SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

Quality and quantity of maize and sorghum vegetative parts harvested at different stages of plant growth as fodder for livestock

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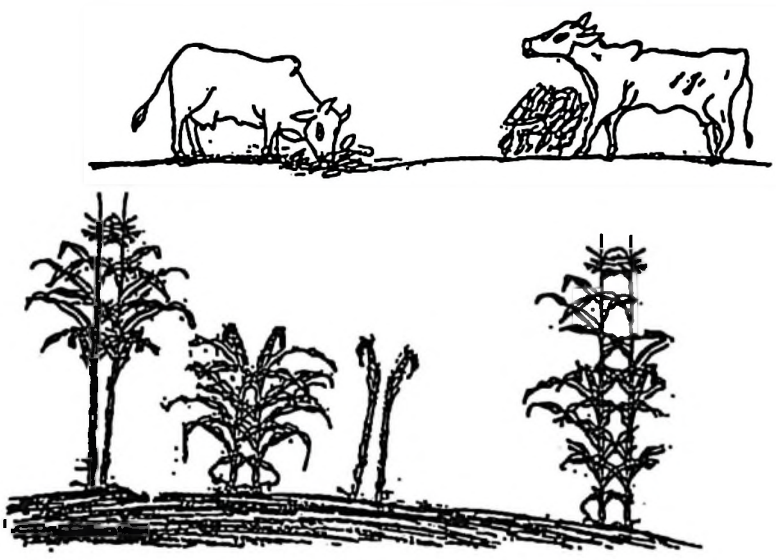

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THIS THESIS IS DEDICATED TO MY MOTHER, ANGELISIA MUSSA SHIRIMA AND FATHER, JOACHIM MUSSA SELEMANI.

1.0 ABSTRACT

Two on-station research experiments were conducted at the Livestock Production and Research Institute, Mpwapwa and one at Pasture Research Center, Kongwa both in Central Tanzania from January to October, 1993. Four treatments in maize, grown in Mpwapwa station, were stripping (SR), topping (TP), stripping + topping (STP) at silking stage and whole plant stover (WPL or control) were assigned randomly within the four blocks of a complete randomized block design experiment. Only SR and WPL treatments were performed in sorghum trials in Kongwa under the same experimental design as in maize but each were replicated twice within each of the four blocks.

Also three treatments replicated thrice for measuring the intake and digestibility of the SR, TP and WPL obtained from the maize trial were done at Mpwapwa center by using nine adult BHP male sheep. Complete block design was used by blocking the sheep on weight basis ranging from 29 to 37 kg live weights (mean 32.8 $\pm$ 1.0). Both animals received equal amount of supplement diet (maize bran + sunflower cake).

A village survey through questionnaire and physical body weight measurement of cattle every other fortnight was carried out in Berege village in Dodoma region from the start of the dry season (June) to mid-dry season (October). Sample collection of forage used by the animals was done on the same day after weighing the animals. Ten farmers with improved dairy cattle (Mpwapwa breed) were incorporated. An additional survey was also conducted in Kilimanjaro region among eight farmers to explore the farmer's knowledge on the use of SR, TP and STP from maize. In maize the highest vegetative biomass production including the final residues after the grain harvest was gained with the STP treatment followed by TP with 5.44 t/ha and 5.35 t/ha respectively ($p<0.05$). Less fodder materials were collected from WPL (4.23 t/ha) due to field losses. No significant difference were found in sorghum fodder yields despite the leaf losses in WPL. Stripping in sorghum yield 2.2 t/ha and WPL as 1.8 t/ha. In maize total CP accrued from STP were (287 kg/ha)), TP (234), SR (177) and WPL (138). The IVOMD of the fractions were in the order of 75%, 69%, 64% and 52% in SR, STP, TP and WPL fractions respectively. Seventy-three percent more CP was produced from SR of sorghum than WPL treatment with 123 kg/ha by 71 kg/ha respectively. Digestibility (IVOMD) of the SR leaves from sorghum was 79 % while 55 % from the WPL leaves. The feed intake of SR leaves in maize was more than twice (850 g/day) that of the WPL stover (361 g/day) when fed to sheep. The total digestible crude protein (DCP) from SR of maize was 51 % while the same from WPL was negative. With the supplement diets, the DCP of SR leaves improved slightly to 55 % but increased greatly in WPL to 51 %.

From the village survey, the cattle in Berege suffered from lack of high quality feeds resulting in body weight losses during the later part of the dry season despite the bigger cultivated crop field farms than in Kilimanjaro region. With small areas of land in Kilimanjaro region, less than 1.5 ha, the maize fractions alone harvested before and after grain harvest accounted for over 39 % of the total annual cattle feed

requirement while in Berege the combination of all dry residues after harvest (maize, sorghum and millet) formed 42 % of the total annual diet. This made the dependence of natural pasture in Kilimanjaro region to be only 28 % while in Berege village the cattle were still depending on 40 % natural pasture for the annual feed resources.

Since the defoliation of maize and sorghum vegetative parts had no deleterious effects on the final grain yield, the technique should be introduced in Central Tanzania so as to make use of the enormous green materials lost in the wet season to be available in dry season. Their higher feeding value also will be an advantage to the farmers as they will buy less supplements to be added to the forage to meet the animal requirements for maintenance and production.

2.0 PAPERS INCLUDED IN THE THESIS

The present thesis is based on the following papers which will be referred to in the text by their Roman numerals:

I Shirima, E.J.M and Wiktorsson, H. Utilization of maize leaves and tops prior to harvesting as fodder for livestock.

II Shirima, E.J.M and Wiktorsson, H. Yield and potential feeding value of defoliated sorghum leaves at pre-grain harvest stage of plant physiological maturity.

III Shirima, E.J.M; Wiktorsson, H. and Komwihangilo, D.N. Intake and digestibility of different maize plant morphological fractions in Black Head Persian (BHP) sheep.

IV Shirima, E.J.M. Crop residue utilization based on cereal stover in Central Tanzania.

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4.0 LIST OF ABBREVIATIONS

BF	butterfat
BHP	Black Head Persian
$C_nH_{2n}O_n$	carbohydrate
CF	crude fibre
cm	centimetres
CP	crude protein
CWC	cell-wall content
DCP	digestible crude protein
DCWC	digestible cell wall content
DM	dry matter
DMD	dry matter digestibility
DMI	dry matter intake
DOM	digestible organic matter
DOMD	digestible organic matter in dry matter
g/day	gramme per day
GJ	Giga Joule
ha	hectare = 10000 m^2
HCN	hydrocyanic acid
H_2O	water
IVOMD	*in vitro* organic matter digestibility
Kg	kilogramme
Kg/ha	kilogramme per hectare
LW	liveweight
m	metre(s)
ME	metabolizable energy
MJ	Mega Joule
mm	millimetre
NDF	neutral detergent fibre
NH_3-N	ammonia nitrogen
OM	organic matter
pH	acid concentation
P_{max}	optimum plant density for maximum DM production
r	correlation coefficient
SEM	standard error of the mean
SNF	solid not fat
TDN	total digestible nutrient
t/ha	ton per hectare
TSh.	Tanzanian shillings ≈ 1/500 US $
SA	sulphate of ammonia
SR	stripping of the leaves below the cob/head
STP	stripping and topping
TP	topping of the plant above cob
TSP	triple super phosphate
UMB	urea mollasses block
WPL	whole plant/stover

5.0 LIST OF TABLES

6.0 INTRODUCTION

The majority of the livestock population in Tanzania are under the traditional livestock sector which is categorized by nomadic pastoralism, semi-nomadic pastoralism and integrated small farmer systems. The rest of the farming population which is only 1% of the total farming population comprise of beef ranching and commercial dairy farms. The pastoralist are mainly found in Central and also partly in the Western zones of the country with arid and semi-arid climatic conditions with the majority of livestock population in the country (MALD, 1988). Under the current livestock production policy in the zone, the integration of crops and livestock is encouraged as the other systems resulted in serious soil erosion. This new integrated system allows the keeping of a few improved animals per household enough to provide milk, manure and income when in excess. Employment is also created under this system and it is sustainable as it exposes less risks of environmental destruction.

Livestock only have access to natural pasture for a short period (the wet season) implying that the large proportion of animal feeds over eight months per year comes from crop residues (Paper IV). The utilization of the residues at this period is done late in the season when the residues are of low feeding value. The value decreases due to the high levels of lignocellulose, low protein and soluble carbohydrate contents. These constraints are among the major constraints to livestock productivity in the area although much of the feeds goes into waste during the wet months (Ørskov, 1993).

Among the world's three most important cereal crops (maize, rice and wheat), maize is the one which has the widest distribution and it is grown primarily for grain which is consumed as human food. In developed countries, maize is grown as forage (maize silage) and for industrial products like oils, syrup and starch. In developing countries Tanzania inclusive, apart from the grains, maize is grown for supplying fodder and bedding for the ruminants after grain harvest. The residues are also used as building materials and as a source of fuel. Grains are also fermented for the manufacture of the local brew.

7.0 OBJECTIVES

The present study aimed at studying the feeding value and total fodder production of maize and sorghum vegetative parts harvested prior to grain maturity. The specific objectives included:

7.1) To determine the nutritive value (protein availability, digestibility of organic matter and metabolizable energy value) of the maize and sorghum morphological fractions defoliated before and after grain harvest (Paper I and II).

7.2) To study the intake and digestibility of different maize morphological components obtained at pre-grain and post-grain harvest (Paper III).

7.3) To compare the utilization of cereal crop residues in agro-pastoralist and intensive agricultural systems in semi-arid and sub-humid areas, respectively (Paper IV).

8.0 GENERAL DISCUSSION

8.1. The botany of maize and sorghum

Both maize [*Zea mays* L.] and sorghum [*Sorghum bicolor* (L.) Moench] belongs to the grass family, the **Gramineae** in which their plant bodies are mainly composed of leaf tissue. The main stems are slender with segmented shafts similar to a stalk of bamboo or sugarcane. The nodes which look like joint segments, mark the point of leaf attachment. The internodes come from the stem segment between the nodes. Usually each node bears a single leaf in a position opposite to the neighboring leaf which gives the plants two vertical rows of leaves in a single plane.

8.2 Maize and sorghum establishment

The optimal plant population in maize and sorghum depends on the agro-ecological and climatical conditions and the plant variety in question. Often cultivation of maize has a bigger spacing than sorghum, however the overall management depends on the objectives and on cultural practices, climate, variety and soil conditions existing in the locality. For example in many tropical countries a range of 18-25 kg of maize seeds/ha are enough to produce 15,000-90,000 plant/ha at harvest (Gibbon and Pain, 1985). In sorghum, the optimal plant population per hectare also depends on the variety where the tall varieties have often grown under lower density than the short/dwarf varieties. But given a similar density, the taller varieties produce more grain per hectare (FAO, 1980). A range of 40,000 to 100,000 plants per hectare have been reported in different agro-ecological zones (FAO, 1980). In Central Tanzania, maize is grown under 30 cm x 60 cm or 30 cm x 75 cm spacings for 1 plant/hill. In the same area, sorghum is grown under 80 cm x 25 cm spacing for 2 plants/hill or 80 cm x 50 cm spacing for 4 plants/hill. All these give 50,000 plants per ha for maize and 100,000 plants per hectare for sorghum after thinning.

For a better performance both maize and sorghum requires soils with ≥ 5 pH and application of about 150 kg N /ha of fertilizer depending on the soil type.

8.3 Growth and development of the maize and sorghum plants

8.3.1 Morphological characteristics of maize and sorghum

In most hybrid maize varieties found in the tropics, Tanzania inclusive, tasselling occurs during the first four weeks after germination. At that stage the growing point of the stem lays down all the nodes and internodes of the plant to facilitate tasselling (Poething, 1982). It is a point where the plant looks taller, as high as 90-120 cm, but the actual height of the stem is as short as 7.5-10.2cm. A short while after tasselling, the stem begins to elongate rapidly with most of the growth occurring at the base of the internodes (Poething, 1982). This kind of growth does not include the lowermost 6-8 internodes whereas the thickness of the stem starts some few centimeters above the ground and tapers gradually toward the tassel. The shank, which is the stem of an ear shoot, differs from the main stem by being relatively short in most varieties with internodes various in number, shape and size and with a more crinkled surface than the normal stem.

Sorghum plants have a variable number of leaves ranging from 7 to 28 depending on the variety. Being a drought resistant crop, the leaves have small size stomata and motor cells which cause them to roll inward under conditions of drought stress. The presence of a continuous layer (waxy) on the leaves inhibits desiccation. These characteristics, among others, make the plant the most resistant to drought as compared to other cereals eg. maize and millet. Unlike other cereals, sorghum is perennial where a new cycle of growth commences just before the grain maturity by tillering from the dormant lateral buds on the old stem. Because of their superior drought resistance, the sorghum plants can send up tillers and still produce a good crop if rains come after the main stalk has been killed by drought (Martin, 1930). It is because of the accumulation of a reservoir of water soluble carbohydrate the pith of the stalks and production of photosynthate after seed maturation which resulting into tiller production (Burns *et al* 1970). Drought resistance of sorghum is imposed by the lower transpiration ratio than maize under conditions of high evaporation. The leaves and stalks wilt and dry more slowly than those of maize.

8.3.2 Morphological development of maize

According to Milbourn, (1975) there are about six distinctive stages of development which can be classified in a maize plant cycle:

i) Sowing to germination
ii) Germination to floral initiation (booting stage)
iii) Floral initiation to tassel emergence (anthesis)
iv) Tassel emergence to silk production (silking)
v) Silk emergence to physiological maturity
vi) Physiological maturity to harvest

8.3.3 Morphological development of sorghum

Three distinctive stages of growth are recognized in the sorghum life cycle (FAO, 1980).
i) Emergence to panicle development
ii) Panicle initiation to anthesis (booting)
iii) Anthesis to grain maturity (milking stage/grain filling)

8.4 Dry matter accumulation in cereal plants

8.4.1 Silking stage in maize

Only 15 % of the total dry matter is accumulated in the first five weeks after planting. This suggests that the rate of growth is very slow. Linear growth is achieved when the grain is in the dough stage. At the silking stage, the moisture content of the grain is about 30-40 %. This is the period when the black speck or abscission layer appears at the base of the kernel where there is rachis attachment. At this time, the removal or defoliation of some plant parts has little or no effect at all on the grain yield (Paper I). More dry matter accumulation is concentrated in the ear development than the other parts. The nutrients are mobilized from the leaves, stalks and other parts to the developing ear, with continuous increase in nitrogen and phosphorus until near to maturity (FAO, 1980).

8.4.2 Vegetative development and grain filling in maize

Apart from the genetic and environmental influences, ear development determines the production of the vegetative parts. The higher and rapid increase in the dry matter content and the ear proportion occurs during the grain filling period while the husk and shank proportion is still very low. It is this period when the final dry-matter content of the whole crop increases prior to senescence. It is the ear development which determines the final crop yield (stover) (Struik, 1983).

Three kinds of vegetative leaves in maize can be distinguished *viz*: foliar leaves, husk leaves and prophylls. The main stem is the one where the foliar leaves are attached while the husks are located on the shank of the ear shoot. Prophylls are located at the base of the shank between the ear shoot and the stem. The foliar leaves (blade + sheath) are those mainly considered for ruminant feeding. The husk leaves which surround the ear could only be utilized after the ear harvest. Struik, (1983) found that the number of leaves was the same as the number of stem internodes and that this has a very significant role in the final cell-wall yield and final cell-wall content with a positive linear relationship (r) of about 0.97. Leaf area has also been found to have a very significant effect on the DM distribution in the plant. The area also differs within the same plant by having more areas above the ear than those leaves below the ear (Struik, 1983).

8.4.3 Defoliation of vegetative parts in maize

Earlier defoliation of the leaves before tasselling has been found to delay tasseling and anthesis (Vasilas and Seif, 1985). The authors found that too early defoliation had an effect on reducing pollination by decreasing the duration of pollen shedding, reduction of transpiration and ultimately plant efficiency to water utilization. Complete defoliation also delayed silking more than tasseling and anthesis while 50 % defoliation had very little effect on flowering. Pre-flowering defoliation therefore, reduces grain yields by reducing the kernel number, while in severe cases, 100 % reduction of grain yield might occur.

8.4.4 Grain filling period in sorghum

This period occurs during the milking stage. It is the time when there is no outward vegetative growth but with decline in dry matter accumulation in the vegetative parts. The period is synonymous to the silking stage in maize. Normally there is a transfer of accumulates stored in vegetative parts to grain development (Poething, 1982).

8.5 Feeding potential of common cereal straws in the tropics

Variations in dry matter, crude protein and fiber contents of the cereal stover and straw residues have been reported in different countries in the Tropics (Table 1). These differences have been due to the genetic variations of the plants, time of harvest and the plant morphological fraction in question.

Table 1: Variations for reported tropical cereal straw in DM, CP and E contents.

Straw	DM %	CP as % DM	CF as % DM	Country	Reference
Maize	90.6-93.4	2.4-3.7	43.5-48.5	Tanzania	Urio et al 1987
Maize	92.1-93.1	6.5-9.6	--	Malawi	Munthali, 1987
Maize	92.05	4.4	56.8	Cameroon	Wegad et al 1987
Maize	--	8.5	30.8	Botswana	Mosimanyana 1987
Maize	93.3	2.5	48.6	Kenya	Musimba 1981
Millet	88.7	5.9	44.4	Botswana	Mosimanyana 1987
Rice	90.93	5.1	38.9	Egypt	Nour 1987
Rice	94.9	4.0	43.3	Kenya	Musimba 1981
Sorghum	92.8	5.1	73.7	Nigeria	Olayiwole et al 1987
Sorghum	--	6.0	35.3	Botswana	Mosimanyana 1987
Wheat	91.5	4.4	39.4	Kenya	Musimba 1981

8.5.1 Crop maturity, harvesting and processing of maize

As the plant matures, the leaves become dry, while the husks become dry and papery. Hand removal of husks and cob from the main stem is a very common practice in the tropics where machineries are limited. The stovers are left in the field for free grazing (*in situ*), collected together in one place (stalked) or transported to nearby homesteads for dry season feeding. The management and the use of these residues depends entirely on the livestock management system existing in a particular place. Under intensive systems the utilization of the stovers is more intensive than the extensive one (Paper IV). In the intensive systems, the stovers are sometimes treated with molasses and sometimes alkalis to increase intake/palatability and digestibility respectively. The estimation of straws from grain production has been done by FAO (1980) statistics but the multipliers used had some limitations and they were later reviewed by using different multipliers by Owen (1976) and Kossila (1984) in which they assumed straw:grain for maize ratio as 2:1 and 3:1 respectively.

8.5.2 **Crop quality of maize as ruminant feed**

The best forage from maize vegetative parts are those harvested at milk stage when the leaves are green and tender (Gohl, 1981; Paper I and Paper III). Table 2 shows the feeding quality of maize and sorghum at different stages of growth. Both crops showed higher digestibility when fed fresh and earlier before maturity. Similar results are presented in paper III where higher feed intake and higher DM and CP digestibility of maize leaves and tops harvested at late silking stage is shown compared to mature stover, when fed to sheep.

Table 2: Digestibility of maize and sorghum fractions in sheep and oxen

	Digestibility	
	CP %	ME MJ/kgDM
Maize		
Fresh milk stage (sheep)	56.8	9.8
Dried stalk(sheep)	36.0	8.6
Sorghum		
Fresh mature plant (sheep)	50.6	8.4
Dried straw (oxen)	30.5	8.2

Source : Gohl, 1981.

The quality of the forage maize as a fodder for ruminants depends on the proportion of different plant fractions at that particular time. Plant parts within the same plant differ in feeding value because of the differences in their cell-wall digestibility, CP content and digestibility (Struik, 1982a, paper II). Table 3 shows the distribution of dry matter of a forage maize plant harvested at silking stage and digestibility of different fractions. The total cell-wall yield is normally affected by the extent of vegetative development, delay of reproductive development and the ear size. In this case, there is significant correlation between the cell-wall content of the whole crop with silking date (Struik, 1982b). In paper I it is shown that harvesting the leaves and tops at the later silking stage instead of as stover after grain harvest, results in doubling the amount of CP (kg) and 34 % more DOM harvested as fodder.

