Production and Utilization of Crop Residues in Three Agro Ecological Zones of Eastern Shoa Zone, Ethiopia

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ABSTRACT

To assess the production and utilization of crop residues in East Shoa Zone of Oromiya Regional State, Ethiopia, 3 Agro Ecological Zones (AEZs), namely, sub-moist (SM2), sub-humid (SH2) and semiarid (SA2) were chosen based on their large area coverage and, a total of 300 households were proportionally selected from these AEZs and interviewed using structured questionnaire. Even if the total annual crop residue produced per household was not statistically different, the contribution of each type of crop residue to the total annual crop residue production per household varied ($p<0.05$) among the AEZs. With regard to utilization, farmers in all the three AEZs used almost all types of their crop residues primarily for animal feeding. Alternative uses of crop residues were observed to vary more with the type of residue than with the AEZs. It could be concluded that with an annual average production of 0.67 to 1.01 tons per TLU of a household, crop residues contributed to 26 to 40% of the total annual maintenance feed requirement of ruminants. Through the use of improved seeds and other inputs that boosted both grain and residue yields, and by the application of better ways of collection and storage that minimized wastages, farmers could derive more benefits from these valuable feed resources.

Key words: agro ecological zone, crop residue, Ethiopia

INTRODUCTION

Crop residues are fibrous by-products which result from crop cultivation. They include leaves, leaf sheath and stems. The availability of crop residues at the farm level depends not just on production levels but also on a variety of social and economic factors. According to Timothy *et al*. (1997), land, crop and animal ownership patterns, cultural practices and the opportunities for market and non-market exchanges all influence a farmer's access to the locally produced residues. Seasonal and inter-year variations in crop residue production can also have a marked effect on availability of the residues at a particular time of the year.

The total annual residue production varies from place to place depending on the production system of the area and hence the type of crops grown. Kossila (1985) described the global situation on production of fibrous crop residues for the year 1981. According to his description, Africa was second to Asia in crop residue production with a total production of 2.2

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Received date : 15/11/05 Accepted date : 17/03/06

tons of dry matter (DM) per livestock unit of herbivores. The same source indicated that about 0.6 ton DM of crop residues per livestock unit was annually produced in Ethiopia. According to Mclntire *et al.* (1988) the average cereal crop residue yields in the medium altitude areas of highlands of Ethiopia was about 2 tons of DM per hectare.

Crop residues are the major source of ruminant feed in mixed crop livestock farming systems. In such systems, the grazing areas are limited as a result of the expansion of cropping land, native grass is seasonally available and ruminants graze on marginal land and/or on roadsides to obtain green forage during the rainy season. Although large quantities of crop residues are used as animal feed in many countries, much is still wasted for various reasons or used for other purposes. According to Timothy *et al.* (1997), in south Asia, crop residues are used as compost and mulch for crop production, bedding for livestock, a substrate for growing mushrooms, fiber for paper manufacture and as fuel. In semiarid sub-Saharan Africa, they are used to control wind erosion and in the construction of roofs, fences, granaries, beds and doormats. Generally, the substantial diversity that exists between production systems in resource endowments, availability of different feeds and types and levels of animal production creates different opportunities for the use of crop residues as animal feeds. In grass/rangelands, for example, crop residues play a minor role whereas they are very important in mixed crop/livestock systems.

Like in many farming areas of Ethiopia, information on the availability, production and utilization of crop residues in small holder farming systems are lacking in East Shoa Zone of the Oromiya Regional State. Therefore, this survey was designed to assess the availability, production and utilization of major crop residues and investigate their potential contribution to the animals' annual feed requirements in three Agro Ecological Zones (AEZs) of the East Shoa Zone, Ethiopia.

