areas. Moreover, the higher cattle herd size with increased proportion of crossbred cows might have necessitated more hay production by contracting pasture land on top of own holding in the study areas. The landless dairy farmers in Fiche town (G/Jaro) mainly produce hay by contracting standing hay grown within the government compounds such as the military camp located in the vicinity of the town. Prices for

Table 4: Applications of different management practices to improve productivity of hay according to the respondents

Question	Response	Sululta (N=58)	G/Jarso (N=15)	Ejere (N=47)	Total (N=120)
		n	n	n	n
Do you apply different management practices to improve productivity of hay?	Yes	11 (19.0)*	2 (13.3)	14 (29.8)	27 (22.5)
	No	47 (81.0)	13 (86.7)	33 (70.2)	93 (77.5)
Types of management practices applied					
Fertilizer application		1 (9.1)	1 (50.0)	2 (14.3)	4 (14.8)
Manure application		8 (72.7)	1 (50.0)	5 (35.7)	14 (51.8)
Weeding		2 (18.2)	-	9 (64.3)	11 (40.7)
Legume over sowing		-	-	-	-

*Figures in the brackets indicate the percentages (proportion) of respondents

contracting standing hay are negotiated based on land area and visually assessed stand performance of the pasture. Moreover, the costs of harvesting, collection, transportation and storage of the hay are covered by the contracting farmers. The farmers were complaining on the extremely high cost of hay production from contracted land which they estimated to range from 1000-1200 Birr/ha for harvesting alone. About 62% of the responding urban dairy producers in G/Jarso were also reported to secure the roughage feed supply mainly by purchasing readily available hay (heaps, bales, donkey loads, etc) from the surrounding areas.

The productivity of pasture (tones DM/ha) was significantly higher ($p<0.05$) in G/Jarso (7.97) followed by Ejere (6.04) and was lower in Sululta (5.63), with the overall average being 6.38 t DM/ha (Table 3). In G/Jarso, the pasture was sampled from the well protected government compounds such as the military camp and FTC`s where the dairy producers were contracting standing hay, and this could be the reason for the higher productivity of pasture as compared to the other study areas. In Sululta area, hay is mainly produced on waterlogged lands which could retard pasture growth with the resulting low herbage yield. On average, the quantity of hay estimated to be produced per household in a season was 6.85 tones (ranging from 0.76-31.88 tones) in dry matter basis. Significantly higher ($p<0.05$) amount of hay was estimated to be produced per household in G/Jarso, 14.01 t (range: 0.88-31.88 t) as compared to Sululta, 6.48 t (range: 1.41-22.52 t) and Ejere, 5.01 t (range: 0.76-12.08 t). This indicates that the urban dairy producers in G/Jarso are opting to secure as much hay as possible to ensure adequate year round roughage feed supply as stall feeding is the sole feeding management in urban settings.

The respondents were requested whether they apply different managerial practices on the pasture land to improve the productivity of hay. As shown in Table 4, 77.5% of all the respondents reported that they do not practice any management technique, while the rest 22.5% reported to apply some management practices. Among the households who reported to apply different management techniques, 14.8% of them reported to apply fertilizers, 51.8% reported to apply manure and 40.7% reported to remove undesirable weeds. Manure application was reported to be the major practice in Sululta, while both manure application and weed removal were practiced by the concerned households to improve pasture productivity in Ejere. However, the respondents do not know the amount of manure/fertilizer applied per unit area of pasture land. Generally, it was understood that the majority of farmers in the study areas do not incur any managerial inputs to improve the productivity of hay. Although they believe that the use of inputs such as fertilizer/manure could help to improve pasture productivity, they refrain from using them due to high cost of fertilizers and the difficulty to transport manure to pasture fields due to its bulkiness. Moreover, manure is mainly used for making dung cakes which are used as important sources of fuel wood by the farmers.