Table 3: Distribution of DM of silage maize (hybrid Circe) at harvest and the DM content (% of fresh weight) and digestibility (% of organic matter) of the various fractions (After Struik, 1982a).

Fraction	Contribution to plant yield %	DM content %	Digestibility %
Tassel	1.3	53.8	47.6
Kernel	43.5	43.1	88.6
Cob	10.1	33.1	68.4
Husk + shank	11.8	24.8	65.5
Midrib	2.1	56.3	56.3
Leaf mesophyll	9.2	35.9	76.7
Leaf sheath	4.5	28.8	55.6
Rind of stem	13.2	18.3	54.4
Pith of stem	4.3	12.2	73.6
Whole plant	100	29.3	75.4

Source: Deinum and Struik, 1982.

Forage maize when harvested for silage making generally at late silking stage has a relatively high nutrient content including non-structural carbohydrates (sugars + starch), protein and ash content resulting in high digestibility and energy value (McDonald *et al*, 1988 and Wilkinson, 1978). Wilkinson, (1978) found that the inclusion of the grain in the forage maize increases the proportion of non-structural carbohydrate (about 40 % of DM). The same author showed the forage maize to have a CP of 9 %, IVOMD of 74 % and ME of 11 MJ/kg DM. The CP shown here has about the same of that of the leaves and tops found in Paper I. However, the digestibility and ME are somewhat higher than in leaves and tops found in Paper I. On the otherhand, McDonald *et al* (1966) showed that forage maize contained high crude protein (CP) content about 60 g/kg DM and a metabolizable energy (ME) value of about 9 MJ/kg DM. This implies that the amount of protein and energy in any particular fraction can be influenced by several factors, both genetical and environmental (Table 4). Furthermore, in Table 5, the early harvesting of the maize plants yield more DM, total digestible nutrients and DCP yield than when compared with late harvesting (Deinum, 1976; Wilkinson, 1978; Struik, 1982a; Struik, 1983; Struik, 1985 and El-Baki et al, 1989; Paper I). The time of utilization of the stover after grain harvest was crucial as the stover keeps on deteriorating in quality if it is left in the field uncollected. Table 6 shows the trend of nutrient decline in maize stover collected every two weeks intervals after grain harvest, in Kondoa district, Central Tanzania. It can be seen that the protein content and digestibility

(IVOMD) decline at the same time as the fiber fraction (NDF) increases in the stover towards September which is in mid-dry season. It is this time of the year when other feed resources like natural pastures are scarce and if available, are highly lignified and unpalatable (Paper IV).

8.5.3 Fodder potential of sorghum plants

The fodder quality in different fractions of sorghum varies depending on variety, crop management and the stage of plant growth (McDonald *et al*, 1988; paper II). The digestibility of organic matter, protein content and metabolizable energy of sorghum leaves harvested at milking stage showed similar values as those found in maize leaves harvested at late milking stage (Paper I and II).

8.5.4 Production and utilization of sorghum tillers

Tiller crop harvested after grain harvest can contribute by 8 to 14 % to the total fodder production (Paper II). Although the development of tillers in sorghum plants seem to be more promising for their higher values of CP %, IVOMD and ME than the stover alone, their utilization is limited by the presence of hydrocyanic acid or prussic acid (HCN). This is poisonous to certain levels when the tillers are excessively fed to cattle (Wall and Ross, 1970). The concentration of HCN is more pronounced in growing leaves and tillers than in the principal stem (Alhassan *et al* 1987). The concentration ranges from traces to 335 mg per 100 gm of dry matter. Higher HCN is associated with stress such as caused by drought. Therefore, the best time for the utilization of sorghum stover for ruminant grazing with less risk of HCN poisoning is after cessation of leaf and tiller growth (Martin and Wedin, 1974; Stallcup and York, 1986).

8.5.5 Nutrient partitioning in sorghum plant

Nutrient and carbohydrates partitioning in sorghum plant varies considerably within the morphological fractions. This depends entirely on the time of measurement and can adversely affect the decomposition rates by soil microbes, palatability to ruminant livestock and usefulness as an alternative energy source (Powell *et al*, 1991; Stallcup and York, 1986). More TDN is concentrated at the lower portion (Powell *et al* 1991). Alhassan et al, 1987 and Powell *et al*, 1991 demonstrated that there is more nitrogen and phosphorus concentration in blades than stalks and this declined from the upper to lower sorghum stover parts. The higher concentration of non-structural carbohydrates in the upper stalk as compared to the lower parts was probably due to the continued photosynthesis by upper leaves and lack of a significant reproductive sink for remobilization (Struik, 1983; Powell *et al* 1991).

The leaves of the same plant differ significantly in quantity and quality (Paper II). The dry matter yield of the three lowest leaves were almost negligible, but increased rapidly from the 4th up to the 6th leaf which had the highest dry matter accumulation. There was then a gradual decline from the 7th to the 10th, which was the last leaf before the panicle (head).

Table 4: The effect of several external factors on digestibility of the maize plant (after Struik, 1983[a]).

Factor	Effect on % DOM	% CWC	% D_{CWC}
PLANT			
High light intensity	+	_	±
High temperature	_ _	+	_
Water abundance	± or+	± or_	±
Long day	_	+	±
CROP			
Increased plant density	_	+	±
Late sowing	_	+	±
Delay of harvest	_	+	_

_ _ : very negative, _ : negative, ±: hardly any effect, + positive effects

Table 5: Effect of stage of harvest on the composition of maize silage

	Stage of harvest Early	Medium	Late
Dry matter %	19.8	26.7	34.6
pH	3.8	4.0	5.6
Composition of DM %			
Starch	14.4	27.5	31.2
Water soluble $C_nH_{2n}O_n$	6.7	*	*
Cell-walls	53.2	45.4	44.1
Total fermentable acids	7.1	6.1	4.8
Ash	5.3	4.4	4.5
CP (N x 6.25)	9.7	8.9	8.9
Composition of total N %			
H_2O insoluble N	51.8	47.3	61.1
NH_3-N	9.9	9.9	15.7

* completely fermented

Source: Wilkinson, 1978.

Table 6: Nutritive value changes of maize stover left uncollected after grain harvest to mid-dry season in Kondoa district, Tanzania during 1993 cropping season.

Collection date	DM %	% Dry matter			IVOMD %
		Ash	NDF	CP	
10/6/1993	94.4	7.6	60.3	4.2	83.8
30/6/1993	94.2	7.2	61.8	3.7	83.3
21/7/1993	92.7	7.1	74.6	2.4	74.9
03/9/1993	94.7	8.7	75.2	3.1	70.0
22/9/1993	94.6	7.7	78.1	2.5	72.1

Source: Gebregziabher, 1993. SAREC project leader, Kondoa-Tanzania (Personal communication).

8.6 Cell-wall production and digestibility in maize plant parts

Feed intake, feed efficiency and digestibility are the key factors in the conversion of forage to animal products. Cellular content and cell-walls are the main composition of the plant, the former being totally digestible by ruminants (Van Soest, 1967). As the plant grows, the dry matter increases as the cell content increases. The maximum DM production occurs during the tassel emergence (Struik, 1982b). At the same time the increase in DM content is negatively correlated with *in vitro* digestibility of the organic matter because of the increase of the cell-wall content and decrease in cell-wall digestibility (Struik, 1982b and Deinum and Struik, 1982).

During the stage of ear development, cell-wall production in the vegetative parts decreases while the cell-wall production in the ear shoots is initiated (Deinum and Struik, 1982a and Struik, 1982b). The authors also found that the digestibility of stover cell-walls is strongly correlated with plant height and age. As the height and age increases, the digestibility decreases due to the decrease in cell-wall content and increase in cell-wall production (Paper III). This is associated with the reduction of photosynthesis caused by the poor conditions and the plant senescence. The ear fraction is the most digestible part in the maize plant with slightly higher digestibility during the early stage of the grain filling period but which subsequently remained constant (Struik, 1982b). The differences in cell-wall content, cell-wall yield, cell-wall digestibility and *in vitro* digestibility of OM are the causes of differences in digestibility between the different plant fractions (Deinum, 1976; Struik and Deinum, 1982 and Struik, 1985). However, the digestibility of the whole plant is fairly constant and predictable with a continuous decline in cell-wall material digestibility over time from the time of emergence until the time of final harvest (Struik, 1985).

8.7 The effect of leaf position on the nutritive value of the forage maize.

There is a difference in organic matter digestibility (OMD) among the leaves of the same plant (Deinum and Dirven, 1971 and Deinum, 1976). They found the digestibility of the lower leaves below the ear (1^{st} - 7^{th} leaves) to have higher OMD descending from the first to the seventh leaf and continuously dropping to the subsequent leaves. This is attributed to the low cell-wall constituents in the first leaves. The constituents increased with the leaf number and the increase of the leaf specific weight due to the subsequent increase of accumulation of assimilates to the top leaves which are closer to the light source than the lower leaves. Similar results were found in paper I where the weight of leaves below the ear increased from leaf 1 to 8 with slightly descending IVOMD. Digestibility also dropped with the age of the leaf but it is more pronounced during the leaf expansion than during the life span of the leaf (Deinum, 1976). The same author found that the low digestibility during the leaf expansion was attributed by the progressive lignification of the cell-walls. Leaves 1-4 were found to be peculiar in their great decrease in digestibility due to shorter life span with abnormal senescence with poorly digestible cell-walls. However in the subsequent leaves, the cell-wall content increased slightly during leaf expansion and dropped again when the leaf mass attained maximum DM (Deinum and Dirven, 1971). They concluded that the difference between the leaves of the same stalks are basically caused by the anatomical features in which the larger leaves require bigger midrib which is less digestible than the leaf blade. to support it. The midrib has higher cell-wall constituents with more cellulose fraction than the leaf blade because of the higher contribution of the sclerenchyma tissues in the midrib fibers.

8.8 Optimizing the fodder and grain yield from maize and sorghum

There are various ways of optimizing the DM, CP and ME quantities from maize and sorghum plants. One of the possibilities which was discussed in detail in paper I, II, III and IV is the earlier harvesting of the different plant fractions before grain maturity. Early harvesting minimized the crop field losses from wind shedding, termites, vermin and leaching of soluble nutrients. Normally the leaves which are more nutritious than the stem are more susceptible to these losses. The remaining stem parts are more lignified and less nutritious. The stem has lower CP, ME and IVOMD than the leaves at any one particular stage. Fractions of the same plant yield more DM, CP and ME when harvested earlier than the late harvested fractions by having less fibre fractions and higher IVOMD (Paper I and II). The fractions harvested earlier were more palatable and acceptable to ruminant animals than the late fractions (Paper III). The dependence of forage from cereal based diets by ruminants could be increased by harvesting the different fractions before the grain maturity by having more DM production from a given piece of land. In Paper IV, cattle in Kilimanjaro region depend on maize fractions as much as up to 39 % of which 24 % was from earlier defoliated fractions (strippings + toppings). Pasture contributes only 28 % of the total annual diets as the land is scarce in Kilimanjaro region. On the other hand, cattle in Berege village where utilization of cereal crop residues is extensively done after grain harvest, the total cereal residues (maize, sorghum and millet combined) form 42 % of the total annual feed supply. The dependence of pasture is 40 %. Both the residues and pasture are low in feeding quality during the dry season which results in low animal productivity and weight loss (Paper IV). To utilize the enormous crop residues during the wet season, harvesting and conserving for dry season use is the best way of optimizing them. The use of green fractions in the dry season will minimize the amount of supplement and chemicals to treat the forage to make them more digestible and acceptable to ruminants. From Paper I, a farmer can save 5,000 TSh. to 16,000 TSh. by using different fractions of maize (green materials) in the dry season by buying very little supplements. By improving the cultural practices and management like proper spacing, weeding and fertilizer application, the DM yield, CP and ME quantities will be optimized from a given piece of land. Various findings have shown that by reduction of plant density, there was no advantage in the grain yield or fodder biomass, however increasing the plant density above a certain level (Pmax) had more effect on reducing the grain yield than the forage production (Pinter *et al*, 1990). More leafy biomass with more CP and IVOMD have been reported when the plant density exceeds P(max) (Martin and Wedin, 1974; Hazra, 1988; Pinter *et al*, 1990).

The third possibility of optimizing the maize and sorghum plants to produce more DM, CP and ME in the semi-arid areas is through inter-cropping them with drought resistant leguminous crops like groundnut, lablab, pigeon pea etc. (Bandyopadhyay and De, 1986a,b; Kitalyi, 1989; Singh and Ahuja, 1990). More nitrogen was found in sorghum leaves when inter-cropped with groundnut and cowpeas. Inter-cropping increased the proportion of nitrogen derived from the soil nitrogen pool by sorghum. When necessary, application of nitrogen fertilizer improves the DM and CP quantity of vegetative fractions (Arnold *et al*, 1974; Martin and Wedin, 1974).

The conversion of the maize vegetative parts yields to the energy requirement of an animal on daily basis could give an overview of the number of livestock which can be supported by the different fractions (Paper I). It can be seen that the feed obtained from different treatments varies significantly in supporting an improved dairy cow of a Friestian type (590 kg LW) producing 10 liters of milk (36 g BF/kg + 86 g SNF/kg) based on MAFF, Bulletin No. 33 (1975) recommendations. The amount of energy obtained from Table 5 in Paper I suggests that to meet the minimum energy of the animal (111 ME MJ/head/day) the animal needs 15.0, 12.1, 11.1 and 10.2 kg DM/day of WPL,TP, STP and SR respectively. But since the nitrogen source is needed for the microbial environment in the rumen, the residues must be supplemented with a nitrogen source or chemically treated (Preston and Leng, 1987). In this case therefore, the authors recommended only 80% of the basal ration and the rest to be supplied with concentrate. Therefore, the animal needs only 80% of the former estimated requirements (88.8 ME MJ/day) which are 12.0, 9.7, 8.9

and 8.2 kg DM of WPL, TP, STP and SR respectively. The same estimates of energy based on MAFF, (1975), if the feeds are combined with their leftovers to optimize the whole field crop harvest, then the same animal can be supported by WPL, SR, STP and TP for a period of 352, 377, 474 and 494 days respectively from one hectare. Although the use of the treatment diets and the concentrate meet the minimum energy requirement, the maximum dry matter intake (16 kg DM/day) can be achieved by the addition of other roughage in different proportions depending on the sum of the test diets. Attaining the rumen capacity is also an important factor for the microbial environment.
Based on protein requirements, a Friestian type cow (590 kg LW) will require a minimum of 484 g/day of digestible crude protein (DCP). The DCP (g/kg DM) supplied by SR from maize is 61.8, TP as 25.6 DCP and 48.1 DCP from STP (Paper I). To meet the requirement of the animal, it must consume 7.8 kg of SR, 18.9 kg of TP and 10.1 kg of STP. For TP, the animal must be supplemented with a higher source of nitrogen based diet as the limit is 16 kg DMI. The diet should supply 74.38 g of DCP to meet the deficit. According to the trials done in Tanzania using urea molasses block (UMB) as a source of nitrogen to the ruminant animals, Mlay and Msangi (Unpub.) found that the UMB had 267.7 g/kg DM of DCP. According to this trial, a lactating animal consumes 800 to 1000 g of UMB/day. Equating the fractions with the UMB, their ratio relative to DCP to UMB was SR = 4.3, TP = 10.5 and STP = 5.6. This means that, from 1 hectare of land a farmer will harvest the UMB (indirectly) as SR = 198 kg UMB, TP = 174 kg UMB and 420 kg UMB from STP. Since Mlay and Msangi (unpub.) indicated the cost value of 60 Tanzania shillings (TSh.) per kg of UMB, then the farmer will get an advantage of 7375 TSh. from SR, 5261 TSh. from TP and 15800 TSh. from STP harvests after deducting the production costs. The actual costs of producing the SR from maize was estimated as 5.3 TSh. for a kg DM, 2.83 TSh. for TP, 4.0 TSh. for STP and 2.31 TSh. for WPL (Appendix 1). Since the primary objective to the farmer is to harvest grains, these costs are almost negligible as the farmer must incur the initial costs like ploughing, planting, weeding etc. whether he harvests the fractions or not.

On the same standards of MAFF, (1975) a Jersey cow [363 kg LW, 49 g/kg BF and 95 g/kg SNF without LW changes] producing 10 litres of milk per day, requires a total of 102 ME (MJ/day) including safety margin. If the basal ration is 80% of the total ration, then the animal will require only 81.6 ME (MJ/day) from the sorghum forages. From these assumptions the feeds from sorghum stripping (20.3×10^3 ME $MJha^{-1}$) will support the animal for 248 days while the sorghum stover (17.9×10^3 ME $MJha^{-1}$) for only 219 days giving a difference of 29 days.

Equating the sorghum fractions with the sunflower cake (based on protein contents) produced in the study area, the cake had 175.0 CP g/kg DM which means that, the ratio of green leaves (92.5 CP g/kg DM) to the cake is 1.9. This means that, the leaves produced (720 kg) from 1 hectare of land would be equal therefore to 379 kg of sunflower cake @ 25 TSh. Since the total costs for leaves production was 5150 TSh., the cake would be bought for 9475 TSh. equivalent. In this case, the opportunity cost of

using the leaves becomes 4325 TSh. The production costs for straw was 6083 TSh. If the cake was to be bought instead, the costs would be 9465 TSh., giving an opportunity cost of 3382 TSh. less than that of the green leaves. However, the use of straw alone would be limited by the bulkiness of the materials relative to the rumen capacity of a ruminant animal. For example, a cow weighing 450 kg LW and producing 10 liters of milk requires 12.3 kg DMI and 4/03 g of protein/day (Chamberlain, 1989). This means the straw intake must be > 11 kg and leaves intake 4.3 kg or above to meet the protein requirement of the animal. The straw intake will almost approach the maximum DMI which will leave no room for nitrogen supplementation for microbe satisfaction.
The DCP of leaves is 48 g CP/kg DM and sunflowers 123 g CP/kg DM.

9.0 CONCLUSION AND RECOMMENDATIONS

The cereal defoliation technique has some implications to the ruminant productivity in the tropics by the fact that it provides fodder of high feeding quality and the availability of the fodder throughout the year. The technique is not difficult to adopt where labor is not a constraint, nevertheless it can be implemented directly to the farmer's field with his/her full participation as it does not involve extra financial investment or machinery.

Qualitatively, the defoliated materials have higher nutrient content especially crude protein and organic matter digestibility (IVOMD) and the overall higher intake to ruminants relative to the stover left in the field uncollected (Paper I, II and III). There is no doubt on the acceptability of the defoliated materials when given to the ruminant animals, as they are characterized by high intake and digestibility (Paper III). The available nutrients in the defoliated materials will greatly reduce the amount of supplements to be used like urea molasses block, urea or chemicals for treating the fodder materials. Generally the supplements are expensive and in most cases, farmers can not afford them. It is recommended therefore, to utilize the enormous forage lost during the wet season by early harvesting of the vegetative parts and preserve them for dry season feeding as the method is relatively cheaper by reducing the amount of supplements and chemicals to be used to improve the stover quality.

Quantitatively, more fodder was available under this technique as most of the pre-grain harvest losses were minimized (Paper I and II). Actually during the time of defoliation, growth in pasture is at maximum growth (Paper IV). The defoliated fodder material can be conserved only under shade for use during periods of feed scarcity which is over eight months in the semi-arid areas of Tanzania. Under semi-intensive system, the collection of the defoliated materials near homesteads will also provide energy sources from dung, cobs and the rejected straws.

For future recommendations, studies on conservation of different fractions should be studied. Feeding studies could be done on different fractions with different forages. On-farm studies for implementations of harvesting different fractions before the grain harvest could be done in different ecological zones. The labor availability should be assessed. These will in turn reduce current deforestation due to the use of fuel wood and locally made charcoal. Finally, with the availability of energy sources nearby home, women will at least get away from the drudgery of firewood collection (Paper IV).

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11.0 REFERENCES

Alhassan, W. S., Bello, S.A. and Obilana, A. B., 1987. Yield and potential feeding value of straws of grain sorghum cultivars developed in Nigeria. Anim. Feed Sci. and Technology, 17: 4, 285-293.

Arnold, J.M.; Josephson, L.M.; Parks, W.L. and Kincer, H.C.; 1974. Influence of N, P and K applications on stalk quality characteristics and yield of corn. Agron. J.Vol. 66 (5) 602-605.