MTERIALS AND METODS

Description of the study area

This survey was conducted in three AEZs, namely, sub-moist (SM2), sub-humid (SH2) and semi-arid (SA2) of East Shoa Zone in the year 2005. The AEZs were purposively selected because they covered more than 75% (46.3, 21.1 and 7.9% by SM2, SH2 and SA2, respectively) of the total area of the zone (Ethiopian Agricultural Research Organization (EARO) GIS unit, personal communication). According to the AEZ classification of Ethiopia (MOA, 1998), SM2 refers to tepid to cool sub-moist mid highland areas with an altitude range of 1000 to 3000 m above sea level and an annual rainfall of 300 to 1600 mm. These areas have a mean annual temperature of 16 to 27.5°C. SH2 encompasses tepid to cool sub-humid mid highlands whose altitude ranges from 1000 to 3200 m. above sea level. These areas receive 700 to 2200 mm rainfall annually and their mean annual temperature is 11 to 21°C. SA2 represents areas with tepid to cool semi-arid mid altitude (1600 to 2200 m above sea level) and receiving rainfall of 400 to 800 mm annually. Their mean annual temperature ranges from 16 to 21°C.

Sampling techniques

Multistage purposive sampling technique was used in this survey. Three AEZs were selected based on their high area coverage, and districts from each AEZ, and peasant associations (PAs) from each district were identified based on their accessibility. Households from each PA were selected according to systematic random sampling using lists of households available with the development agents. Generally, in proportion to the area the three AEZs cover, 3 districts from SM2 and 1 district from each of the SH2 and SA2 were considered. Then 3, 4 and 2 PAs from each of the districts of SM2, SH2 and SA2, respectively were selected. Finally 20 households were included per PA thus forming a sample size of 300 respondents (180, 80 and 40 from SM2, SH2 and SA2, respectively).

Data collection

Information on demographic characteristic of the respondents, farm size, livestock type and number, crops grown and their yield, uses of crop residues, perceived constraints to crop residue production and utilization were obtained from primary sources using structured questionnaire. For comparison purpose, information on land allocation to the major crops during the year 2003 and on crop production during the year 2004 was also obtained from the respondents. Grain yield data were used to estimate their equivalent residue yields using the previously established residue to grain ratios which were 1.5, 2.0, 3.0 and 5.0 for barley, wheat, maize and sorghum residues, respectively (Kossila, 1988) and, 1.0 and 3.0 for haricot bean and tef residues, respectively (Tesfaye, 1999).

Statistical analysis

Descriptive statistics and frequencies were conducted using the statistical package for social sciences (SPSS, 1999). Some parameters were analyzed using the GLM procedure and differences among the AEZs were tested by Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Allocation of cultivated land to crops

The allocation of cultivable land to the major crops by households in the study area during the year 2003 and 2004 is indicated in Table 1. In both years households in SM2 allocated more ($p<0.05$) of their land to tef than households in the other two AEZs. In SH2 and SA2 more land were allocated to maize followed by tef in 2003. However, in 2004, the order of tef and maize was interchanged in SH2 and, haricot bean came out to occupy the second largest area in SA2. Generally as SA2 encompasses more moisture stress areas than the other two AEZs, the households seem to prefer allocating more land to maize and haricot bean as these crops demand relatively less moisture than other crops.

Table 1 Allocation of crop land to the major crops by households in the three AEZs in 2003 and 2004.

AEZ	Percentage area allocated to:					
	Tef	Wheat	Barley	Maize	Sorghum	Haricot bean
2003						
SM_2	55.7^a	8.6^b	4.0^{ab}	16.3^c	4.6^a	10.8^c
SH_2	28.5^b	15.0^a	3.0^b	30.8^b	5.7^a	17.0^b
SA_2	27.1^b	2.2^c	5.89^a	40.0^a	0.3^b	24.5^a
2004						
SM_2	55.0^a	10.2^b	4.4	16.1^c	2.5	11.8^c
SH_2	28.2^b	18.2^a	4.1	25.7^b	5.0	18.9^b
SA_2	26.1^b	3.1^c	4.9	33.4^a	2.3	30.2^a
Two years' average						
SM_2	54.8^a	9.5^b	4.3	16.2^c	3.8^{ab}	11.5^c
SH_2	28.5^b	16.7^a	3.6	27.8^b	5.4^a	18.2^b
SA_2	26.6^b	2.6^c	5.7	37.0^a	1.2^b	26.9^a

[abc] Within each year, means in the same column followed by different letters are different ($p<0.05$).