Hay is produced on continuously grazed pockets of pasture lands by protecting the lands from livestock for a certain period of time during the main rainy season to allow the pasture to grow and provide harvestable biomass. In some areas like Sululta, hay is produced on waterlogged bottomlands which are usually less accessible to livestock during the rainy season. Time of protection of the pasture land from livestock, harvesting time and duration of field drying period of hay as reported by the households are shown in Table 5. The majority of the respondents (85.8%) have indicated that the pasture land is protected beginning from early July, 13.4% beginning from mid July and only few (0.8%) respondents reported to protect the land beginning from late July. According to the respondents, the harvesting time of hay ranged from early October to late November. However, the peak harvesting time reported by majority (58.3%) of the respondents was between mid- and late October. Generally, it was understood that the pasture growing period ranged from 3 to 4.5 months including the harvesting operations in the study areas. Three months seem to be too short to support better pasture growth and higher biomass yield per unit area especially from the pasture land which has been under heavy continuous

Table 5: Time of protection of the pasture land from livestock, harvesting time and duration of field drying of hay prior to storage according to the respondents

Variable	Sululta (N=58)	G/Jarso (N=15)	Ejere (N=47)	Overall (N=120)
	%	%	%	%
Time when the pasture is protected from livestock				
Early July	89.7	86.7	80.9	85.8
Mid July	10.3	13.3	17.0	13.4
Late July	-	-	2.1	0.8
Total	**100**	**100**	**100**	**100**
Harvesting time of hay				
Early-Mid October	27.6	26.7	23.4	25.8
Mid-Late October	67.2	66.7	44.7	58.3
Early-Mid November	5.2	6.6	27.7	14.2
Mid-Late November	-	-	4.2	1.7
Total	**100**	**100**	**100**	**100**
Duration of field drying of hay (days)				
3-6	44.1	60.7	74.5	58.2
7-10	44.1	39.3	25.5	36.6
>10	11.8	-	-	5.2
Total	**100**	**100**	**100**	**100**
Mean	**7.20^{a} (3-15)***	**5.93^{b} (4-10)**	**4.89^{b} (3-10)**	**6.13 (3-15)**

N=the number of households who reported to produce hay on own land and/or by contracting land
$^{a-b}$ Means with different superscripts within a row differ significantly (P<0.05)
*Figures in the brackets indicate total range in the duration of field drying of hay

grazing, the case in the highlands of Ethiopia. Various studies (Teshome et al., 1994; Zinash et al., 1995; Adane and Berhan, 2007; Ashagre, 2008) have indicated increased herbage yields with the delay in harvesting time of hay, but that was achieved at the expense of loss in feed quality. For instance, a recent study at Holetta have shown that the CP content and in-vitro digestibility (IVDOMD) were reduced by 30.2% and 17.8%, respectively with the delay in harvesting from mid October to late November (Authors, unpublished data). Hence, delaying harvesting time beyond the late October is not recommendable and protecting livestock beginning from mid June may be adopted as an option to provide the pasture with adequate growing period resulting in the production of large quantity and better quality hay.

Field drying is the other important component of hay making operations aiming at reducing the moisture content in the pasture to safe levels for storage which should be less or equal to 20%. Observations at Holetta indicate that 4 to 5 days field drying is adequate to bring the moisture content in the pasture to safe level for storage under bright sunlight conditions. In this study, the overall average duration of field drying period of hay reported by the responding households was 6.13 days (ranging from 3-15 days) (Table 5). 58.2% of all the respondents reported to dry hay for 3-6 days, while the rest 41.8% reported to take more than a week for drying hay. The mean duration in field drying of hay was significantly longer ($p<0.05$) in Sululta, 7.20 days (range: 3-15 days) than in G/Jarso, 5.93 days (range: 4-10 days) and Ejere, 4.89 days (range: 3-10 days). Coincidence with harvesting of food crops and the associated labour shortage was the main reason for the delay in collection and storage of hay according to the respondents in Sululta. Substantial loss in hay quality has been reported in the field drying process (Gupta et al., 1990; Barr et al, 1995) as a result of one or more of the following factors viz. plant respiration, leaching of soluble nutrients by rainfall, microbial activities and bleaching by the sun. As this loss can be further enhanced by extended duration of drying, timely collection and storage of harvested hay is highly advisable.