Bandyopadhyay, S.K. and De, R.; 1986a. Plant growth and seed yield of sorghum when intercropped with legumes. J. of Agric. Sci.; UK 107; (3), 621-627.

Bandyopadhyay, S.K. and De, R.; 1986b. Yield, nitrogen and water use efficiency and soil fertility imperatives of a sorghum based intercropping system with seed legumes. J. of Agric. Sci.; U.K. 107; (3) 621-627.

Burn, J. C.; Barnes, R.F.; Wedin, W.F.; Rhykerd, C.L. and Noller, C.H., 1970. Nutritional characteristics of forage sorghum and sudan grass after frost. Agron. J. 62: 348-350.

Chamberlain, A., 1989. Milk production in the tropics. In: Intermediate Agric. series [W.J.A. Payne (Ed.)]. Longman, UK. 242pp.

Deinum, B. 1976. Effect of age, leaf number and temperature on cell wall and digestibility of maize. In: Agric. Univ., Wageningen. Miscellaneous papers, nr. 12: 29-41.

Deinum, B and J.G.P. Dirven, 1971. Climate, Nitrogen and Grass,4.The influence of age on chemical composition and in vitro digestibility of maize (*Zea mays,* L) and tall fescue *Festuca arundinacea* Schreb). Neth. J. Agric. Sci. 19:264.

El-BAki, S. M. A.; Nowar, M. S.; Hassona, E.M.; Sohman, I; Ghanem, H.M.; and Gad-Alla, S. A. 1989. Evaluation and utilization of corn stover fodder and its silage by sheep. Proc. of the 3rd Egyptian British Conf. on animals, fish and poultry production. Alexandria, Egypt, 169-175.

Food and Agriculture Organization of the United Nations (FAO),1986. Better utilization of crop residues and by-products in animal feeding: research guidelines 2. A practical manual for research workers. FAO animal production and health paper 50/2. (Ed. T. R., Preston).

FAO, 1980.Improvement and production of maize, sorghum and millet. Vol.1. General principles. FAO plant production and protection paper 24/1 pp. 216.

Gibbon, D. and Pain, A.; 1985. Crops of the drier regions of the tropics. Intermediate tropical agric. series. Longman group Ltd, UK. Gohl 1981. Tropfeed. Food and Agriculture Organization ofthe United Nations. Rome, Italy. pp 529.

Hazra, C.R.; 1988. Soil and water management for increased dryland crop productivity in Bundelkhand region. Indian J.of range mgt. 9; 97-103.

Kossila, V. L. 1984. Location and potential feed use. In: Straw and other fibrous by-products as feed (Eds: F. Sundstol and E. Owen). Elsevier, Amsterdam, pp 4-24

MAFF (Ministry of Agriculture, Fisheries and Food), 1975. Energy allowances and feeding systems for ruminants. MAFF technical Bulletin No. 33, HMSO London.productivity in Bundelkhand region. Indian J. of range mgt. 9; 97-103.

Kitalyi, A., 1989. Production and nutritional characteristics of local lablab bean (Lablab purpureus (L) Sweet) in a semi-arid area of Tanzania. In: Development and utilization of forages for livestock feeding in Tanzania. Proc. of the TALIRO/SAREC conf., Mpwapwa Tanzania, 14-15 March, 1989, pp. 32-40.

Ministry of Agriculture (MALD), 1988. Statistical abstract of the livestock census (Tanzania mainland). Livestock statistic unit, planning and marketing division, Dar es Salaam.

Martin, J.H., 1930. The comparative drought resistance of sorghums. J. Am. Soc. Agron. J. 22 (12): 993-1003. McDonald, P.; Edwards, R.A. and Greenhalgh, J.F.D.,1991. Animal nutrition. 4th ed. Longman, England.

Martin, N.P. and Wedin, W.F.; 1974. Effects of fall weathering on yield and composition of grain sorghum stover. Agron. J.66, (5):669-672.

Milbourn, G.M., 1975. Maize growers handbook. 3rd ed. Home-grown cereal authority, Hamlyn Hse, Highgate Hill, London. defoliation regimes. Acta-Horticulturae. No. 218, 77-82.

Mosimanyana, B. and Kiflewahid, B., 1987. In: Utilization of agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi. (Eds: D. A. Little, A.N. Said, J. A.Kategile, S. Sibanda, M. A. Naga and M. Y. Nuwanyakpa). ARNAB/ILCA pp.127-135.

Munthali, J. T., 1987. Cattle fattening on basal diets of maize stover and groundnut in Malawi. In: Utilization of agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi. (Eds: D. A. Little, A.N. Said, J. A. Kategile, S. Sibanda, M. A. Naga and M.Y. Nuwanyakpa). ARNAB/ILCA pp. 127-135.

Musimba, N.K.R., 1981. Chemical composition of maize stover, rice straw and wheat straw treated with sodium hydroxide (NAOH).In: J. A Kategile, A.N. Said and F. Sundstol (Eds). Proc. Workshop 'Utilization of low quality roughage' Arusha, Tanzania, 18-22 January 1981.Agric. Univ. Norway, Agric. Development Report No. 1, pp.17-20.

Nour, A. M., 1987. Rice straw and rice hulls in feeding ruminants in Egypt. In: Utilization of agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi. (Eds: D.A. Little, A.N. Said, J. A. Kategile, S. Sibanda, M. A. Naga and M. Y Nuwanyakpa). ARNAB/ILCA pp. 53-61.

Olayiwole, M.B.and Olorunju, S.A. 1987. Feedlot performance of yearling steers previously maintained on different crop residue/supplementation regimes. In: Utilization of agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi. (Eds: D. A. Little, A.N. Said, J. A. Kategile, S. Sibanda, M. A. Naga and M. Y. Nuwanyakpa). ARNAB/ILCA. pp. 72-82.

Owen, E.; 1976. Farm wastes:straw and other fibrous materials. In: Food production and consumption [Eds. A.N. Duckham, W.G. Jones and E.H. Roberts]. Elsevier, Amsterdam. Chp. 7.

Owen, F.G. and Moline, W.J., 1970. Sorghum for forage. In: Sorghum production and utilization: Major feed and food crops in agriculture and food series. (Eds. J.S. Wall and W.M. Ross). The AVI Publ. Co., Inc., London.

Ørskov, E.R., 1993. Reality in rural development aid with emphasis on livestock. Rowett Research Service Ltd., Aberdeen U.K.

Pinter, L.; Schimidt, J.; Jozza, S.; Szabo, J. and Kelemen, G.,1990. Effect of plant density on the feed value of forage maize. J. Maydica 35 (1990): 73-79.

Poething, S.R., 1982. Maize. The plant and its parts. In: Maize for biological research [Ed. W. F. Sheridan]. N. Dakota, Grand Forks, N.D. USA.

Powell, J.M.; Hons, F.M. and McBee, G.G., 1991. Nutrient and carbohydrate partitioning in sorghum stover. Agron. J. 83: 933-937.

Preston, T. R. and Leng, R. A., 1987. Matching ruminant production systems with available resources in the tropics and sub-tropics, Armidale, Australia, pp. 93-102.

Singh, S.P. and Ahuja, K.N.; 1990. Intercropping of grain sorghum under dryland conditions in north-western India. Indian J. of Agron. 25:3, 287-296.

Stallcup, O.T. and York, J.O., 1986. Nutritive value of the grain sorghum plant in cattle diets. Bull. Agric. exp. station, Arkansas Univ. No. 893, 37pp.

Struik, P.C., 1982a.Production pattern, chemical composition and digestibility of forage maize (*Zea mays*, L). Mededeling no. 64, Vakgroep Landbouwplantenteelt en Graslandkunde, Agric. Univ., Wageningen, pp. 1-28.

Struik, P. C. 1982b. Production pattern, chemical compositionand digestibility of forage maize (*Zea mays* L). Mededeling no.64, Agric. Univ. Wageningen, pp. 1-28.

Struik, P. C. 1983. The effect of switches in photoperiod on crop morphology, production pattern and quality of forage maize (*Zea mays* L.) under field conditions. Wageningen Agric. Univ.,The Netherlands, 83-2: 1-27.

Struik, P. C. 1985. Digestibility of plant fractions from different genotypes and predictability of quality of forage maize in northwest Europe. Neth. J. agric. Sci.33 (1985) pp. 56-58.

Struik, P. C. and Deinum, B. 1982. Effects of light intensity after flowering on the productivity and quality od silage maize. Neth. J. agric. Sci., 30:297-316.

Struik, P.C. and Deinum, B., 1982. Effects of light intensity after flowering on the productivity and quality of silage maize. Neth. J.agric. Sci., 30: 297-316.

Van Soest, P. J., 1982. Nutritional Ecology of ruminants. O & B Books, Corvallis, Oregon.

Vasilas, B.L. and Seif, R.D., 1985. Effect of defoliation on the timing 6 anthesis and silking of maize inbred lines. J. Maydica (1985):

427-435.

Wall, J.S. and Blessin, C.W., 1970. Composition of sorghum plant and grain. In: Sorghum production and utilization [Eds. J.S. Wall and W.M. Ross]. The AVI Publ. Co., Inc. London. pp.118-166.

Wegad, D. and Ndumbẹ, R.D., 1987. The effect of different protein supplements on weight gain and voluntary intake of maize stover by cattle. pp. 99-102. In: Utilization of agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi. (Eds: D. A. Little, A.N. Said, J. A. Kategile, S. Sibanda, M. A. Naga and M. Y. Nuwanyakpa). ARNAB/ILCA. pp. 72-82.

Wilkinson, J.M., 1978. The ensiling of forage maize: Effects on composition and nutritive value. In:Forage maize production and utilization (Eds: E.S. Bunting, F. Pain, R. H. Phipps, J.M. Wilkinson and R.E. Gunn). Agric. Res. council, London, pp. 200-237

I

UTILIZATION OF MAIZE LEAVES AND TOPS PRIOR TO HARVESTING AS FODDER FOR LIVESTOCK.

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ABSTRACT
An experiment on different methods of defoliating maize plant morphological fractions for animal feeding was conducted in Central Tanzania with four treatments *viz:* stripping, topping, stripping + topping and whole plant stover (control). The treatments were randomly allocated in a completely randomized block design experiment. The green fodder yield (t/ha) obtained from stripping, topping and stripping + topping were 0.85, 1.83 and 2.45 with a left over of 3.06, 3.52 and 2.99 respectively. The control had the dry matter yield of 4.23 t/ha. The digestibility *in vitro* of the organic dry matter was in the order of stripping >stripping + topping > topping > control. The crude protein (CP kg/ha) increased with the increase of leaf proportions ranging from 138.0, 177.0, 234.0 and 287.0 in stover, stripping, topping and the combination of stripping + toppings respectively. None of the treatments significantly affected the grain yield (P >0.05).

KEY WORDS: maize stripping; maize topping; pre-grain harvest; feeding value

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INTRODUCTION

Maize (*Zea mays* L.) is mainly grown for its grain which is used as human food and as a cash crop in Tanzania and other tropical countries. The common practice of using the residues from the maize and other cereals after the grain harvest is to allow ruminant animals to graze freely in the fields (*in situ*). In some areas the residues are harvested and taken to the homesteads nearby. Where this is applicable, the stover and the straws are sometimes treated with alkali or urea to increase their feeding value to the animals. The cereal stover and straws which are produced have poor feeding quality as the harvest is late in the season. In this season they are highly indigestible to the ruminant animals due to the high levels of cell wall material especially lignin which inhibits microbial digestion of cellulose and hemicellulose. The low content of nitrogen and deficiency of readily available carbohydrates in the stover also inhibit the rumen microbial activity.

The crude protein (CP%) content of the maize stover is not significantly high to support animal maintenance and production. Various findings in Africa reported the CP content of maize stover to be in the range of 2 to 6 % (Musimba, 1981; Kossila, 1984; Dzowela, 1987; Urio and Kategile, 1987). All the values reported here dictate supplementation to be inevitable for better productivity.

Within the same plant, the chemical composition differs depending on the fractional part and the stage of plant growth in question (Struik, 1982b). Struik also indicated that the differences are caused by the proportions of the sclerenchyma and vascular bundle tissues. Deinum (1976), quoted by Struik (1982b), showed that even within the same leaf fraction, there is variation in digestibility. Small leaves have low cell content with higher digestibility compared to the higher leaves with low digestibility, this being due to the high concentration of cell wall materials in the leaf midribs which are supporting in structure.

A study conducted in Kenya by Said and Wanyoike (1987) showed that it was possible to harvest one ton of green forage dry matter per hectare of green maize through defoliation before the grain harvest without affecting the final grain yield. Similar findings were found by Dzowela (1985).

Apart from the quality deterioration in the stover, the total dry matter yield of the residues is greatly reduced due to the various losses occurring before and after the grain harvest mainly as a result of biological and physical factors. Termites, vermin and pests contribute to the great losses while wind shedding, rains and leaching are some of the physiological problems. The losses could be as high as 50% (Kossila, 1984; Oberle and Keeney, 1990). Early harvesting of the stover therefore increases the dry matter (DM) and the total digestible nutrients (TDN)(Dzowela, 1985; El-Baki et al, 1989).

In the tropics, most small holder farmers have different perceptions of the uses of the green fodder materials before the grain harvest as most of them are not sure whether the defoliation can affect the grain yield or not.

The overall aim of this experiment was to optimize the utilization of nutrients available in cereal crop residues harvested at different stages of maturity without affecting the grain yield.

MATERIALS AND METHODS

Study site:

The project location was in Dodoma Region, Central Tanzania which has a semi-arid climate. The area receives about 400-800 mm of unimodal rainfall per year falling between November and May (Fig. 1) followed by more than six dry months. It is also between 900-1200m a.s.l. with temperatures ranging from 20^0C to 32^0C (Fig. 2). The soils are clay and sand loams with black soils in depressions. Maize is grown alongside drought resistant crops like sorghum, millet and groundnuts.

Crop establishment and management.

The whole experimental field was 39 m x 67 m area with 16 subplots each 8 m x 15 m area. The maize variety used was (STAHA) and the planting spacing of 30 cm x 75 cm with 2 plants/hole was adopted. Planting was done on 31st December, 1992 almost one week after the commencement of the first rains. Phosphatic fertilizer [Triple Super Phosphate (TSP)] was applied at a rate of 125kg/ha during planting. Thinning of the weaker plants (30 days after planting) leaving one plant/hill was also done prior to the application of nitrogen fertilizer [Sulphate of Ammonia (SA)] at the rate of 150 kg Nitrogen/ha which is recommended in the study area. Weeding was performed four times throughout the season and pesticide application was used at the booting stage on top of the plants.

Experimental design and treatments.

The design was a completely randomized block (CRBD) where four treatments were randomized in each block.
There were four treatments as follows:
Treatment 1 : Stripping (SR); Treatment 2 : Topping (TP) ; Treatment 3: Stripping + Topping (STP) and Treatment 4 : Whole plant/stover or the control (WPL).

Sampling procedures.

Four plots were used in SR, TP, WPL and three in STP. One of the STP plots located in one of the corners of the field was discarded due to poor growth performance from the beginning. In a plot of 120 m^2 size, the two outer rows and 4 plants from each end of the 20 rows/plot were discarded to eliminate the border effects making an effective area of 75.225 m^2. Each time the harvested samples were mixed thoroughly and sub-sampled for further chemical analysis.

Criteria used :

SR: All 8 leaves below the cob, starting from the date when 50% of the WPL plots were at the silking stage (day 60), were defoliated with an interval of 2 leaves /week starting from the bottom.
TP: Topping was done when the last leaves were defoliated in SR.

STP:The leaves below the cob were defoliated concurrently with those in the SR treatment while the toppings were harvested on the same date as those in TP.
WPL:The stover from SR, TP, STP and WPL were harvested immediately after grain harvest at 165 days after planting.

Laboratory tests
The fresh weights of all the harvested materials and the thinned plants were recorded and processed for proximate analysis (DM, ASH and CP) according to the procedures of AOAC (1985) while the NDF was determined according to the methods of Goering and Van Soest (1970).

Digestibility studies
The two-stage technique according to Tilley and Terry (1963) for determination of *in vitro* dry matter (IVDMD) and organic matter digestibility (IVOMD) of each sample collected was used. *In sacco* dry matter digestibility (DMD) of the materials obtained including the thinned plants from each treatment was determined in duplicate at 0, 12, 24, 48 and 72 hour intervals using a fistullated steer. The bags for this technique had 52 μm pore size and 80 mm x 15 mm size to contain 2 gm of the sample grounded in 3 mm mesh size. The degradability values obtained were fitted to the degradability curve using the following equation:
$Y = a + b(1 - e^{-ct})$ where Y = degradation which has taken place,
a = intercept or washout value, b = amount degraded in time t,
t = time in hours, c = degradation rate constant and e = the natural logarithm

Feed evaluation
Utilizing the *in vitro* digestibility of the organic matter (IVOMD), the metabolizable energy (ME MJ kg/DM) content was computed according to the MAFF (1975) standards as:
DOMD % = (0.92 x IVOMD) - 1.2 and ME MJ/kg DM = 0.16 x DOMD where DOMD = Digestible organic matter in dry matter (D-value). The crude protein was also used to compute digestible crude protein (DCP g/kg DM) in the feeds as:
DCP (g/kg DM) = [CP (g/kg DM) x 0.9115] - 36.7 (MAFF, 1975). The energy and protein values obtained were extrapolated to hectare basis from the respective forage dry matter yields from each treatment. Total grain yield was also determined from each treatment.

Statistical analysis
The data were analyzed by Minitab Statistical Package, (1991) using one-way analysis of variance.

RESULTS AND DISCUSSION

Fodder production

Table 1 shows the means and standard errors of the means for total maize biomass fodder production (t/ha) from stripped (SR), topped (TP), stripped + topped (STP) and whole plant stover (control) (WPL) as 3.91$\pm$0.39, 5.35 $\pm$ 0.76, 5.44 $\pm$ 0.67 and 4.23 $\pm$ 0.42 respectively. Total yield for the treatments were not significantly different ($P>0.05$) but were significantly higher ($P<0.05$) compared to TP and STP. The lower quantity of stover was mainly a result of higher pre-grain losses, which might partly have been due to old leaves falling off, losses of plant tops and termite and vermin attack. Various physiological changes in the plant might also have resulted in reduced photosynthetic activity in the later growth stages (Struik, 1983). Struik (1983) also suggested that the stover must have had the highest DM content due to the rapid increase in the dry matter content and the ear proportion which occurs during the grain filling period. The fractional (green material only) dry matter yield (t/ha) shown in Table 1 ranged from 0.85 $\pm$ 0.10 for SR, to 2.45 $\pm$ 0.01 for STP. These are the actual fodder materials which can be obtained from defoliation of the vegetative parts before grain harvest. The yields from SR was almost similar to those reported in Kenya by Said and Wanyoike (1987) who found the yield of 1 ton DM/ha.

The cob production was not significantly different ($P>0.05$) in the treatments, but their role in substituting fuel wood and feed for animals is also very important (Jeroch *et al*, 1990). The grain yield found in this study was not significantly different ($P>0.05$) between the treatments which is in agreement with the findings of Dzowela (1985) and Said and Wanyoike (1987).

Feeding quality of the fodder materials

The ratio of leaf:stem in the components (Table 2) determines the CP and IVOMD value. The ratio was positively correlated with the protein level and IVOMD. Also it is determined by the date of harvest. The late harvested dry tops had only 1:2 ratio of leaves to stems while the green tops had 1.5:1. The stover which was harvested late in the season had the highest proportion of stem (1:8). The early harvested materials ie. the leaves from the stripping and the tops contributed about 22% and 34% to the total fodder as compared to yield after the grain harvest when they contributed only 8 % and 24% respectively (Table 3). The leaves and tassels which are more digestible were mostly affected by these losses. Struik, (1982b) suggested that the proportion of the various plant parts in the final crop can be adversely affected by the harvesting date, cultural practices, genotype and climate. The amount of nutrients in different plant fractions differs depending on the time of measurement. However in general, maize has a relatively high level of nutrients including non-structural carbohydrates (sugar + starch), protein and ash contents resulting in higher digestibility and energy value compared to other cereal straws (McDonald *et al*, 1988 and Wilkinson, 1978).