Production and contribution of crop residues

Table 2 indicates the crop residue production by households in the three AEZs during the years 2004 and 2005. There was no statistically sound variation among the AEZs in the total crop residue production during the two years. However, respondents in all the AEZs produced relatively more crop residue in year 2004 than in 2005. This could be attributed to the inter-year variability in crop production, which could in turn be influenced by climate (especially rainfall) and soil conditions, utilization of various agricultural inputs, planting and crop management practices, and the size of land allocated to different crops. Moreover, as Butterworth and Mosi (1985) stated, there could be variation in accuracy of estimation as it was difficult to make precise estimation of residue production because of uncertainty both as crop production figures and extraction indices. These authors stated that the relationship between grain yield and that of crop residue depended on many factors particularly rainfall and time of planting.

Contribution of each crop residue to the annual total crop residue production of the interviewed households in the three AEZs in 2004 and 2005 is shown in Table 3. In SM2, during both years, the households obtained half of their crop residue from tef straw. Respondents in SH2 and SA2 did not differ (p>0.05) in the amount of tef straw they obtained in both years. In these two AEZs, maize stover, followed by tef straw constituted the largest share of the total annual crop residue production of the households. This was in accordance with the proportion of land annually allocated to the respective crops of these residues. The larger the area allocated to the crop, the higher the contribution of its residue. The higher contribution of maize stover in SH2 and SA2 was

Table 2 Average crop residue production per household in the three AEZs during the year 2004 and 2005 (in tons).

AEZ	2004	2005	Average
SM_2	8.04	6.72	7.38
SH_2	7.46	5.56	6.51
SA_2	6.35	4.70	5.52
Overall	7.66	6.14	6.90

Table 3 Contribution of different crop residues to the total annual residue production of households in the three AEZs in 2004 and 2005.

AEZ	Percentage annual contribution of:					
	Tef straw	Wheat straw	Barley straw	Maize stover	Sorghum stover	Haricot bean haulms
2004						
SM_2	51.9[a]	9.7[b]	3.3[a]	23.3[c]	7.4[a]	4.4[c]
SH_2	22.7[b]	13.9[a]	2.5[b]	44.1[b]	10.4[a]	6.5[b]
SA_2	21.9[b]	2.0[c]	6.3[a]	58.9[a]	0.4[b]	10.4[a]
2005						
SM_2	52.3[a]	10.8[b]	3.5[b]	23.3[c]	4.9	5.3[b]
SH_2	25.7[b]	21.4[a]	4.6[ab]	31.9[b]	8.8	7.5[b]
SA_2	30.4[b]	3.2[c]	6.9[a]	42.2[a]	3.9	13.4[a]
Two years' average						
SM_2	50.6[a]	10.0[b]	3.2[b]	23.5[c]	8.2[a]	4.5[c]
SH_2	23.8[b]	16.4[a]	3.2[b]	39.0[b]	10.9[a]	6.7[b]
SA_2	24.6[b]	2.6[c]	6.6[a]	53.3[a]	1.8[b]	11.2[a]

[abc] Within a year, means in the same column followed by different letters are different (p<0.05).

in agreement with the findings of De Leeuw (1997) who stated that in the mid- to low-altitude zones, residues from maize and from sorghum/pearl millet appeared more important with maize stover contributing 39% of the total.

Livestock ownership in Tropical Livestock Unit (TLU, 1 TLU = 250 kg bovine on maintenance level) and annual crop residue production per TLU of the interviewed households are summarized in Table 4. Animal numbers were converted to TLU as 1 cattle, 1 goat or sheep, 1 horse and 1 donkey equals 1.0, 0.15, 1.0 and 0.65 TLU, respectively (Ramakrishna and Assefa, 2002) and 1 calf equals 0.25 TLU (IFPRI, 2004). Households in SH2 owned higher ($p<0.05$) number of animals than those in the other two AEZs which did not differ in their livestock ownership. However, households in all the AEZs did not differ ($p>0.05$) in their annual crop residue production per TLU even if there was a slight difference both between years and among the AEZs. Assuming that the number of animals the respondents in 2004 was similar to that in 2005, relatively more tons of crop residues were produced per TLU in 2004 than in 2005. This seemed justifiable as the crop residue production per household was higher during the former year than during the latter. In accordance with their higher annual crop residue production, farmers in SM2 registered higher crop residue production per TLU than those farmers in the other two AEZs. Farmers in SA2 produced fewer tons of crop residues than those farmers in SH2. However, because of the relatively lesser number of animals they owned, they produced more tons of crop residue than farmers in SH2.