Hay storage systems and utilization

The prevailing aspects of hay storage systems and utilization for feeding dairy cattle in the study areas are presented in Tables 6 and 7. As shown in Table 6, hay was stored in loose form by the majority (77.5%) of all the respondents, whereas 22.5% of the respondents reported to store baled hay. Baling hay was totally uncommon in Ejere, while 31.7% of the respondents in Sululta and 35.9% of the respondents in G/Jarso reported to make baled hay. The sources of baler were private owners and the average baling costs reported were 3.85 Birr/bale in Sululta and 4.17 Birr/bale in G/Jarso, with an overall average of 3.96 Birr/bale (ranging from 3.00-5.00 Birr). According to this, a farmer has to pay at least 1500 Birr in order to bale hay produced on 1 ha of land. Such a high

Table 6: Form of storage and method of storage of hay according to the respondents

Variable	Sululta (N=60)	G/Jarso (N=39)	Ejere (N=48)	Overall (N=147)
	%	%	%	%
Form of storage of hay				
Loose hay	68.3	64.1	100	77.5
Baled hay	31.7	35.9	-	22.5
Total	**100**	**100**	**100**	**100**
Cost of baling (Birr/bale)	**3.85 (3.0-5.0)***	**4.17 (3.25-5.0)**	**-**	**3.96 (3.0-5.0)**
Method of storage of hay				
Under shelter shade	38.3	25.6	20.8	29.3
Under open air	55.0	61.5	58.3	57.8
Using plastic cover	6.7	12.8	20.8	12.9
Total	**100**	**100**	**100**	**100**

*Figures in the brackets indicate the ranges in cost of baling hay

cost of baling was the major reason for not producing baled hay by the majority of responding households. Baled hay is advantageous over loose hay in terms of reducing field losses and facilitating the overall hay management practices such as collection, transportation, storage and feeding. Therefore, future dairy development projects and government extension programs should consider possible introduction of balers to organized groups of farmers in potential hay producing areas.

Storage method was the other important factor assessed in this study. The majority (57.8%) of the responding households reported to store hay under open air, 29.3% under shelter shade, and 12.9% reported to use some plastic covering on the hay stored outside (Table 6). It can be generally deduced that about 70% of the households store hay under open air as the protection provided by plastic sheets is only partial and does not equate to shelter shades. Most of the respondents believe that hay quality can be highly deteriorated when stored outside than under shade, and mentioned lack of capacity (resources) as the major limitation to construct shelter for hay storage. According to the respondents, mold growth, change in colour (black or brown-reddish), bad smell (unpleasant odour), and low animal preference and too much refusal are some indicators of spoiled hay. On the other hand, about 30% of the respondents had the perceptions that if well thatched and piled properly, hay can be stored outside without any problem. A recent study at Holetta indicated that the CP content in natural pasture hay was reduced by 23.3 and 36.7% between the pre-storage period and eight months after storage when stored under shelter shade and under open air, respectively (Authors, unpublished data).

This shows that storing hay outside for a long period will result in substantial loss in feed quality to the level detrimental to the nutrition of dairy cattle in hay based feeding systems such as the case in the highlands of Ethiopia. Exposure to adverse weather conditions is the major factor responsible for the loss in hay quality under open air storage. Hay that is stored outside and subjected to wetting and drying cycles will develop a fibrous, weathered layer and this process is generally termed as “weathering”. Weathering in hay refers to the wet, discolored, and frequently moldy layer on the exterior and bottom surfaces of baled and/or loose hay (Lemus, 2009). The weathering process will decrease digestibility, increases fiber concentration and reduces the overall hay quality. The highest nutrient loss in hay due to weathering is caused by leaching which refers to the dissolving and removal of nutrients by the passage of rain water over the surface of the hay. In this process, the more soluble/digestible nutrients (carbohydrates, lipids, fatty acids, etc) are washed out of the forage. The loss of nutrients in this way causes the fiber component of the forage to represent a larger proportion of the dry matter with the consequent reduction in total digestible nutrients. Hence, there is a likelihood of substantial loss in hay quality under open air storage system (the practice by majority of the respondents in this study). Therefore, further studies may be required to assess the changes in nutritional quality of hay during storage and the corresponding performance of dairy cattle fed to this feed during different seasons of the year under farm conditions.

The feeding practice and contribution of hay for feeding dairy cattle in terms of the duration of feeding in a year in the study areas is presented in Table 7. Feeding stored hay to dairy cattle was reported to be started soon after storage by 45.9% of all the respondents, one month after storage by 19.2% of the respondents, two months after storage by 24.7% of the respondents, three months after storage by 8.9% of the respondents and only 1.4% of the respondents reported to start feeding hay after three months of storage. The majority (94.7%) of the respondents in G/Jarso (urban based dairy production) reported to start feeding hay soon after storage, while only 31.7% of the respondents in Sululta and 25% of the respondents in Ejere reported to start feeding hay immediately beginning from the time of storage.