Chemical composition of the fodder

Qualitatively, the SR and STP had the highest ($P<0.05$) CP of up to 108.1 and 93.0 g/kg DM respectively (Table 4). Table 4 shows composition, digestibility and metabolizable energy values of the different fractions of maize. The energy available (ME MJ/kg DM) ranged from 6.9 to 10.9 in STP left over and pure green stripping respectively. The ME value from STP left over (6.9 ME) was higher than most of the cereal by-products described by MAFF, (1975) and McDonald *et al*, (1988) because of the presence of husks and prophyll. Chamberlain, (1989) described the husks as the most digestible fraction of maize residues while cobs were the lowest.

The energy values for the green maize tops and leaves are equal to what is normally found in maize silage. Thus this must be regarded as high quality fodder for ruminants. The combination of the CP obtained before and after grain harvest was the highest in STP (287 kg CP/ha) followed by TP (234 kg CP/ha). SR had a CP of 177 kg/ha while WPL had a CP of 138 kg/ha (Table 5). This means that the delay of harvest gave a total loss of 149 kg CP/ha which is almost 52 %.

Dry matter degradability

The dry matter degradability (DMD) of the fractions were in the order of SR > STP >TP > WPL (Figure 3). The leaves were more degradable and the rate increased as the leaf fraction increased. The observed differences in dry matter disappearance could also be due to their differences in chemical composition. The higher fibre content (NDF) in WPL made them the least degradable of all the fractions tested. Various findings in Africa have shown the maize stover to have high crude fibre content ranging from 39 to 52 % (Musimba, 1981; Urio *et al*, 1987; Wegad *et al*, 1987). The degradability values at 48 hour incubation period are the most important as this period is closely related to the mean retention time of most of the low quality roughage (Preston and Leng, 1987). Since the TP, STP and SR had dry matter degradability (DMD) between 57% to 66% at 48 hours, they can be considered as feed of high potential to ruminants which can support growth and milk production (FAO, 1986; Preston and Leng, 1987). Preston and Leng recommended feeds with 55 - 65% DMD at 48 hour to be a potential feed resource. From these recommendations, the WPL with 51% DMD at 48 hrs are considered as feed of low potential with satisfactory degradation which needs chemical treatment before feeding them to productive animals.

Leaf position and nutritive value

Individual leaves have some different cell wall contents depending on their roles in plants and also the stage of plant growth (Deinum, 1976; Struik, 1982b). Table 6 shows the specific variation in leaf composition and yield within the same plant. It can be seen that the yield increases higher up the plant, probably because of the different roles of leaves at different levels in the plant. For example the higher leaves primarily contribute to ear development, and there was a tendency for CP% to increase from the first to the eighth leaf. Since the upper leaves are more responsible to ear development, the accumulation of assimilates in the leaf blade become higher than the lower leaves (Teyker *et al*, 1991). The digestibility (IVOMD) showed a similar trend from the first to the fifth leaf but declined from the sixth to the eighth leaf. The decline might be due to the higher accumulation of the cell wall materials in the upper leaves which are closer to the light sources than the lower leaves. For this they have a bigger size midrib in proportion to the blade. The former is less digestible than the leaf blade but more of a supporting structure in function (Deinum and Dirven, 1971 and Deinum, 1976).

Harvesting time for different fractions

Since the best time to harvest SR, TP and STP fractions might coincide with other on-farm activities especially weeding, then the time to be spent by the farmer to harvest the fractions must be considered. In this study more time was spent in SR than all the other fractions (Table 7). But the nutrients which accrued are far better than the others. Therefore, the farmer has to compromise on this as the harvesting time here is directly proportional to the feeding value of the feeds. The stover for example, needs the least time to harvest but it is the poorest in feeding value in comparison with the three fractions.

CONCLUSION

Harvesting leaves and tops of maize plants at silking stage increases the fodder yield of crude protein by 100 % and metabolizable energy by 30 % as compared to stover.

From these findings, it can be concluded that it is advisable to strip and top the leaves just after the silking stage. At this period, the plant had already accumulated maximum dry matter in the ear (over 40 % maturity) as at this stage the defoliation of leaves had no effect on the grain yields. In some areas there is no critical shortage of animal feed in this period. Thus it is suggested from these findings that shade drying and storage of these valuable materials for dry season feeding could be a way of solving the problem of feed shortages during the dry season. Shade drying is the easiest and cheapest technology when compared to other conventional ways of preserving green forages such as silage making which is more sophisticated and expensive to a small holder farmer in the tropics.

ACKNOWLEDGEMENT

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REFERENCES CITED

Association of Official Analytical Chemists (AOAC),1985. Official methods of analysis. 12 ed. Washington, D. C.

Chamberlain, A., 1989. milk production in the tropics.In: Intermediate Agriculture Series [W. J. A. Payne (Ed.)].Longman, UK. pp.37-59.

Deinum, B. 1976. Effect of age, leaf number and temperature on cell wall and digestibility of maize. In: Agric. Univ., Wageningen. Miscellaneous papers, nr. 12: 29-41.

Deinum, B and J.G.P. Dirven, 1971. Climate, Nitrogen and Grass,4. The influence of age on chemical composition and invitro digestibility of maize (*Zea mays*, L) and tall fescue *Festuca arundinacea* Schreb). Neth. J. Agric. Sci. 19:264.

Dzowela, B.H. 1985. Maize stover improvement with legume forages. Pasture Network for Eastern and Southern Africa Workshop (PANESA) on Animal Feed Resources for Small-scale Livestock Producers, November 11-15, Nairobi, Kenya.

Dzowela, B.H. 1987. Efforts to enhance maize stover utilization for small holder livestock producers in Malawi. African Research Network for Agricultural by-products (ARNAB) Workshop on 'Utilization of Agricultural By-products as Livestock Feeds in Africa'. Sept. 1986, Blantire, Malawi.

El-Baki, S. M. A.; Nowar, M. S.; Hassona, E.M.; Sohman, I; Ghanem, H. M and Gad-Alla, S. A. 1989. Evaluation and utilization of corn stover fodder and its silage by sheep. Proc. of the 3rd Egyptian British Conf. on animals, fish and poultry production. Alexandria, Egypt, 169-175.

FAO (Food and Agriculture Organization of the United Nations), 1986. Better Utilization of Crop Residues and By-products in Animal Feeding: Research Guidelines. 2. Apractical manual for research workers. (Prepared by T. R. Preston). In: FAO Animal Production and Health paper 50/2, Rome.

Goering , H. K. and P. J. Van Soest, 1970. Foragefibre analysis. U.S.D.A. Agricultural handbook No. 379, pp. 1-20.

Jeroch, H.; Kurbis, G.; Soffrant, S.; Freygang, G. and Gehardt, G. 1990. Feeding value of maize products for rabbits. Archives of Animal Nutrition, 40:5/6, 443-447.

Kossila, V. L. 1984. Location and potential feed use. In: Straw and other fibrous by-products as feed. (Editors: F. Sundstol and E. Owen). Elsevier, Amsterdam, pp 4-24.

MacDonald, P.; Edwards, R.A. and Greenhalgh, J. F.D., 1988. Animal nutrition, 4th. edition.Longman Scientific and Technical, Longman Group Ltd., England.

MAFF (Ministry of Agriculture, Fisheries and Food), 1975. Energy allowances and feeding systems for ruminants. MAFF Technical Bulletin No. 33, HMSO London.

MINITAB, Release version 8., 1991. Minitab Inc., Birmingham.

Musimba, N.K.R., 1981. Chemical composition of maize stover, rice straw and wheat straw treated with sodium hydroxide (NAOH). In: J. A. Kategile, A.N. Said and F. Sundstol (Eds). Proc. Workshop 'Utilization of low quality roughage. Arusha Tanzania, 18-22 Jan. 1981. Agric. Univ. Norway, Agric. Development Report No.1, pp. 17-20.

Oberle, S. L. and Keeney, D. R. 1990. Factors influencing corn fertilizer and N requirements in the Northern V. S. corn belt. J. of Production Agriculture , 1990, 3:4, 527-534.

Preston, T.R. and Leng, R.A., 1987. Matching ruminant production systems with available resources in the tropics and sub-tropics. Armidale, Australia.

Said, A. N. and Wanyoike, M. M. 1987. The prospect of utilizing urea-treated maize stover by small holder in Kenya. ARNAB orkshop on 'Utilization of Agricultural By-products as Livestock feeds in Africa, Sept. 1986, Blantyre Malawi.

Teyker, R, H., Moll, R. H. and Jackson, W. A.,1991. Differences among prolific maize hybrids in the effects of lower leaf removal. J. Maydica 36, (1991):1-10.

Tilley, J.M.A. and Terry, R. A., 1963. A two-stage technique for *in vitro* digestion of forage crops. J. of the British Grassland Society 1:104.

Urio, N. A. and Kategile, J. A. 1987. Maize stover and cobs as a feed resource for ruminants in Tanzania. In: Utilization of Agric. By-products as Livestock Feeds in Africa. Proc. of the Workshop, Blantyre, Malawi, Sept. 1986, By ARNAB.

Wegad, D. and Ndumbe, R. D., 1987. The effect of different protein supplements on weight gain and voluntary intake of maize stover by cattle. In: Utilization of agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi. (Eds.D.A. Little, A.N. Said, J. A. Kategile , S. SIbanda M.A. Naga and M. Y.Nuwanyakpa). ARNAB/ILCA. pp. 72-82.

Wilkinson, J. M. 1978. The ensiling of forage maize: Effects on composition and nutritive value. In: E. S. Bunting, B. F. Pain, .H. Phipps, J. M. Wilkinson and R. E. Gunn (Eds). Forage maize: Production and utilization, Agric. Res. Council, London. pp. 200-237.

TABLES AND FIGURES

Table 1: Total biomass production (t/ha) of different fractions of maize plant (n = 4)

	Treatment					
	SR	TP	STP	WPL		
	Mean	Mean	Mean	Mean	SEM	P-value
Green DMY[1]	0.85^{a}	1.83^{a}	2.45^{a}	0^{a}	0.11	0.000
Resi. DMY[2]	3.06^{b}	3.52^{c}	2.99^{cd}	4.23^{bd}	0.27	0.014
Cummulative DMY[3]	3.91^{fg}	5.35^{fi}	5.44^{gj}	4.23^{hij}	0.29	0.009
Thin-plants	0.82	0.73	0.90	0.65	0.09	0.366
Cob yield	0.69	0.73	0.78	0.68	0.07	0.628
Grain yield	3.20	3.62	3.35	3.46	0.35	0.784

Key|
:Values in a row with same letter script are significantly different (P>0.05).
:Green DMY[1]/= Fodder yield obtained before grain harvest
:Resid. DMY[2]/= (Residual dry matter yield) = Fodder yield after grain harvest (left over).
:Cumm. DMY[3]/ = (Cumulative fodder yield) = Green DMY[1] + Resid. DMY[2]
:Thin-plant = Dry matter yield from the thinned plants

Table 2: Leaf:stem ratio of upper and whole stover plant

	Leaf : stem ratio
Green tops[1]	1.5 :1
Dry tops[2]	1 : 2
Whole stover plant	1 : 8

[1] :Harvested at silking stage
[2] :Harvested after grain harvest

Table 3: Proportion of strippings, toppings as % of the whole plant when harvested before and after grain harvest

	Early harvest	Late harvest
Strippings	21.7	8.2
Toppings	34.2	24.5

Table 4: Composition, digestibility values and metabolizable energy of different fractions of maize plant.

	Treatments						
	Stripping		Topping		Stripping + topping		Control
	SR	LO	TP	LO	STP	LO	WPL
DM %	27.3	82.8	42.1	83.7	33.2	83.1	86.2
Composition (g/kg DM)							
CP	108.1	27.9	68.4	30.3	93.0	29.4	32.8
OM	863.6	945.2	918.7	945.8	887.4	945.0	863.6
NDF	631.9	806.9	735.0	798.0	661.3	808.8	796.4
ASH	136.4	54.8	81.3	54.2	112.6	55.1	55.4
Digestibility (% of DM)							
IVOMD	75.3	54.8	63.7	53.7	69.0	48.2	51.7
DOMD	68.1	49.2	57.4	48.2	62.3	43.1	46.3
Energy (MJ/kg DM)							
	10.9	7.9	9.2	7.7	10.0	6.9	7.4

Key (both Table 4 and 5):
ME(MJ/kgDM) = 0.16 x DOMD% (MAFF, 1975)
DOMD % = (0.92 x OMD%) - 1.2 (MAFF, 1975)
ME = Metabolizable energy
DOMD% = Digestible organic matter in dry matter (D-value)
OMD = Organic matter digestibility
LO = Left overs after grain harvest

Table 5: Total amount of digestible organic matter, crude protein and metabolizable energy from the different fractions of maize plant.

Yield per ha	Treatments						
	Stripping		Topping		Stripping + topping		Control
	SR	LO	TP	LO	STP	LO	WPL
CP kg	92	85	125	108	207	80	138
Total CP		177		234		287	138
DOM kg	579	1505	1050	1697	1464	1164	1958
Total DOM kg		2084		2747		2628	1958
ME MJ x 1000	9	24	17	27	23	19	31
Total ME MJ		33		44		42	31

Table 6: Quantity of nutrients in the different maize leaves

Leaf #	CP kg/ha	OM kg/ha	DMY kg/ha	ME (MJ/ha)
1st	5.8	54.9	75.5	845
2nd	7.8	53.1	71.2	806
3rd	8.0	63.0	77.2	902
4th	9.6	68.1	86.5	1018
5th	13.8	100.4	126.5	1514
6th	13.0	104.3	125.0	1290
7th	13.1	92.8	113.7	1115
8th	20.5	139.6	172.2	1748

Table 7: Time spent to harvest one ton dry matter of different morphological fractions of maize from a pure stand of maize field.

	Morphological fractions			
	SR	TP	STP	WPL
Hours per ton	106	24	54	8

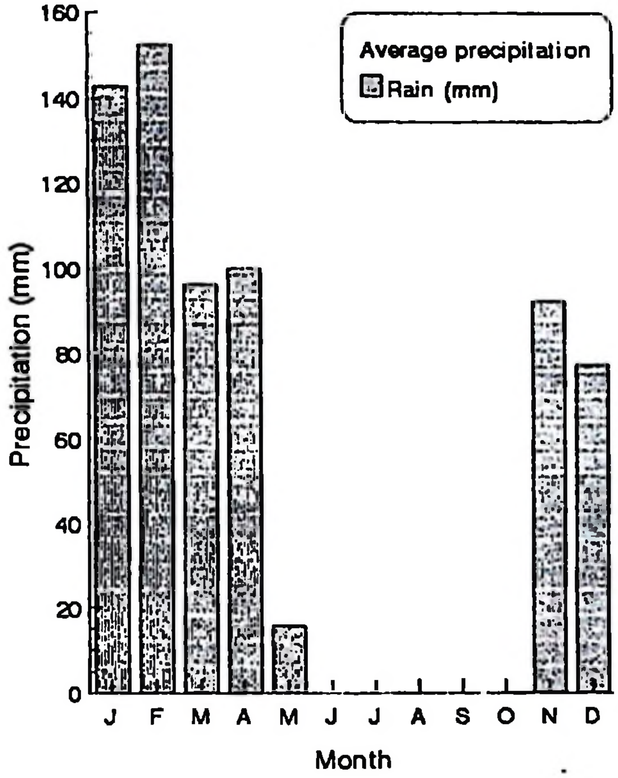


Figure 1: Mean monthly rainfall (mm) from 1990 to Oct. 1993, LPRI, Mpwapwa-Tanzania

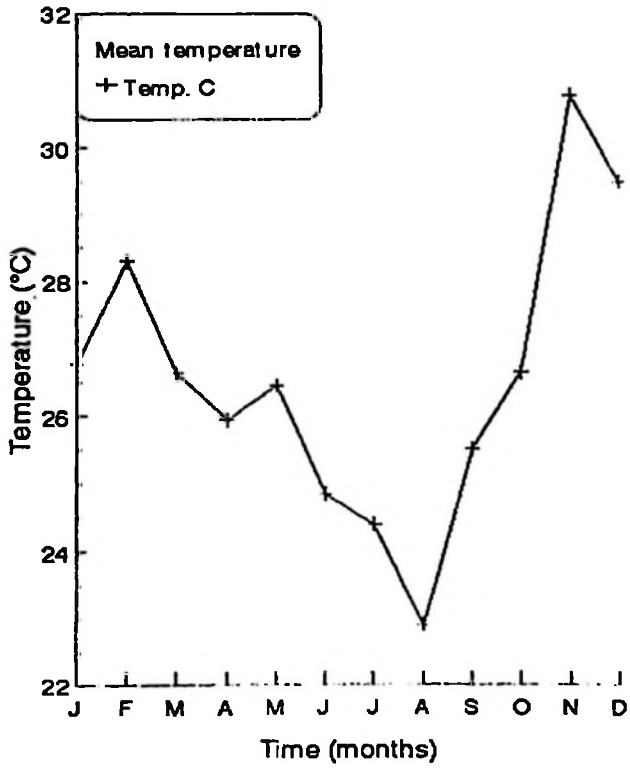
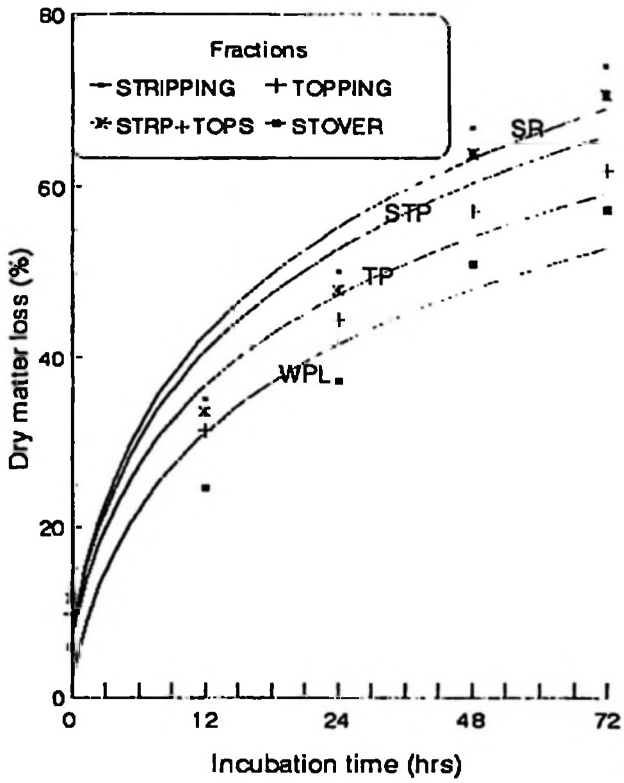


Figure 2: Mean monthly temperature from 1990 to Oct. 1993 LPRI, Mpwapwa-Tanzania



Two leaves harvest per week from silking stage

Figure 3: Dry matter degradability (DMD) of maize fractions

II

YIELD AND POTENTIAL FEEDING VALUE OF DEFOLIATED SORGHUM LEAVES AT PRE-GRAIN HARVEST STAGE OF PLANT PHYSIOLOGICAL MATURITY.

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ABSTRACT

The improvement of straw management before and immediately after harvest has been suggested as one of the alternatives to feed improvement strategies in Central Tanzania.

Defoliation of two leaves per week from a local sorghum variety (SANDALA) at reproductive stage (milking) gave high quality fodder of 92.5 g CP/kg DM, *in vitro* digestibility of organic matter (IVOMD) of 79% and 11.4 MJ ME /kg DM from the green leaves ($P<0.05$) relative to the late harvested leaves with 32.3 g CP/kg DM, 59.6 % IVOMD and 7.8 MJ ME/kg DM. Through defoliation, more protein and energy are obtained from a given piece of land by 123 kg $CPha^{-1}$ and 20.3 GJ ME/ha^{-1} compared to 70.7 kg $CPha^{-1}$ and 17.9 GJ ME/ha^{-1} from the unstripped plants. The total dry matter of fodder production accrued from the defoliation treatments was 2.19 tha^{-1}, slightly higher ($P>0.05$) than the unstripped (control) treatment with 1.84 tha^{-1}. None of the treatments affected the grain yield ($P>0.05$). Tiller production after the grain harvest was not affected by any treatment ($P>0.05$) but they had slightly higher CP, IVOMD and ME than the straw plant components.