Assuming the edible proportion of the crop residues to be 70% (Kayouli, 1996), if the average annual crop residue production per TLU was converted to the daily production, it could be noted that the least amount of annual crop residue produced per TLU in SH2 would mean a supply of 1.16 kg crop residue DM (assuming 90% DM content) per TLU per day. This was equivalent to 26% of the daily DM requirement of a 250 kg cattle, which according to Kearl (1982), was 4.4 kg DM for maintenance level. Similarly, the highest average crop residue production per TLU, attained in SM2 would supply 1.74 kg crop residue DM per day which was equivalent to 40% of the daily requirement of the same type of animal. Therefore, from these, it could be generalized that crop residues, on average, could annually contribute between 26 to 40% of the total maintenance feed requirements of animals in the entire study area.

Utilization of crop residues and their left over

To assess the different uses to which crop residues were put, farmers were asked to identify, in order of importance, three major uses of each crop residue. These orders were later converted to scoring system whereby score 3 was given for the most important use and score 1 for the least important use. Then the percentage score for each use of a crop residue was calculated as its total

Table 4 Average herd size and crop residue production (on air dried basis) per TLU in the three AEZs during the years 2004 and 2005.

AEZ	Herd size per household in 2005 (TLU)	Residue production/TLU (tons)		
		2004	2005	Average
SM2	7.32[b]	1.10	0.92	1.01
SH2	9.66[a]	0.77	0.58	0.67
SA2	7.53[b]	0.84	0.62	0.73
Overall	7.98	0.96	0.77	0.86

[ab] Means in the same column followed by different letters are different ($p<0.05$).

weighted score divided by the total scores given for all uses of that crop residue. Based on this percent score, the primary, secondary and tertiary uses to which each crop residue was put by respondents in the three AEZs were summarized. (Table 5)

The three AEZs seemed to use their crop residues for similar purposes. All the crop residues, with the exception of sorghum stover, were primarily used as livestock feeds. This, on one hand, indicated the high dependence of farmers on crop residues as the other feed resources were scarce and, on the other hand, the relative betterment of the feeding value of these residues were due to both their physical nature and chemical composition. With regard to chemical composition, crude protein contents of 5.5% for tef straw, 5.4% for haricot bean haulms and 3.6% for maize stover (Tesfaye, 1999); 4.0% for wheat straw and 3.1% for sorghum stover (Seyoum and Zinash, 1989); and 4.7% for barley straw (Lulseged and Jemal, 1989) were previously reported. Sorghum stover was used for construction purposes. This was likely to be because of its poor feeding value resulting mainly from its physical nature (stemmy with few leaves). From the table it could be seen that the alternative uses of crop residues slightly varied with the type of residue. Stovers were alternatively used as firewood and for construction of fences, granaries, and shades, whereas straws of wheat and barley were used either for mattresses making or were sold to generate a limited amount of income for the family. Next to animal feeding, tef straw was used, together with mud, for construction of walls of local houses. Here the straw served as a binding material thus avoiding cracking. The bulk of haricot bean haulms were used as livestock feed as it was known to be of high feeding value because of being a legume. Alternatively it was majorly used for mulching to improve soil fertility and for sale.

The left overs was meant the orts left by animals after they were fed on crop residues. Uses of left over of each crop residue were determined using the method described previously for assessing the uses of crop residues. As notable differences were not observed among the AEZs with respect to utilization of left overs of different crop residue. Their uses in the entire study area

Table 5 Primary, secondary and tertiary uses of different crop residues in the three AEZs.

AEZ	Crop residue types and their uses					
	Tef straw	Wheat straw	Barley straw	Maize stover	Sorghum stover	Haricot bean haulms
Primary uses						
SM2	Animal feed	Animal feed	Animal feed	Animal feed	Fire wood	Animal feed
SH2	Animal feed	Animal feed	Animal feed	Animal feed	Construction	Animal feed
SA2	Animal feed	Selling	Animal feed	Animal feed	Construction	Animal feed
Secondary uses						
SM2	Construction	Mattress	Mattress	Fire wood	Animal feed	Mulching
SH2	Construction	Selling	Selling	Fire wood	Animal feed	Mulching
SA2	Construction	Animal feed	Selling	Fire wood	Fire wood	Selling
Tertiary uses						
SM2	Selling	Selling	Selling	Mulching	Construction	Fire wood
SH2	Selling	Mattress	Mattress	Construction	Fire wood	Selling
SA2	Selling	Mattress	Mattress	Construction	Animal feed	Mulching