Table 7: Starting time of feeding and duration of feeding stored hay to dairy cattle according to the sample respondents

Variable	Sululta (N=60)	G/Jarso (N=39)	Ejere (N=48)	Overall (N=147)
	%	%	%	%
Starting time of feeding stored hay after storage				
Soon	31.7	94.7	25.0	45.9
One month	20.0	2.6	31.3	19.2
Two months	36.7	2.6	27.1	24.7
Three months	11.7	-	12.5	8.9
After three months	-	-	4.2	1.4
Total	**100**	**100**	**100**	**100**
Duration of hay feeding period in a year (months)				
2 - 4	3.3	-	39.6	14.3
5 - 7	33.3	2.6	43.7	28.6
8 - 10	38.3	51.3	14.6	34.0
>10	25.0	46.1	2.1	23.1
Total	**100**	**100**	**100**	**100**
Mean	**8.52^{b} (3-12)***	**10.51^{a} (5-12)**	**5.35^{c} (2-12)**	**8.01 (2-12)**

$^{a-c}$ Means with different superscripts within a row differ significantly (P<0.05)
*Figures in the brackets indicate ranges in the duration of feeding period of hay per year

According to most of the peri-urban dairy farmers in Sululta and Ejere, dairy cattle are maintained on aftermath grazing (both on harvested crop and pasture fields), crop boundaries and pasture leftovers for 1 to 2 months during the harvesting season, and this practice helps to provide some break for the stored hay. On the other hand, in the urban center of G/Jarso (Fiche town) feeding management of dairy cattle is based on stall feeding throughout and the only option is to feed hay just beginning from the time of storage.

The overall average duration of hay feeding period to dairy cattle by the responding households was 8 months (ranging from 2 to 12 months) per year (Table 7). The average duration of hay feeding period was significantly ($p<0.05$) longer in G/Jarso, 10.5 months (range: 5-12 months) followed by Sululta, 8.5 months (range: 3-12 months), and was shorter in Ejere, 5.4 months (range: 2-12 months). The majority of the responding households in G/Jarso (97.4%) and Sululta (63.3%) reported to feed dairy cattle using hay as a major source of basal diet for 8 months or more per year. On the other hand, 83.3% of the respondents in Ejere reported to feed hay to dairy cattle for 2-7 months per year. Overall, 42.9% of all the respondents reported to feed hay to dairy cattle for 2-7 months per year, while the rest 57.1% reported to feed hay for 8 months or more per year. Moreover, 46.1% of the respondents in G/Jarso and 25% of the respondents in Sululta reported to feed hay for more than 10 months per year. Hay is considered as a better quality source of roughage by the dairy farmers and is preferably fed to lactating cows, while the other groups of cattle are fed with crop residues especially in Ejere where the supply of hay is very limited as compared to Sululta and G/Jarso.

CONCLUSIONS

From this study, it has been concluded that dairying is the important livelihood activity for the households in the study areas. The average number of lactating cows owned per household was 2.5 heads (ranging from 1-17 heads) with higher proportion of crossbred than local cows by majority of the respondents indicating the increased tendency of market orientation by the producers. Natural pasture hay was the dominant feed produced and conserved for feeding dairy cattle in the study areas, especially in Sululta and G/Jarso. Peri-urban dairy farmers in Sululta and Ejere produce hay both on their own land and by contracting standing hay, while the urban dairy producers in G/Jarso produce hay by contracting standing hay mainly from the pasture grown within government compounds available in the vicinity of Fiche town. The overall average area of pasture land used for hay making per household in a season was 1.10 ha (25.9% of the total land owned), and the average pasture productivity was estimated to be 6.85 tones DM/ha. Dairy cattle are fed with hay as the major source of basal diet for an average duration of 8 months (ranging from 2-12 months) per year in the areas.

The majority of households conserve hay in loose form and under open air for the whole duration of feeding. Such a practice could inevitably lead to the loss in hay quality as a result of exposure to adverse weather conditions (such as the combined effects of wetting and drying cycles); a process generally termed “weathering” loss in hay quality. Therefore, the changes in hay quality during storage and the corresponding animal performance should be further studied in order to design proper feeding scheme which ensures adequate supply

of the required nutrients in hay based feeding system of dairy cattle in the highlands of Ethiopia.

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