It is possible to store these valuable materials for dry season feeding when the quality of the forage is limited to livestock production in the area.

Key words: Sorghum leaves defoliation, field losses, feeding value, tiller production

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INTRODUCTION

The feeding value of different cereal straws varies greatly depending upon their species, cultivar, maturity, fertilizer and time of utilization. Normally the quality of straws varies from one species to another and they are categorized as the best or the poorest depending on their ability to support maintenance and production in the ruminants (Nicholson, 1984). Tissues within the same plant give more variation than the differences in plant species (Nicholson, 1984; Wilkinson, 1978).

Being one of the drought resistant crops in semi-arid Central Tanzania, sorghum is grown primarily for its grain as human food while the straw is left in the field for free grazing. This is done late in the season when the straws are characterized by higher fibre content, low soluble carbohydrates and nitrogen (Theander and Aman, 1984). However, Nicholson (1984) showed the organic matter digestibility of the sorghum straw to be higher than most of the other straws such as oats, barley, wheat, rice and maize.

Although the leaves have higher CP, DM and soluble carbohydrate than other straws, the sorghum leaves have more phenolic than other cereal leaves and higher lignin content (Alhassan, *et al.*,1987).

The aim of this experiment was to optimize the utilization of nutrients from the sorghum crop residue by harvesting the leaves before plant maturity without affecting the grain yield.

MATERIALS AND METHODS

Location

A local variety of grain sorghum (SANDALA) was planted on 6th January, 1993 at the Pasture Research Center (PRC) Kongwa, Central Tanzania where the annual rainfall is between 300 mm - 900 mm. (Figure 1). The rain season is between November and May while the other months remain dry (Figure 2).

Crop establishment

Planting was done by hand hoe at a spacing of 25 cm x 80 cm for 2 plants/hill after thinning. Phosphatic fertilizer (Triple super phosphate) was applied at a rate of 125 kg/ha during planting. Thinning was done at day 30 after planting when the plants were at knee height (60 cm). This was followed by application of Sulphate of Ammonia fertilizer (150 kg N/ha).

Experimental design and sampling procedure

There were two treatments.

Treatment 1 = Stripping of all the leaves within the plant by defoliating two leaves/week starting from the bottom when 50% of the control plants were in milking stage (day 92). The stem was harvested after grain harvest (SR). Treatment 2 = Control, ie. harvesting the straw after grain harvest (WPL).

The plot sizes of 8 m x 15 m area were allocated in a randomized complete block design experiment with 4 blocks and 4 plots/block. The two treatments were randomly allocated in each of the 4 blocks. In the plot of 120 m^2 with 8 row lines of sorghum plants, the 2 outer rows and 5 hills at each end of the remaining rows were discarded leaving an effective area of 71.4 m^2 with a total number of 600 plants. Grain harvest was done on day 132, one day after the stripping of the last 9^{th} and 10^{th} leaves. Harvesting of the straw (intact) and tiller plants was done 48 days after grain harvest when the tillers were in maximum sprout. The remained plants (leftovers) from the SR were harvested in the same day. Sub-sampling was done at each time after sample collection to obtain a representative sample for chemical analysis.

Chemical analysis

This was performed to determine dry matter, ash and nitrogen according to the procedures of AOAC (1985), while fibre (NDF) fractions followed the methods of Goering and Van Soests (1970). *In vitro* organic matter digestibility (IVOMD) of the leaves, straw components (stem +leaf), thinned plants and tiller components were determined according to the Tilley and Terry (1963) methods. *In sacco* degradability of the dry matter at 0, 12, 24, 48 and 72 hours using the leaf position (1^{st} + 2^{nd}, 3^{rd} + 4^{th}, 5^{th} + 6^{th}, 7^{th} + 8^{th}, and 9^{th} + 10^{th}) and the thinned plants was performed using a fistulated steer. About 2 grams of representative grinded sample from a 3 mm mesh size were put in nylon bags of 80 mm x 15 mm (52 µm pore size) in duplicate. The grain production from each plot was determined from the weighing of air dried grains after being manually shelled.

Statistical analysis

The data were analyzed by Minitab Statistical Package, (1991) using two-way analysis of variance. Tukey's Honestly Significant Difference Test was used to compare differences in treatment means where approriate.

Analysis of variance table:

Source of variation	df
Between block	3
Between treatments	1
Interaction	3
Error	8
Total	15

RESULTS AND DISCUSSION

Quantity of fodder and grain components

The fodder and grain yield are presented in Table 1. The dry matter yield of leaves was 50 % higher when harvested before the grain harvest. Much of the lower leaves on the control plants were observed to be lost by wind shedding. However total fodder yield was not significantly affected inspite of a difference of 16 % in favour of the leaf stripping treatment. The continuous growth of tiller after grain harvest was one of the reasons. This unique characteristic of sorghum allows the stover crop to remain green and sometimes improve its nutritional composition before utilization during the dry season. Similar results were observed by Martin and Wedin, (1974) where the dry matter percentage and maximum dry matter yield of sorghum stover increased when the harvest was delayed beyond grain harvest.

Defoliation of leaves at the reproductive stages did not affect the grain yield (P>0.05) as shown in Table 1. Similar observations were found by Ogunlela and Ologunde (1985); Alhassan *et al* (1987). Trials with other cereals like maize have shown almost similar results when the leaves were defoliated at the reproductive stage (Dzowela, 1987., El-Baki *et al*, 1990., Struik, 1982b; Teyker *et al*, 1990; Shirima and Wiktorsson, (unpubl.). The quantity of the thinned plants was 0.2 tha^{-1}. Neither the quality nor quantity can be affected by any of the treatments.

Chemical composition and feeding value of leaves and straws

Earlier harvesting of the cereal plant fractions usually leads to higher feeding values than the late harvesting materials due to the lower levels of fibre fractions and higher levels of nitrogen and soluble carbohydrates in the former (Bilanski, 1990; Devendra and McLeroy 1982; Teyker *et al*, 1991; Wilkinson, 1978). Table 2 shows the chemical content of the materials harvested in this study. The CP content of the green leaves was significantly higher (P<0.05) as compared to the same leaves harvested after grain harvest (93 g CP/kg DM Vs 32 g CP/kg DM). If using the MAFF (1975) formula for calculating digestible crude protein, the CP in the stover leaves even shows a negative digestibility. The delay of harvesting the leaves affected the protein losses more than energy. Sixty-five percent of the leaf protein was lost and the total protein losses of feed residues went as high as 43 % per hectare while the energy losses were 12 % per hectare only (Table 3). The decrease in digestibility (IVOMD) of the fractions was positively correlated to the loss of protein (Table 2). The differences in digestibility of the early and late harvested leaves was 31 %. The chemical composition of different fractions within a crop or plant differ between places and environments and it is difficult to establish a clear cut feeding value for a given fodder material (Preston and Leng, 1987). For example, Alhassan *et al*, (1987) found the CP% of sorghum leaves to be > 7% and IVOMD as 66.7% while Nicholson (1984) found the IVOMD % of the leaves to be 65-78% and a CP of 3.1-5.0% (Table 4). The thinned plants in Table 5 had the highest digestibility

(IVOMD) and CP content as the plants were not matured when thinned out, the time when the level of fibre content was very small.

The leaves of the same plant differ significantly ($P<0.05$) in quantity and quality (Figure 3). The dry matter yield (DMY) of the 1^{st} to the 3^{rd} leaves were almost negligible ie. 11.5 to 22.0 $kgha^{-1}$ but increased rapidly from the 4^{th} up to the 6^{th} leaf which had the highest dry matter accumulation and then gradually declined from the 7^{th} to the 10^{th} leaf. This might be due to their role in the plant during the reproductive stage, the period when more accumulation of the DM take places (Struik, 1982b). Booting stage (at the onset of inflorescence) occurred when leaf 5, 6 and 7 are on their maximum expansion and most exposed to light sources. In Figure 4, protein content and digestibility tend to increase from leaf 2 to 5 but decline rapidly in leaf 6 then increase again from leaf 7 to 8 before declining again from the 9^{th} to the 10^{th} leaf. The decline in the 6^{th} leaf might be due to the bigger size midrib to support the most expanded lamina among the leaves in the plant. There is decline in fibre content from leaf 1 to leaf 5 which might be due to their lesser role in the plant than leaf no. 6 explained above. The midrib which is composed of heavier, less nitrogenous and fibrous tissues makes the leaf less digestible than the others.

Dry matter degradability (DMD %) of leaves

By mixing the leaves, it was not easy to see the differences (*in sacco*) in the dry matter loss (Table 6). All the leaves (1^{st} to 10^{th}) showed a potential DMD % of more than 67% at 48 hours of incubation, the values which we can consider them to be potential sources of feed for growing and productive ruminant animals (FAO, 1986). The thinned plants had the highest degradability because of the lower fibre content by the time of thinning.

Tiller production

The contributions from the green leaves and tillers were almost 41.1 % of the total fodder collection in stripped plants (Table 1), indicating that the overall quality of the fodder was slightly higher ($P>0.05$) than that from the control plant with a contribution of 39.7%. The tillers quality was higher (Table 2) with CP (g/kg DM) between 83.2 to 85.7 when compared to the straw plants. The fibre levels (NDF) had a lower value of 68.2 to 68.4 % of the DM in comparison to that of the straw with 75.8 %. The tiller production (t/ha) from Treatment 1 and 2 was not affected by any treatment method ($P<0.01$). It has been found that the tiller production in sorghum has some significant effect on the grain and green dry matter yields (Dremlyuck and Gamandii, 1986). In this case the tiller production did not affect the grain yield ($P<0.05$) (Table 2). Defoliation trials with non-cereal crops have shown the effects on the final dry matter yield of the crop. Mnzava and Msikita, (1989) in the trial with the Ethiopian mustard *Brassica carinata* A. Br.) found that the final yield of the crop increased with the defoliation rates which also prolonged the vegetative phase.

Cost of producing different fractions

The time to be used in harvesting different fractions is very important as far as labour availablity is concerned. Table 7 gives an estimate of different time used to harvest 1 ton of different fractions of sorghum fodder. Leaves need almost four times as much time as straw to harvest. However, the nutrient content from the leaves are justfiable as less supplements are required as compared to the cheap straw. The cost of harvesting 1 kg DM of green leaves was 7.15 Tanzania Shillings (TSh.) and straw 3.30 TSh./kg DM including transportation costs.

It can be concluded that the defoliation of sorghum leaves is of great benefit to the overall quality of the final crop for having higher quality of protein, digestibility and energy values. And since the defoliation was found to be non-hazardous to the grain production which is a primary objective of small holder farmers in the tropics, then it is advisable to defoliate the leaves at the milking stage preferably two leaves per week so as to optimize the higher quality fodder materials.

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REFERENCES

Alhassan, W. S., Bello, S.A. and Obilana, A. B., 1987. Yield and potential feeding value of straws of grain sorghum cultivars developed in Nigeria. Anim. Feed Sci. and Technology, 17: 4, 285-293.

Association of Official Analytical Chemists (AOAC), 1985. Official methods of analysis. 12 ed. Washington, D. C.

Bilanski, W. K.,1990. Fractionating forage plants to increase feeding efficiency. In: V. M.Salokhe and S. G.Ilangantilcke (Eds). Proc. of the International Agric. Engineering conf. and exhibition, Bangkok, Thailand, 3-6 Dec. 1990. pp. 455-463.

Devendra, C. and McLeroy, G. B., 1982. Goat and sheep production in the tropics. In: W. J. A. Payne (Ed). Intermediate tropical agriculture series. pp.178-193.

Dremlyuk, G. K. and Gamandii, V. L., 1986. Nature of the interactions between quantitative characters in sweet sorghum. Nauchno-techpicheskii-Byutten: No.1, 24-27.

Dzowela, B. H., 1987. Efforts to enhance maize stover utilization for smallholder livestock producers in Malawi.In: Utilization of agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi. (Eds: D. A. Little, A.N.Said, J. A. Kategilc, S. Sibanda, M. A. Naga and M. Y.Nuwanyakpa). ARNAB/ILCA pp. 27-36.

El-Baki, S.M.A., Nowar, M. S., Hassona, E.M., Soliman, I.,Ghanem, H. M.and Gad-Alla, S. A., 1990. Evaluation and utilization of corn stover fodder and its silage by sheep. Proc. of the 3rd Egyptian British conf. on animals, fish and poultry production, 7-10 Oct. 1989, Alexandria, Egypt. pp. 169-175.

FAO (Food and Agriculture Organization of the United Nations). 1986. Better Utilization of Crop Residues and By-products in Animal Feeding: Research Guidelines. 2. A practical manual for research workers. (Prepared by T. R. Preston). In: FAO Animal Production and Health paper 50/2, Rome.

Goering, H.K. and Van Soest, P.J.; 1970. Forage fibre analysis. U.S.D.A. Agricultural handbook No. 379, pp. 1-20.

MAFF (Ministry of Agriculture, Fisheries and Food), 1975. Energy allowances and feeding systems for ruminants. MAF technical Bulletin No.33, HMSO London.

Martin, N. P. and Wedin, W.F., 1974. Effect of fall weathering on yield and composition of grain sorghum stover. Agron. J. Vol.66 (5), 669-672.

MINITAB Release version 8., 1991. Minitab Inc.Birmingham.

Mnzava, N. A. and Msikita, W. W., 1988. Leaf yield response of Ethiopian mustard (*Brassica carinata* A.Br.) selections to defoliation regimes. Acta-Horticulturae. No. 218, 77-82.

Nicholson, J.W.G., 1984. Digestibility, nutritive value and feed intake. Straw and other fibrous by-products as feed (Eds: F.Sundstol and E. C. Owen). Elsevier, Amsterdam.pp.340-372.

Ogunlela, V.B. and Ologunde, O. O., 1985. Some aspects of yield-leaf area relationships in grain sorghum. Zeitschrift-fur-Acker-und-Pflanzenbau 154: 2, pp. 104-111.

Preston, T.R. and Leng, R.A., 1987. Matching ruminant production systems with available resources in the tropics and sub-tropics. Armidale, Australia.

Shirima, E.J.M. and Wiktorsson, H., (unpubl.). Utilization of maize leaves and tops prior to harvesting as fodder for livestock.

Struik, P. C., 1982b. Production pattern, chemical composition and digestibility of forage maize *(Zea mays* L.). Mededeling no.64, Agric. Univ. Wageningen, Netherlands. pp.1-28.

Teyker, R.H., Moll, R.H. and Jackson, W. A., 1991. Differences among prolific maize hybrids in the effects of lower leaf removal. In:Maydica 36 (1991) : pp.1-10.

Theander, O and Aman, P., 1984. Anatomical and chemical characteristics. In: Straw and other fibrous by-products as feed (Eds: F. Sundstol and E. C. Owen). Elsevier, Amsterdam. pp. 45-78.

Tilley, J.M.A. and Terry, R.A., 1963. A two stage technique for in vitro digestion of forage crops. J. Br. Grassld. Soc., 18, 104-111,

Wilkinson, J.M., 1978. The ensiling of forage maize. Effects on composition and nutritive value. In: E. S. Bunting, B. F. Pain, R. H. Phipps, J. M. Wilkinson and R.E. Gunn (Eds). Forage maize: Production and utilization. Agric. Research Council, London. pp. 200-237.

Table 1: Grain and dry matter yields (DMY) (t/ha) of stripped and unstripped sorghum plants.

	Stripped plants	Control plants	SEM	P-value
	Mean	Mean		
Leaf DMY[a]	0.72	0.48	0.00	0.000
Left over(DMY)[b]	1.29	1.11	0.18	0.267
Tiller crop (DMY)[c]	0.18	0.25	0.04	0.238
Total fodder[d]	2.19	1.84	0.20	0.180
Grain yield	1.50	1.49	0.12	0.966

[a] :Defoliated leaves
[b] :Straw harvested after grain harvest (after stripped in T1 and intact plants in T2)
[c] :Tiller production after grain harvest
[d] :Cumulative DMY of [a] + [b] + [c]

Table 2: Dry matter, chemical composition and *in vitro* organic matter digestibility of sorghum plant materials.

	Stripped plants			Control		
	Green stripped leaves[a]	Tiller plant	Left over	Stripped leaves[d]	Tiller plant[e]	Intact straw[f]
DM %	36.8	33.2	51	39.7	31.6	44.6
Comp. g/kgDM						
CP	92.5	85.7	34	32.3	83.2	36.0
ASH	136.3	98.2	105	119.6	98.7	99.7
NDF	626.5	681.7	763	732.8	684.1	758.2
OM	863.7	901.8	895	880.4	901.3	900.3
IVOMD %	79.0	61.5	57	59.6	55.6	52.9

Table 3: Protein and energy production from different fractions of sorghum harvested at different stages of plant growth.

	Stripped plants			Control		
	Green stripped leaves	Tiller plant	Left over	Dry stripped leaves	Tiller plant	Intact straw
CP $kgha^{-1}$	66.6	15.4	41.0	15.7	20.8	34.2*
Total CP $kgha^{-1}$			123.0			70.7
ME MJ/kgDM	11.4	8.9	8.2	7.8	8.0	7.6
Total ME MJ $x10^3$	8.2	1.6	10.5	3.8	2.0	12.1*
Total ME/ha^{-1}			20.3			17.9

* Highly significant (P<0.001)

Table 4: Range of chemical composition of sorghum fractions.

	In vitro OMD %	CP as % DM	Reference
Leaf	65 - 78	3.1-5.0	Nicholson, 1984
Leaf	66.7	> 7	Al-hassan et al 1987

Table 5: Chemical composition of thinned sorghum plants

Component	Mean	SEM
Composition g/kgDM		
CP	130.2	0.35
ASH	128.6	0.26
Digestibility %		
IVOMD	85.1	1.18
DOMD	77.1	1.08
Energy		
ME MJ/kgDM	12.3	0.17
ME MJ/ha ($x10^3$)	2.5	1.15

Table 6: Dry matter disappearance (DMD %) of sorghum leaves and thinned plants at different incubation time.

Leaf #	Incubation time (hours)				
	0	12	24	48	72
1st + 2nd	19.4	43.4	56.6	67.7	71.0
3rd + 4th	20.3	46.0	59.2	69.3	71.9
5th + 6th	20.5	46.7	59.2	68.0	70.0
7th + 8th	24.0	44.8	57.4	69.5	73.5
9th + 10th	23.7	49.3	61.4	69.8	71.7
Thinned plants	20.9	52.4	67.7	78.6	81.1

Key: Leaf counting from the bottom

Table 7: Time spent to harvest 1 ton of green sorghum leaves and straw.