are summarized in Table 6. More than 90% of the respondents stated that they used left overs of their crop residues for different purposes. Except for the left overs of stovers, which were primarily used as fire wood, left overs of all other by-products were used as surface mulch to amend the fertility of crop lands. The respondents stated that as the left overs were mixed with dung during feeding, spreading such left overs on to their fields had positive impacts on fertility of their lands. In this regard, however, the farmers needed to be taught that they could get more benefit if they prepared the left overs, together with other wastes, as compost. Those farmers who stated that they used left overs for animal feeding explained that they did this by mixing the left overs with fresh residues or by spraying them with salt to make them more palatable. Some other farmers feeded the left overs to less selective animals like donkeys.

Regarding the use of crop residues, a general question was presented to the respondents as to whether or not they used their crop residues efficiently. Fifty six, 59 and 64% of the respondents in SM2, SH2 and SA2, respectively replied that they used their crop residues efficiently by collecting and storing them properly. Out of the causes of wastage cited by those respondents who stated that they did not use their residues efficiently, in SM2 and SA2, improper storage and inability to collect, in that order, were the major causes (Table 7). In SH2, inability to collect followed by nature of the residue (being stemmy and bulky) were the major causes of wastage. Other reasons for inefficient utilization included lack of know-how as to how to manage the residues, poor feeding system (lack of feeding troughs), lack of fences around the stacks and damage by rodents. In studying constraints to cereal crop residue utilization in central Tanzania, Kabatange and Kitalyi (1989) found that efficient utilization of the crop residues was limited by big herd sizes, long distances from crop fields to homesteads, lack of transport and low level of technology.

Table 6 Percentage scores for uses of left-overs of the major crop residues in the entire study area.

Residue type	Percentage score for uses as:				
	Fire wood	Animal feed	Mulching	Construction	Not used
Tef straw	2.4	28.1	59.2	2.5	7.1
Wheat straw	9.5	16.6	62.6	1.4	8.9
Barley straw	8.1	19.3	62.0	1.0	8.6
Maize stover	59.8	9.5	26.1	_	4.6
Sorghum stover	54.0	5.2	26.6	_	14.1
Haricot bean haulms	10.4	12.5	65.0	_	12.2

Table 7 Percentage scores for major causes of crop residue wastage in the AEZs.

AEZ	Causes of wastage and their percentage score			
	inability to collect	improper storage	nature of the residue	Others
SM2	30.3	39.7	17.9	12.0
SH2	35.1	20.8	25.3	18.8
SA2	25.0	40.3	13.9	20.8
Overall	30.7	35.4	19.1	14.4

CONCLUSSION AND RECOMMENDATIONS

The major crop residues available in the three AEZs were tef, wheat and barley straws, maize and sorghum stovers and haricot bean haulms. In accordance with the differences in the annual allocation of cultivable land to the different crops, the annual contribution of each crop residue to the total annual crop residue production by households in the AEZs varied greatly. However, the total annual crop residue production per household was not statistically different among the three AEZs. Farmers in all the AEZs used their crop residues primarily for animal feeding. Alternative uses of the residues were observed to vary more with the type of residue than with the AEZs. It could be concluded that with an annual average production of 0.67 to 1.01 tons per TLU of a household, crop residues contribute 26 to 40% of the total annual maintenance feed requirement of ruminants. On the other hand 30 to 40% of the respondents indicated that some of their crop residues were wasted mainly because of improper storage and inability to collect. To this end, farmers needed to be trained as to how best and economical they could collect and store their residues. Moreover, a coordinated effort of government and expertise is essential in availing improved technologies and inputs that boost both grain and residue yields so that farmers can derive more benefits from their residues.

ACKNOWLEDGEMENTS

The authors would like to thank Assistant Prof. Dr. Panwadee Soparnnarath and Assistant Prof. Dr. Skorn Koonawootrittriron for their wholeheartedly advice on statistical analysis. This research was financed by the Ethiopian Agricultural Research Organization through the Agricultural Research and Training Project.

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