	Sorghum leaves	Sorghum straw
Hours/ton		
Harvest	163	38

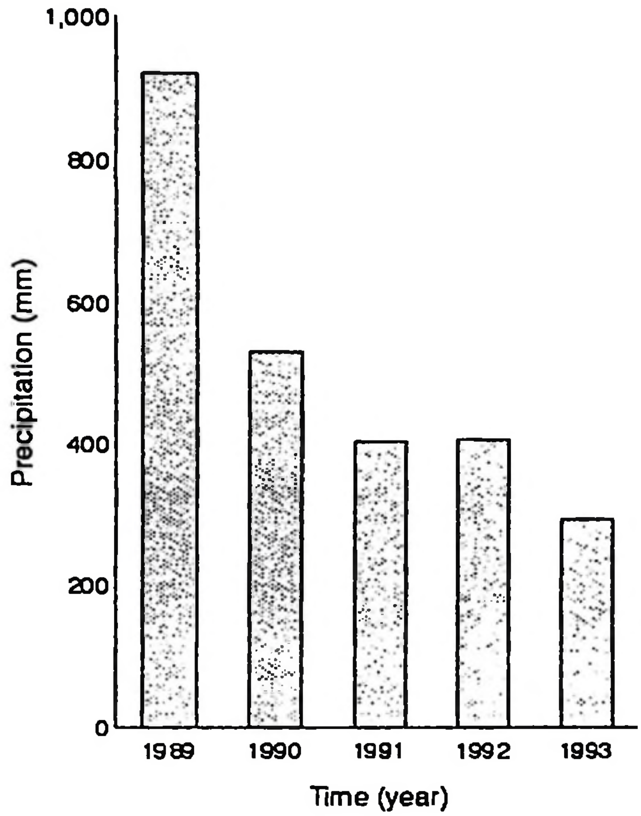

Figure 1: Annual rainfall (mm) from 1989 to 1993
at PRC Kongwa, Tanzania

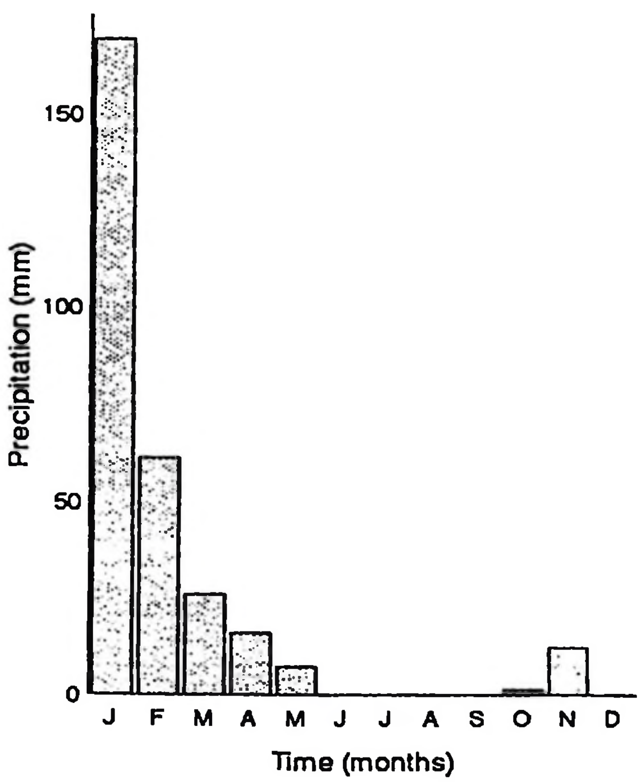

Figure 2: Monthly rainfall (mm) distribution for 1993
at PRC Kongwa, Tanzania

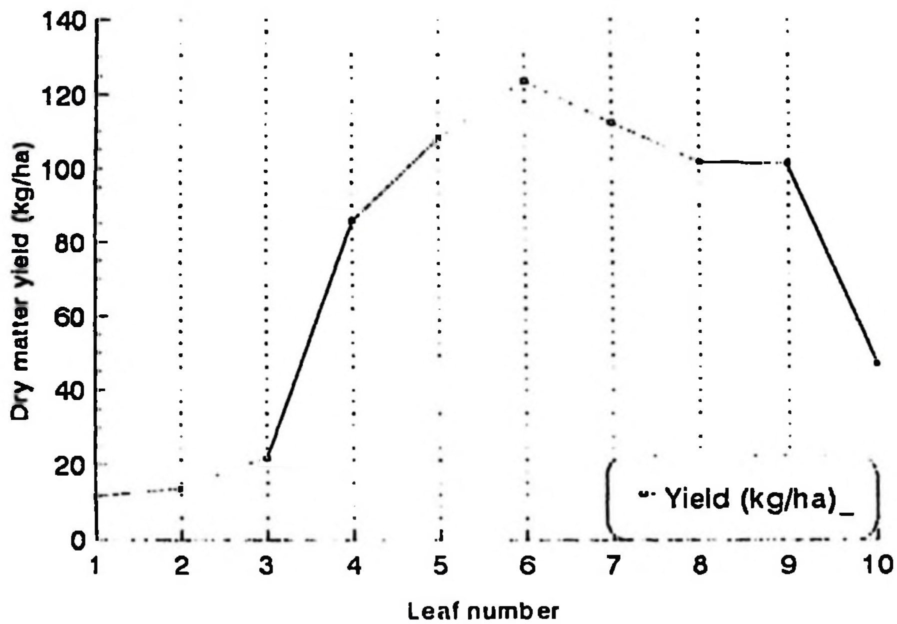

Figure 3: DM yield (kg/ha) of sorghum leaves harvested before grain maturity

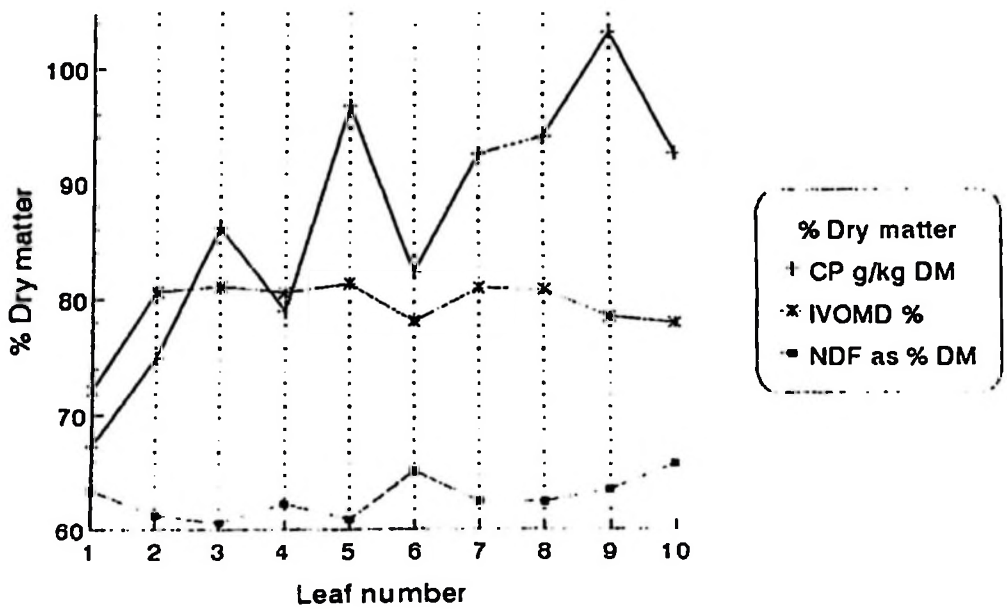

Figure 4: Crude protein, NDF and IVOMD of sorghum leaves harvested before grain maturity

III

INTAKE AND DIESTIBILITY OF DIFFERENT MAIZE PLANT MORPHOLOGICAL FRACTIONS IN BLACK HEAD PERSIAN SHEEP

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ABSTRACT
The late harvesting of agro-byproducts in the tropics reduces their feeding value to ruminants due to high levels of fibers, low protein and soluble carbohydrates content. Earlier harvesting at silking stage of the stripping (SR) and toppings (TP) of the maize plant morphological fractions was superior to the stover (WPL) in terms of acceptability and digestibility in sheep. Both intake and digestibility of the dry matter and organic matter were in the order of SR > TP > WPL ($P<0.05$). The SR intake (850.3 g/day)was more than twice that of the WPL (360.6 g/day). The feed intake accounted for 68.5 %, 48.4 % and 28.7 % of the total feed offered as SR, TP and WPL, respectively. Crude protein digestibility (DCP) was negative in WPL but with supplementation both dry matter digestibility and DCP were improved ($P<0.05$). Earlier harvesting reduces the field losses by more than 50 %. Therefore, the best way of optimizing the quality from different maize vegetative fractions without affecting the grain yield is to defoliate them at silking stage, thus alleviating the dry season feed shortage.

Key words: Silking stage, morphological fractions, defoliation, feeding value.

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INTRODUCTION

In crop-livestock interaction systems where a majority of small holders operate, the use of crop by-products and kitchen waste to feed animals is yet to be maximized. The limitations to use the residues include, among others, the bulky nature and the time of utilization (Owen and Jayasuriya, 1989). The last point is more serious as at this time the residues have very poor feeding quality due to the higher cell wall materials and low protein and mineral levels (Preston and Murgueitio, 1992; Ørskov, 1993). Since they are indigestible and unpalatable, chemical treatment and self selection by offering extra feed of up to 50% to increase intake and selectivity have been attempted (Owen and Kategile, 1984., Preston and Leng, 1987; Preston and Murgueitio, 1992). The high prices of the chemicals and the ambient temperatures in the tropics limit the extensive use of these techniques (Ørskov, 1993).

For sustainable livestock production systems, initiatives have been made to ensure that the farming systems continue to operate using the resources within the reach of the farmers (Amir and Knipscheer, 1989., Preston and Leng, 1987; Preston and Murgeitio, 1992). A farmer growing maize and keeping a few cows for example, can maximize the maize field to provide grain and green fodder of high quality which can be used in the dry season. When the residues are unlimited, he can feed them with minimal supplementation and the rejected materials which are more lignified and dried can be used for other purposes such as fuel, bedding and building.

The present study will discuss the differences in intake and digestibility of maize plant morphological fractions harvested before and after grain harvest.

MATERIALS AND METHODS

Nine Black Head Persian (BHP) male sheep (rams) weighing between 29 to 37 kg live weight with the mean 32.78 $\pm$1.02 standard error were used at the Livestock Production and Research Institute, Mpwapwa Tanzania. A complete randomized block design experiment was used where animals were grouped into three blocks according to their weight ie. heaviest, medium and lightest each with 3 sheep. The three sheep within a block were randomized to one of the treatments.

The experimental period lasted for 42 days with the first 21 days as the adaptation for the diet, followed by a 21-day collection period. The first 7 days of this period were used to study intake of the experimental diet alone while the remaining 14 days were used to study both intake and digestibility responses.

Feeds and feeding procedure:

The collection of the test diets was carried out in two phases, one before and the second after the grain harvest. Before grain harvest, stripping of the lower leaves up to the cob (SR) for diet 1 was done between day 60 to 81 after planting. At day 60, 50 % of the control plot plants had shown dry silk ie. commencement of the physiological maturity of the grain. Topping (TP) ie. diet 2, was done at day 81. The green materials were shade dried and stored under the same conditions to maintain the green coloration until the feeding period. For diet 3, the stover (WPL) was harvested within a week after grain harvest (day 165).

The quality and quantity comparison of some stover components were also divided into leaves, tops and other fractions (lower stem, sheath, cob, husk). These samples were not used in the intake and digestibility studies.

The procedure for feeding the animals was based on the NRC (1985) recommendations. They were offered basal rations of 30% of body weight with dry matter intake (DMI) of 1.3 kg DM with 70% and 30% basal and supplement diets respectively. The feeds were adequate to supply 10 % crude protein in dry matter per day. Basal diets (maize vegetative fractions) were provided *ad libitum* with 50 % surplus over expected intakes to allow selection. The composition of the rations fed (g DM/day) were: SR = 1241 gm of leaves + 351 gm supplement, TP = 1258 gm tops + 351 gm supplement and WPL= 1255 gm stover + 351 gm supplement. The forages were chopped by hand sickle before feeding. The supplement (88.4% maize bran + 11.6 % sunflower cake) were fed once every morning before giving the test diets. These diets were portioned and fed thrice a day ie. at 08.00, 13.00 and 18.00 hours. Fresh water and mineral lick were provided ad libitum throughout the experimental period.

Refusal and faeces collection

Refusals were collected, weighed and sampled every day (based on aliquot). Later on these were analyzed for proximate after pooling based on total weekly collections. The faeces collection was done every morning before feeding using harnessed faeces-collection bags. The faeces were stored in a deep freezer (-5°C) and bulked weekly for further analysis. The sheep were harnessed with the bags 10 days before the actual collection. Feed used, refusals and faecal samples were sub-sampled and processed for proximate analysis (DM, Ash and CP) according to the procedures of AOAC, (1985) . The NDF was determined according to the methods of Goering and Van Soest, (1970).

RESULTS AND DISCUSSION

Table 1 shows the differences in quality of the similar fractions harvested at different stages of plant maturity ($P<0.05$). Those harvested late in the season had low digestibility (IVOMD) and lower crude protein (g/kg DM) and higher fibre levels indicating that they become more lignified. The late harvested toppings and the stover whole plant (intact) fractions were most affected as the more nutritious parts, the leaves, were already shed out. The contribution of the leaves to the total vegetative biomass at the time of harvest was twice as much as if they were harvested later in the season. The late harvest resulted in a more stemy fodder (66.5 %) indicating more leaf losses. Within the same plant, the digestibility varies within the different fractions at any one particular time due to the differences in the cell wall contents in tissues (Struik, 1982b). Early harvesting of the fractions without affecting the grain yield had been found to be advantageous in quality and quantity as it increases the feeding value of the stover due to less leaching and field losses (Devendra and McLeroy, 1982.; Dzowela, 1987.; Mowat and Wilton, 1984.; Struik, 1985.; Struik and Deinum, 1982.; Wilkinson, 1978.).

Dry matter intake (DMI g/day) for different fractions differs significantly ($P<0.05$) with the proportion of the leaf quantity (Table 2). Stripping (SR) had the highest proportion (100 %) of leaves and it was the highest in dry matter intake (850.3 g DM/day), the value which is more than double that of stover (360.6 g DM/day). The maize fodder from SR, TP and WPL accounted for 68.5 %, 48.4 and 28.7 % of the total feed offered, respectively. Although the leaves had the highest CP (108.1 g/kg DM), it is not worthwhile to conclude that they can support the ruminant animal's requirement for maintenance and higher rate of production. Nitrogen supplementation is still inevitable for an optimal microbial environment in the rumen. However, the amount of supplement to be added would be minimal as compared to the WPL with the negative DCP. The digestibility (*in vivo*) of the different diets was relatively smaller when compared to the value obtained from *in vitro* value. This might be attributed to the supplementation effect (Table 3). However, the *in vivo* values in all cases differ significantly between one to thirteen units.

Also, it can be seen that the CP (g/kg DM) from the faeces (17.5) was higher than that of the forage (11.8) for the WPL indicating that the excess was from the metabolic origin. It was easier to identify the excess amount as the stover does not meet the maintenance requirement. The digestible crude protein (DCP) of the WPL alone was negative meaning that the use of stover alone without supplementation will not meet the CP requirement of the animals.

There is also a correlation of the fractional quality with organic matter digestibility (Table 4). Wilkinson (1978) found that the voluntary intake of maize silage by cattle is influenced by the dry matter content which also influenced the stage of fractional harvest. The intake was higher when the DM content was between 20-35 % and decreased at 35-40 % due to the decrease of soluble carbohydrates and nitrogen. The earlier harvested fractions (stripping and toppings) had the highest intake and DMD with the least refusal in the following order SR >TP > WPL for intake and DMD and SR< TP < WPL for the refusals.The low intake was attributed to various factors which include the long retention time and the volume imposed in the rumen (Chesson and Orskov, 1984; Owen and Kategile, 1984; Preston and Leng, 1987).

In the tropics however where the quantity of residues are not an issue, the efficient use of crop residues to maximize intake and digestibility and timely harvesting of the residues is most recommended (Komwihangilo and Shirima, 1993 Unpubl. paper). The techniques of optimizing the plant morphological fractions from different cereal crops for animal feeding should also be done in different agro-ecological zones, different cereal crop varieties and different management systems like inter-cropping and alley-cropping.

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REFERENCES

Association of Official Analytical Chemists (AOAC), 1985. Official methods of analysis. 12 ed. Washington, D. C.

Amir, P. and Knipscheer, H. C. 1989. Conducting on-farm research:Procedures and economic analysis Chpt. 2. Winrock International, USA. Chesson, A. and Orskov, E. R., 1984. Microbial degradation in the digestive tract. In: Straw and other fibrous by-products as feed (Eds: F. Sundstol and E. Owen). Elsevier Publishing Company Inc., New York. pp. 305-339.

Devendra, C and McLeroy, G. B., 1982. Goat and sheep production in the tropics. In: Intermediate Tropical Agriculture series (Ed: W.J.A, Payne).

Dzowela, B. H., 1987. Efforts to enhance maize stover utilization for small holder livestock producers in Malawi. In:Utilization of Agricultural by-products as livestock feeds in Africa. Proc. Blantyre, Malawi.(Eds: D. A. Little and A. N. Said) ARNAB/ILCA PP.27-36.

Goering, H.K. and Van Soest, P.J., 1970. Forage fibre analysis. U.S.D.A. Agricultural handbook No. 379; pp1-20.

Komwihangilo, D. N. and Shirima, E. J. M. (unpub.). Utilization of crop residues, multipurpose trees and shrubs to increase milk production in semi-arid, Central Tanzania. Paper presented at the first biennial workshop of cattle research network, ILCA, Addis Ababa, Ethiopia, 17-21 May,1993.

Mowat, D. N. and Wilton, B., 1984. Whole crop harvesting, separation and utilization. In: Straw and other fibrous by-products as feed (Eds: F. Sundstol and E. Owen). Elsevier Publishing Company Inc., New York. pp. 293-304.

National Research Council (NRC), 1985. Ruminant nitrogen usage. National Academy Press. Washington, D. C.

Owen, E. and Kategile, J. A., 1984. Straw in practical rations for sheep and goats. In: Straw and other fibrous by-products as feed (Eds: F. Sundstol andE. Owen). Elsevier Publishing Company Inc., New York.

Owen, E. and Jayasuriya, M. C. N., 1989. Use of crop residues as animal feeds in developing countries. A review. Research and Development in Agriculture, 6, 3, pp. 129-138.

Orskov, E. R., 1993. Reality in rural development aid with emphasis on livestock. Rowett Research Service, Ltd., Aberdeen, pp. 31-36.

Preston, T. R. and Leng, R. A., 1987. Matching ruminant production systems with available resources in the tropics and sub-tropics, Armidale, Australia, pp. 93-102.

Preston, T. R. Murgueitio, E. 1992. Strategy for sustainable livestock production in the tropics. CIPAV, CONDRIT, Cali, Colombia, pp.69-80.

Struik, P. C. 1982b. Production pattern, chemical composition and digestibility of forage maize (*Zea mays* L). Mededeling no. 64, Agric. Univ. Wageningen, pp. 1-28.

Struik, P. C., 1983a. The effect of switches in photoperiod on crop morphology, production pattern and quality of forage maize (*Zea mays* L.) under field conditions. Mededelingen Landbouwhogeschool Wageningen 83-2, 22pp.

Struik, P. C. 1985. Digestibility of plant fractions from different genotypes and predictability of quality of forage maize in northwest Europe. Neth. J. agric. Sci. 33 (1985) pp. 56-58.

Struik, P. C. and Deinum, B. 1982. Effects of light intensity after flowering on the productivity and quality od silage maize. Neth. J. agric. Sci., 30:297-316.

Wilkinson, J.M., 1978. The ensiling of forage maize: Effects on composition and nutritive value. In:Forage maize production and utilization (Eds: E.S. Bunting, F. Pain, R. H. Phipps, J.M. Wilkinson and R.E. Gunn). Agric. Res. council, London, pp. 200-237.

TABLES AND FIGURES

Table 1: Quality of maize plant morphological fractions harvested in early (E) and late (L) seasons.

	Stripping		Topping		Others[a]			Whole plant[b]
	E (SR)	L	E (TP)	L	E	L		L (WPL)
% of total biomass	21.7	8.5	12.7	25.0	50.1	66.5	-	100.0
DM %	27.3	83.0	42.0	84.0	33.0	84.0	-	86.2
NDF %	63.2	65.4	73.5	77.5	66.1	82.8	-	79.6
CP (g/kg DM)	108.1	48.7	68.4	48.5	108.2	19.1	-	32.8
Ash (g/kg DM)	136.4	130.5	81.3	83.0	77.4	76.9	-	55.4
IVOMD %	75.3	69.3	63.7	60.9	75.3	52.3	-	51.7

[a] : lower stem, sheath, cob, husk
[b] : Excluding grain

Table 2: Intake and digestibility of dry matter and crude protein in different maize fractions fed in BHP sheep.

	Fractions				
	SR	TP	WPL	SEM	P-value
DM intake (g/day)					
Maize foliage alone	850.3	608.6	360.6	19.1	0.00
Maize bran	310.0	310.0	310.0		
Sunflower cake	41.0	41.0	41.0		
Total intake (g/day)	1201.0	959.6	711.6		
Faecal DMW (g/day)	546.3	443.1	349.7	22.2	0.00
Digestibility of DM (%) (exlc. suppl.)	50.4	48.0	38.0		
Digestibility of DM (%) (incl. suppl.)	54.5	53.8	51.0	1.9	0.33
CP in DM fed (g/day)					
CP from foliage	91.9	41.6	11.8	1.2	0.00
CP in supplement	35.1	35.1	35.1		
Total CP intake	127.0	76.0	46.9	1.2	0.00
Faecal CP (g/day)					
CP from foliage	45.3	31.1	17.5	2.5	0.00
CP from suppl.	11.3	11.3	11.3		
Total CP in faeces	56.6	42.4	28.8		
DCP in foliage	50.7	25.2	48.5	10.3	0.00
Total DCP (foliage + suppl.)	55.4	44.7	38.6	2.9	0.00

Table 3: Composition and estimated digestibility of supplements used to feed sheep

		g/kg DM			
	DM %	CP	Ash	DCP[a]	DMD[b]
Maize bran	92.0	90.0	52.0	59.4	65.0
Sunflower cake	93.8	175.0	50.0	131.2	60.0

Table 4: Correlations between quality at harvest of forage maize and organic matter digestibility (OMD) %.

Criteria	No. of obs.	Correlation with OMD invivo	F-value
Crude Protein (CP) % DM	122	0.032	NS
Crude Fibre (CF) % DM	122	0.457	***
CP, CP	122	0.485	***
DM content, CP, CP	122	0.500	***
Ear %	115	0.540	***
DM %, Ear %, CP %, CF%	115	0.610	***

Source : Wilkinson, 1978
NS : Not significant
***: Highly significant

IV

CROP RESIDUE UTILIZATION BASED ON CEREAL STOVERS IN CENTRAL TANZANIA.

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ABSTRACT

A village survey was conducted in Berege village, central Tanzania and Kilimanjaro region in Tanzania. The utilization of different crop residues in Kilimanjaro region was found to be the most successful especially the early defoliation of maize leaves and tops before grain maturity. The stored fodder materials are used in the dry season with higher nutritive values than that left in the fields. Although the cultivated land area was bigger in Berege, the dry season feed shortage remained unsolved. A new approach must be found in the area to utilize the enormous crop residue losses during the wet season for dry season feeding.

Key words: Village survey, crop residues, defoliation of maize leaves, nutritive value

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INTRODUCTION

The majority of the inhabitants in central Tanzania are agro-pastoralists who depend mainly on agriculture for subsistence, but maintain herds of cattle and small stalk for social, capital and security purposes. The livestock also supply manure and protein in many households (Christiansson *et al*, 1991). The area is occupied by 20 % of the human population and the majority of the livestock in the country (MALD, 1988). The area is now characterized by a low carrying capacity and is overstocked and badly eroded. Insufficient water supply and dwindling fuelwood remain unsolved problems at the moment. For the past 15 years, animals have been evicted in some areas which were thought to be the most eroded like Berege village which has then been left with very few animals for immediate slaughter and draught-power. A maximum of 4 animals per household was allowed within this area. Recently, the reintroduction of improved genetical breeds of cattle developed in Tanzania (Mpwapwa breed) was done in an attempt to compensate for evicted stock. The breed utilizes the available resources better and is more productive than the indigenous Tanzania Shorthorn Zebu (TSZ) breeds (Kasonta and Mkonyi, 1991). The introduction of breeds also created a necessity of management improvement especially as far as feeding, breeding and housing are concerned. Feeding constraints are caused by the poor quality crop residues and natural pasture during the dry season for over 8 months a year. A development intervention in the area, which means a deliberate, well-thought out action from outside to improve or develop the system is necessary (Beets, 1990). Therefore, collection and conservation of crop residues before and after grain harvest could be one of the alternatives to increase the quality and quantity of crop residues to be used in the long dry season.

Therefore the present study aimed at looking at the availablity and the relationship between the forage quality changes in two different ecological zones and animal performance (growth and milk yield) during the dry season. It also considered the knowledge of the farmers of the utilization of the crop residues from the intensive area of Kilimanjaro region and if they can be adopted in the semi-intensive area of Berege village in Dodoma region.

MATERIALS AND METHODS.

Locations:

a)Berege village in Dodoma region is in the semi-arid part of the country with annual precipitation of 400 to 600 mm and with more than 8 dry months. The wet season commences in mid-December and lasts until April.

b)Four villages in the Kilimanjaro region, Tanzania, two of them with a low density population (650/km^2) and the other two with a high density (2000/km^2) were selected. The former occupy a maize/banana zone while the latter a coffee/banana belt. The maize/banana zone is located at medium to low altitudes below Mount Kilimanjaro (850 metres a.s.l. and below), while the banana/coffee zone at 850 to 2000 metres a.s.l. Bi-modal rains range between 800-1200 mm and 1200-2100 mm in the maize/banana and coffee/banana zones, respectively (Laurent and Centres, 1990).

A great number of families from the coffee/banana zone walk every morning to the lowlands to cultivate maize, beans and finger millet. This means they keep very few animals while those who stay permanently in the lowlands keep a bigger stock. At present, the scarcity of land is the most acute problem the people of Kilimanjaro area are facing.

Selection of farmers

Ten farmers in Berege village owning improved dairy animals from Mpwapwa breed and 8 farmers from Kilimanjaro, 2 from each of the 4 villages were selected. The data collection was also based on the household of one wife who owned improved Friesian, Jersey or Ayshire dairy breed cows crossed with the local zebu breeds.

Questionnaire administration

A questionnaire was prepared and administered to the farmers by the time of the first visit. The villages in Kilimanjaro were visited twice (January and October) and those in Berege were visited twice a month. The components of the questionnaire included:

a)Village survey on feed supply.

Through the questionnaire administration, visual assessment and sample collection, the following parameters were looked at:-

i) Survey of feed quantity:

The quantity of feeds were recorded by spring balances. The feeds were from the agricultural lands (cultivated fodder, weeds, crop residues, brans and cakes), common lands (forests, natural vegetation and roadside) and those feeds obtained around the homesteads (tree leaves, weeds, established fodder banks and vegetable wastes like banana pseudostems).

ii)Quality evaluation of feeds.

This was done in Berege village only where the quality changes of the feeds were evaluated from the commencement of the dry season (June) to mid-dry season (October). Various feed samples mainly from cereal residues were collected from the farmers fields at intervals of two weeks and sent to Mpwapwa nutrition laboratory for nitrogen, fibre and digestibility analysis.

iii)Survey of feed supply.

Seasonal feed supply was done by taking the two dominant feeds for each month through questionnaire and visual assessments.

b) Crop production.
The questionnaire included information on the farm size, crop types (mixed or monocropping), method and time of utilization, proprietor of the residues, distance from field to the homestead and other uses.

c) Livestock production system.
This included number of livestock per household, type and class of animals, main sources of feed, liveweight measurement of cattle every second week from June to October (Berege only) and constraints to production. Animals were weighed by a weigh bridge installed in the village by LPRI Mpwapwa.

d) Technological transfer (Kilimanjaro only)
Eight women from the low density population villages were involved in harvesting of leaves below and tops above the maize ears from a $10m^2$ plot planted with maize only. The feed was conserved under tree shade where the following were recorded:-
i)Fresh weights at harvest (February) and dry weights in October.
ii)Time spent to harvest the fodder from the $10m^2$ plot.

RESULTS AND DISCUSSION

a) Fodder production in Berege village and Kilimanjaro region.
Table 1 shows the size of the farms, grain and feed supply in the study area. More millet is cultivated than the other cereals in Berege village because farmers believed that millet is the most drought resistant of all the cereals in the area. In this case, almost every household cultivates millet in addition to other crops like sorghum or maize. This is one way, as pointed out by Chambers (1991), in which poor people tend to multiply their enterprises to raise their income and reduce risk.

Of all the cereals, sorghum produces most stover (3.8 t/ha). This could be the tiller production after the grain harvest and agronomically, it is the most resistant of all the cereals in the area. Other sources of feed like *Acacia* pods, water-melon and by-products from the artisan extractions of locally made oils and flour are important as protein sources to the ruminants in the area. For example, water-melon in this case are very important as a good source of drinking water and protein from their seeds and *Acacia* pods as protein supplement to animals in the area (Shayo, 1992).

Less amount of fodder production was observed in Kilimanjaro than in Berege because of the soil variations, cultural practices and the crop varieties used (Table 2). Comparing the farm size in Berege and those from the Kilimanjaro region (Table 3), the farm sizes in the latter are smaller forming the major constraint to livestock and crop production (Laurent and Centres, 1990).

b) Household structure
From the observations of farm activities at Berege, the labor contribution from men and women in the households is similar to each other (Figure 1). From the figures, it can be seen that women spent slightly more time in farming than men. Figure 2 gives the overall annual contribution of labor where women contribute 47.6 % and men 40 % of the major activities. Men in Berege care for animals for more than 3 hours per day while their counterparts in Kilimanjaro care less than 2.5 hours per day. Most of the productive activities related to cattle are done by women in the Kilimanjaro region. These activities include, among others, milking, feeding, carrying fodder, cleaning sheds etc. Also for other farming activities, women contribute considerably more than the men in Kilimanjaro region (Figure 2). Men only occasionally assist as they mainly deal with outside activities like the sale of crops and purchase of inputs. They are also the incharge of income. According to Beets (1990), there are three crop husbandry techniques when dealing with any intervention. These involve a well-known proven and already widely used technique. The second technique is the one known in some areas but not in others. The defoliation technique falls under this category as it is well known to many farmers in Kilimanjaro and unknown in Berege village. The last technique is the one which is unknown to many farmers and it needs more research. Improvement of post-harvest techniques of cereal forage conservation is needed in both study areas. The introduction of new techniques of harvesting cereal forages in Berege village could be accepted beyond reasonable doubt.

c) Livestock production systems in Berege and Kilimanjaro regions
Due to the soil conservation program in Dodoma region, Central Tanzania, farmers are not allowed to keep more than four dairy animals and these animals should be stall fed or tethered in the crop fields. According to the by-laws made by the soil conservation program in the region (HADO : Hifadhi ardhi Dodoma), if the animals are left free grazing in the crop field they should not be allowed to move further than 50 m from the homesteads. Table 4 gives a comparison of the average number of animals per household in the study areas. From the mean values of cattle population, it can be seen that the number of cows per household in Kilimajaro was 2 while in Berege this was one despite the bigger amounts of land in the latter. This proves how land is extensively used. Milk production in Kilimanjaro was almost twice that of Berege due to the difference in breed and environment.

d) Animal feed distribution
Soon after the first rains, the weed and natural green pasture from uncultivated land dominates the feed availability to the animals. This dominance persists from January to March (Figure 4). The improved pasture (cultivated) is preserved as standing hay for the peak dry season feeding (October to December). From the rainfall pattern including in the figure, the rains stop in May up to November. During this period, crop residues mainly from cereals (sorghum, millet and maize) and the natural

pasture become the main sources of feed. The dependence on crop residue is almost 100 % right after grain harvest in April to June. Due to the tillering ability of sorghum, the animals also get almost 25 % of their feed from tiller (ratoon crop) from sorghum in September. Twenty-five percent also comes from the groundnut haulms. The groundnuts are harvested in April and stored and dried unshelled until the time of the year when the demand for groundnut seed is higher from external sources especially from the capital city, Dar-es-Salaam. At this time, farmers get a slightly higher price for the groundnuts.

The annual distribution of feeds in Kilimanjaro region is more evenly distributed than Berege village as the former receives bimodal rains. Crop residues from the maize origin (stripping, toppings, thinned plants and stover) are used evenly almost throughout the year except in April (Figure 5). The main reason is, firstly the nature of rainfall which allows two cropping seasons for maize and secondly, the already existing system of storing the by-products for dry season feeding.

The overall annual contributions from different feed resources in Berege village and Kilimanjaro region is shown in Figure 6 and 8 respectively. Cereal crop residues in the former account for almost 42 % while 39 % in the latter comes from maize by-products alone. In Berege, the poor feed resources from the dried pasture and weed contribute more than 56 % of the annual total feed while they contribute only 28 % in the Kilimanjaro region. When necessary, supplementation of low quality feeds is done in Kilimanjaro as the milk prices are high (Laurent and Centres, 1990). The authors found that weeds and pasture contribute more than 45 % of the total feed requirement while 39 % of the bran and other supplements come from homemade artisan extraction from sunflower and cotton cake. Figure 7, shows a hypothetical profile of crop residues and pasture availability in Berege village. By combining the contribution of pasture and weeds, the profile tells us that much can be done to decrease the dependence on natural pasture and increase the dependence on crop residues. If the residues are efficiently utilized, this could even cover up to 70 % of the total feed requirement as it is in Kilimanjaro where 72 % comes from crop residues including maize plant components (39 %), banana fractions (10 %) and other sources (23.4%) (Figure 8). The residues though they lose some of their the feeding value, are better than standing hay and it is more possible to manipulate the residues in terms of labor and costs than hay or silage production from pasture.

g) Animal performance during the dry season

Figure 9 and 10 show animal liveweight changes in growing and adult animals respectively. The trend of forage (cereal residues and pasture) quality changes are also shown in the same graphs. All the groups lost weight from September as the decrease of protein and increase of fibre content in forages advanced. It is also the period when water shortage is critical in the village. Mortality cases due to body weakness were reported especially among the calves.

h) Cost of producing maize fractions

One hectare of land can be harvested in at least 9 days by an adult person in the Kilimanjaro region (Table 5). This means that, the cost of harvest is 2250 Tanzania Shillings (TSh.) assuming minimum daily payment of 250 TSh. The amount of maize fodder reported in Table 5, ie. 2.0 ton per hectare, can be harvested in 9 days @ 250 TSh. If another 2250 TSh. are added as the cost of transportation of the fodder near to the homesteads, then overall costs for a kilogram of maize feed fraction would be 2 TSh. This is far cheaper than the pasture bought from the roadside verges. The bought fodder is carried uphill as much as several kilometers to homesteads. The observations made by this author found that a kilogram of fresh grass from the roadside was sold at a minimum of 15 TSh. per kilogram during 1993 excluding transportation costs. This condition also forced some farmers to look to some alternatives of preserving the maize foliage during the peak production period.

CONCLUSION

The utilization of crop residues existed in Berege could be improved through proper management of green crop residues through the intervention of harvesting and storage techniques. As they have a lower number of animals kept under a stall feeding system as compared to Kilimanjaro, less amount of residues are needed and since the land is not a constraint, the by-products could be collected as much as labor availability allows. The shortage of nitrogen source feeds in the area can be solved by planting multi-purpose trees like *Leucaena Spp.* which will also provide fuelwood. The improvement of the *Acacia Spp.* which is a potential for its pods and water-melons for their nitrogen supply were mentioned elsewhere. More information about intercropping with cereal forages is still needed however.

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REFERENCE

Beets, W. C., 1990. Raising and sustaining productivity of smallholder farming system in the tropics. Alkmaar, Holland pp. 738.

Christiansson, C.; Kikula, I. S and Ostberg, W., 1991. Man-land interrelations in semi-arid Tanzania. A multi-discplinary research programme. In: AMBIO. J. of human environment Vol. XX No. 8. Royal Swedish Academy of Sci., Sweden pp. 357-361.

Chambers, R. 1991. Complexity, diversity and competence, toward sustainable livelihood from farming systems in the 21^{st} century. J. of Asian Farming Systems Association 1 (1): 79-89.

Kasonta, J. and Mkonyi, J.,1991. Mpwapwa breed cattle as sustainable milk and beef producing animals in semi-arid areas of Tanzania. In: Milk production from smallholder systems with emphasis on feeding strategies. Proc. of a seminar held at Sokoine Univ. of Agric., Morogoro, Tanzania from 22-24, Jan.1991. SAREC/Mpwapwa pp. 166-172.

Laurent, C. and Centres, J.M., 1990. Dairy husbandry in Tanzania. A development programme for smallholders in Kilimanjaro and Arusha regions. Versailles. Document de travail de I'URSAD Versailles-Dijon-Mirecourt. 108 pp.

Ministry of Agriculture (MALD), 1988. Statistical abstract of the livestock census (Tanzania mainland). Livestock statistic unit, planning and marketing division, Dar es Salaam.

Shayo, C.M., 1992. Evaluation of water melons as a source of water, and water melon seeds and acacia pods as protein supplement for dairy cows in central Tanzania. MSc. thesis. Dept. of Anim. Nutr. and Mgt., Swedish Univ. of Agric. Sciences 137 pp.

TABLES AND FIGURES

Table 1: Farm size (ha), grain and crop residues production (t/ha) in Berege village (mean from 10 farmers). the Kilimanjaro region.

Crop	Farm size		Grain yield		Stover yield	
	Mean	SEM	Mean	SEM	Mean	SEM
Millet	7.1	3.1	1.8	0.5	2.8	0.7
Sorghum	5.4	1.3	1.7	0.2	3.8	0.5
Maize	2.7	1.1	0.9	0.2	1.4	0.4
G/nut	3.5	1.0	0.7	0.3	1.2	0.3
Acacia Spp. pods		-	-	-	2.0	0.5
Water-melon		-	-	-	9.8	1.3
Cereal bran		-	-	-	0.3	0.1
Potatoes leaves		-	-	-	0.2	0.1
Sunflower cake		-	-	-	0.3	0.2

Table 2: Grain and crop residues production (t/ha) in four villages in Kilimanjaro region (n=8).

	Grain yield		Fodder yield	
	Mean	SEM	Mean	SEM
Maize	1.4	0.9	2.5	1.2
Bean	0.4	0.2	0.5	0.3
Banana	1.0	0.4	1.4	0.6
Finger millet	0.6	0.5	0.5	0.4
Coffee	1.4	0.9	-	-
Others	-	-	1.8	0.5

Table 3: Farm size in mixed and monocropping systemsin Kilimanjaro region (ha) n= 4.

Mixed cropping		Mono-cropping	
Mean	SEM	Mean	SEM
4.1	1.6	1.5	0.9

Table 4: Average and range number of livestock per household on 10 farms in Berege and 8 farms in Kilimanjaro region.

	Berege village		Kilimanjaro region	
	Mean	Range	Mean	Range
Cows	1[a]	1-2	2[b]	1-4
Heifers	<1	0-1	<1	0-1
Steer	<1	0-1	<1	0-1
Calves	<1	0-1	1	1-3
Bulls	1	0-1	<1	0-1
Goats	7	0-30	20	6-40
Sheep	<1	0-3	2	0-6
Pigs	<1	0-2	1	0-4
Poultry	17	0-30	14	0-46

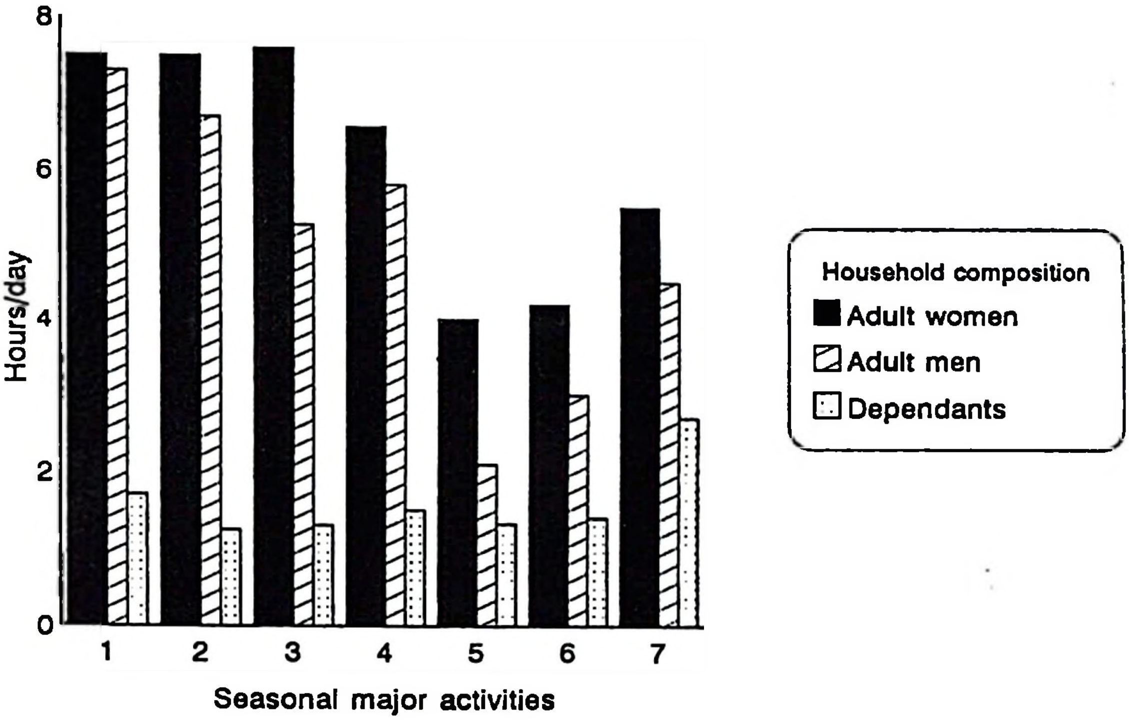
1[a] :Milk yield = 4.75 lts/day and range of 2 to 8.5 lts/day.

2[b] :Milk yield = 8.25 lts/day and range of 2 to 14 lts/day.

Table 5 :Time spent for stripping and topping maize by women in two villages in Kilimanjaro village.

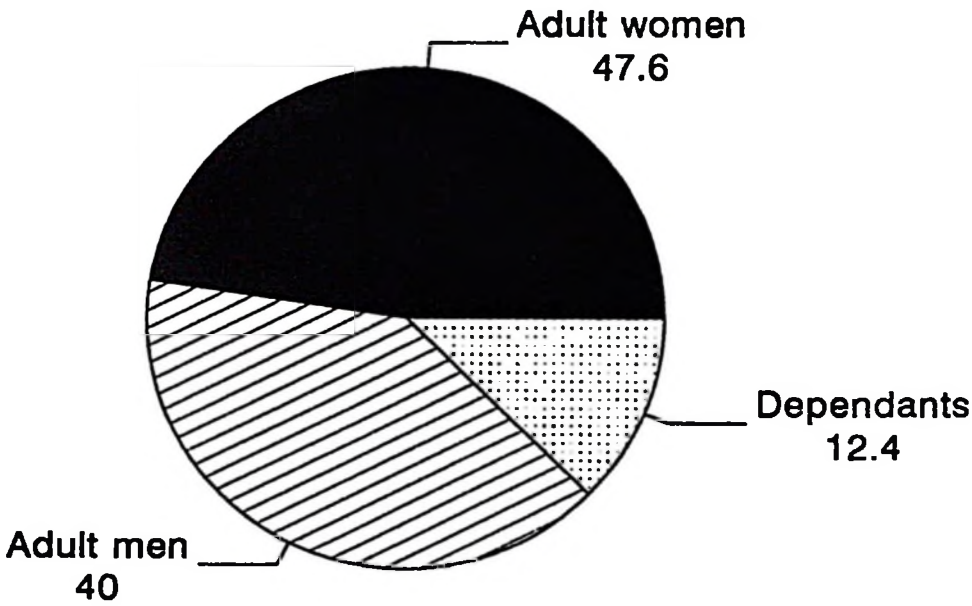
	Mean	SEM
Fresh fodder harvested[1](kg)	61.2	14.0
Dry fodder[2](kg)	20.1	5.0
Dry matter yield (t/ha)	2.0	0.5
Time spent in harvesting (min)	23.7	4.6
Est. time to harvest 1 ha (days)[3]	9.1	1.7

[1]: Fresh materials harvested in February, 1993 from a 10 m^2 plot area.
[2]: Dry materials after drying the fresh materials in October, 1993.
[3]: Est. time = Estimated time for a working day = 8 hours/day



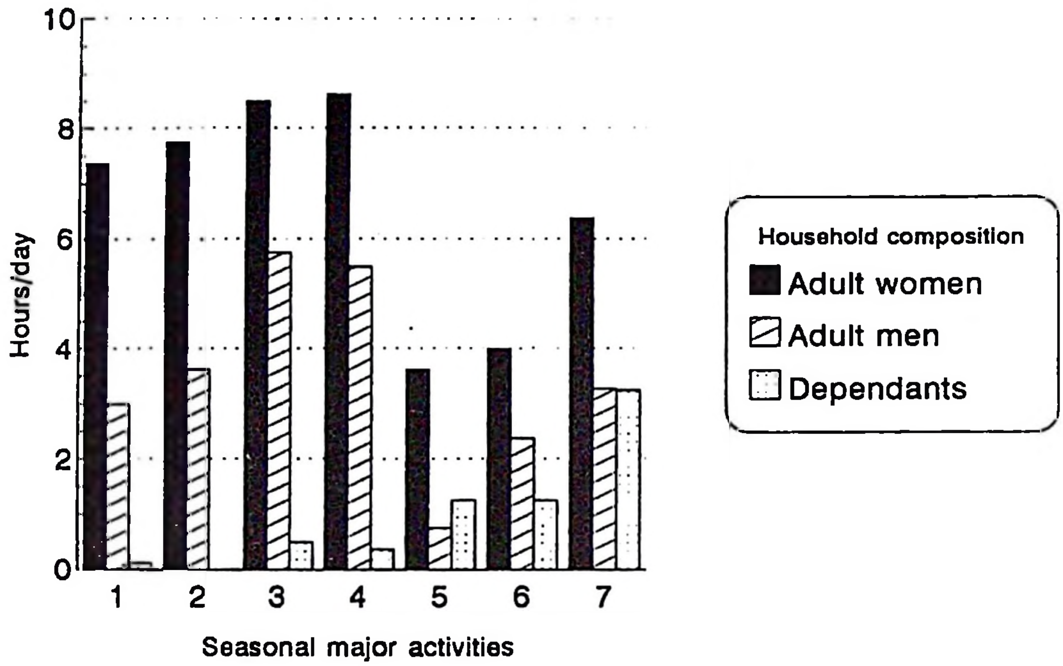
Activities 1=ploughing, 2=planting, 3=weeding, 4=harvesting, 5=processing, 6=animal care, 7=others

Figure 1:Gender labour distribution (hrs/day) for the major activities in Berege village



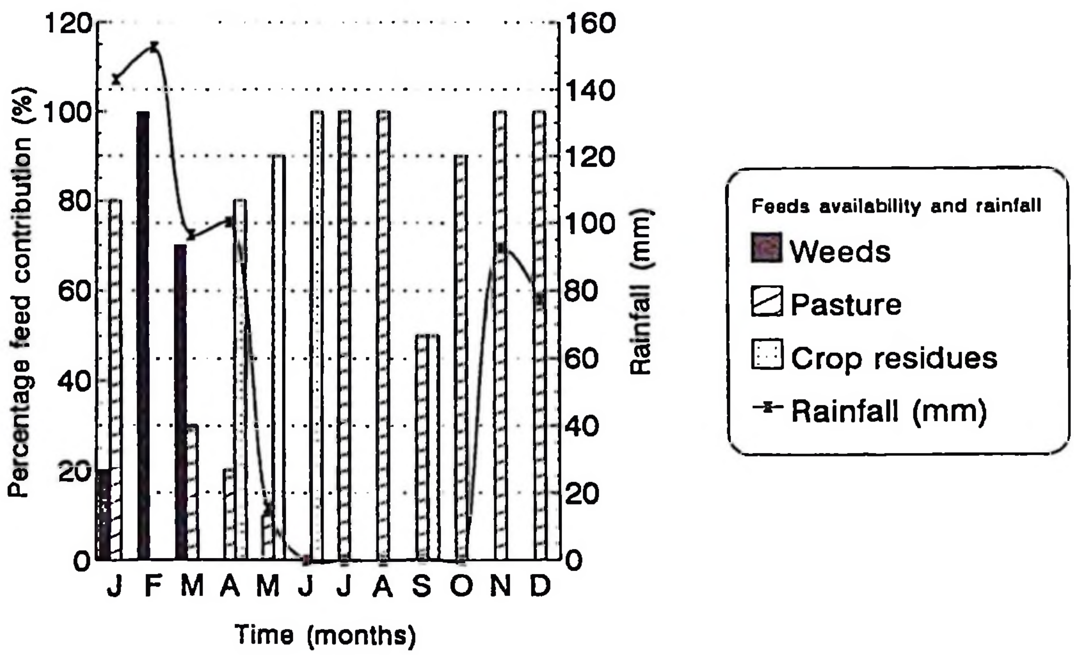
Dependants= children, old people, temporary visitors

Figure 2: Annual labour distribution within the household
Berege village 1992/93 cropping season.



Activities 1= ploughing, 2=planting, 3=weeding, 4=harvesting, 5=processing, 6=animal care, 7=others

Figure 3: Division of labour in the household (hrs/day)
Mean from eight farms in four villages in Kilimanjaro region.



Cereal residues= maize, sorghum, millet

Figure 4: Monthly feed contribution (%)
Feed supply 1993, Berege village.

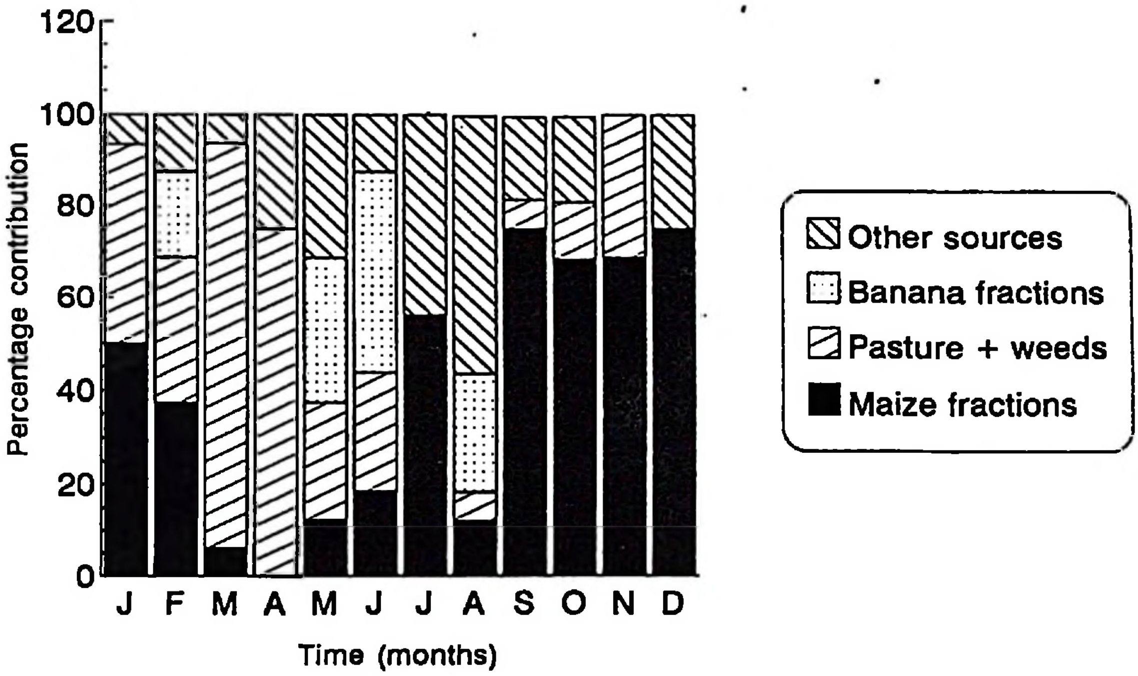


Figure 5: Monthly feed contribution from different forages.
Mean feed supply in four villages in Kilimanjaro region.
(n = 8)

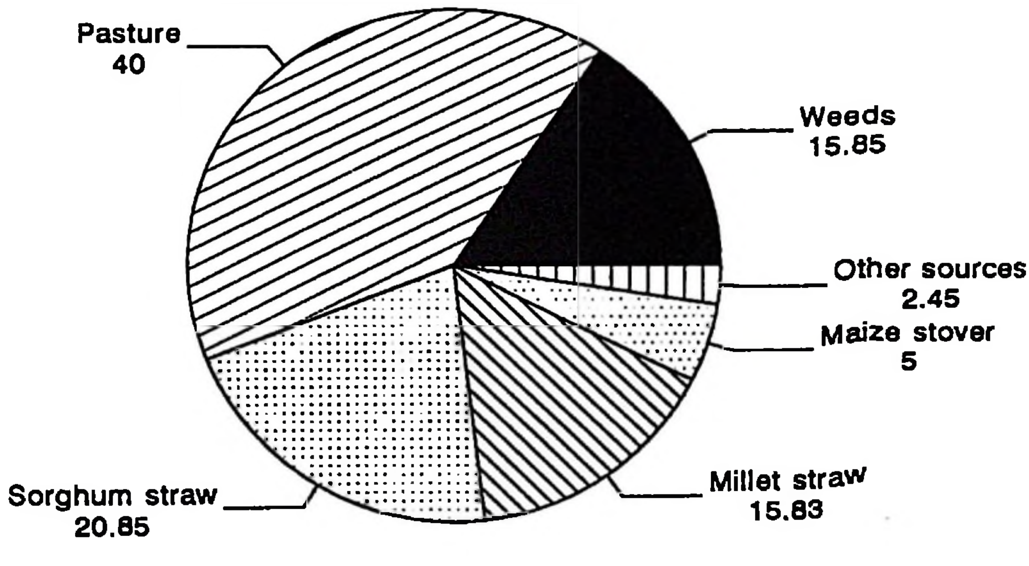
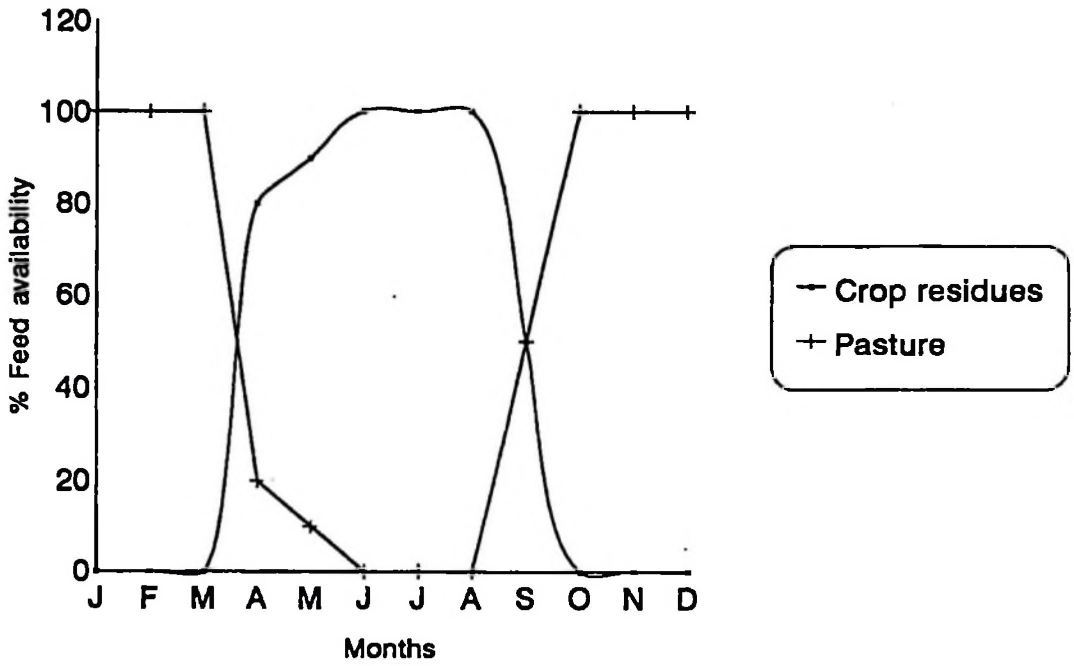
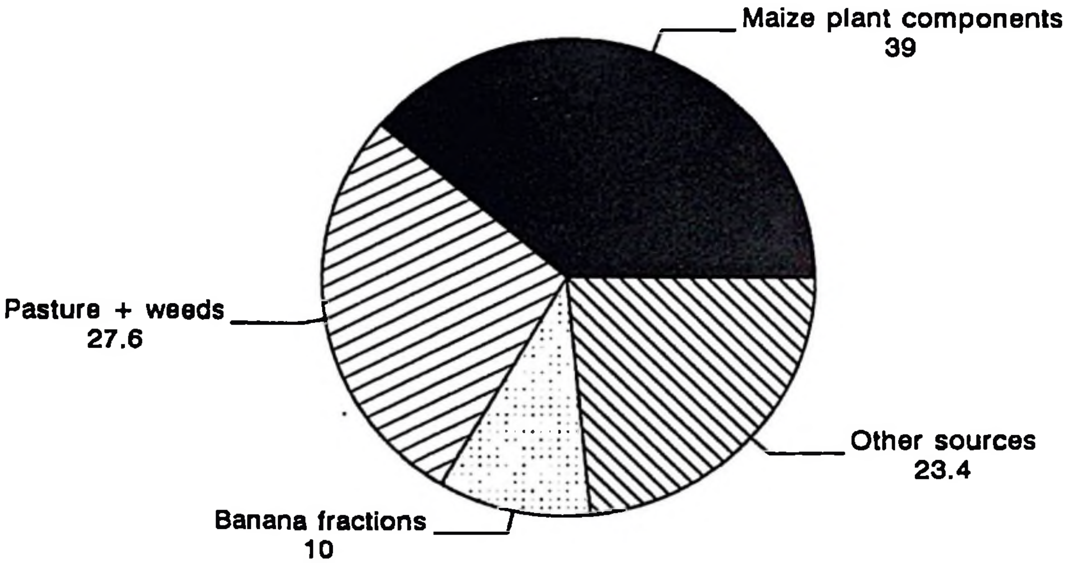


Figure 6: Annual feed contribution (%) from different resources
Berege village, 1993.



Pasture= natural + established pasture, tree foliage + pods, weeds

Figure 7:Hypothetical profile of crop residues and pasture availability Berege village, 1993 cropping season



Other sources= browse and legume species, agro-industrial by-products,bean and finge

Maize components= thinned plants (5%), strippings (9%), stripping + toppings (15%), stover (10%)

Figure 8: Annual feed resources (%). Mean from eight farms in four villages in Kilimanjaro region in 1993

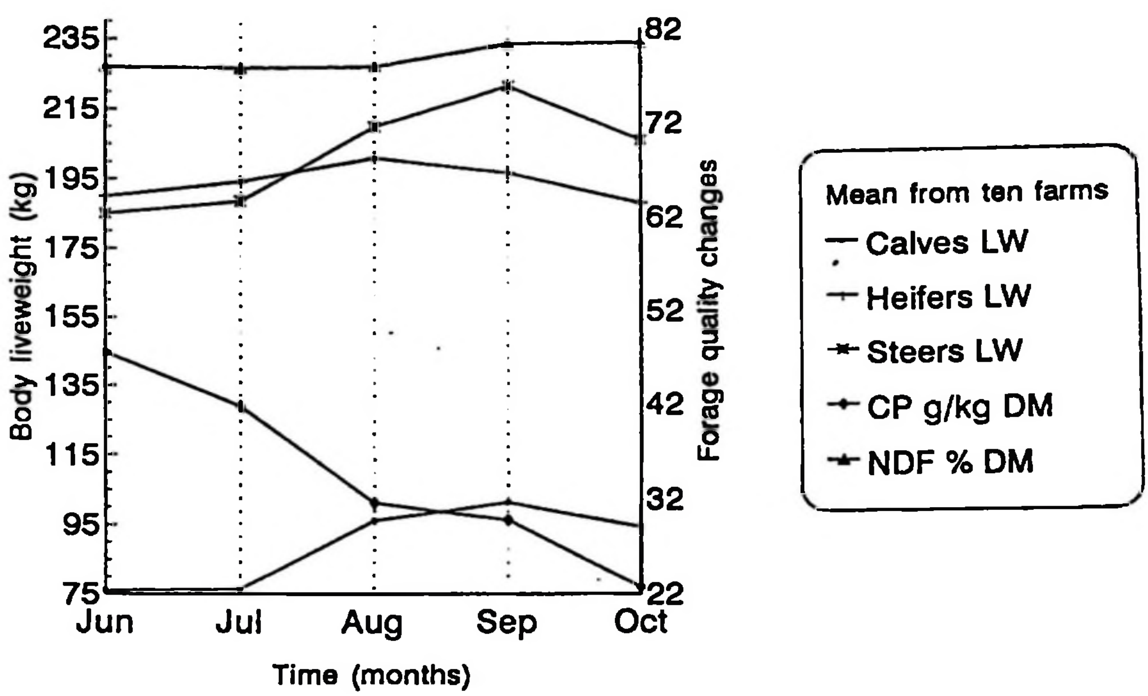


Figure 9: Cattle liveweight in growing animals and forage quality changes from early to mid-dry season in Berege village for 1993, cropping season

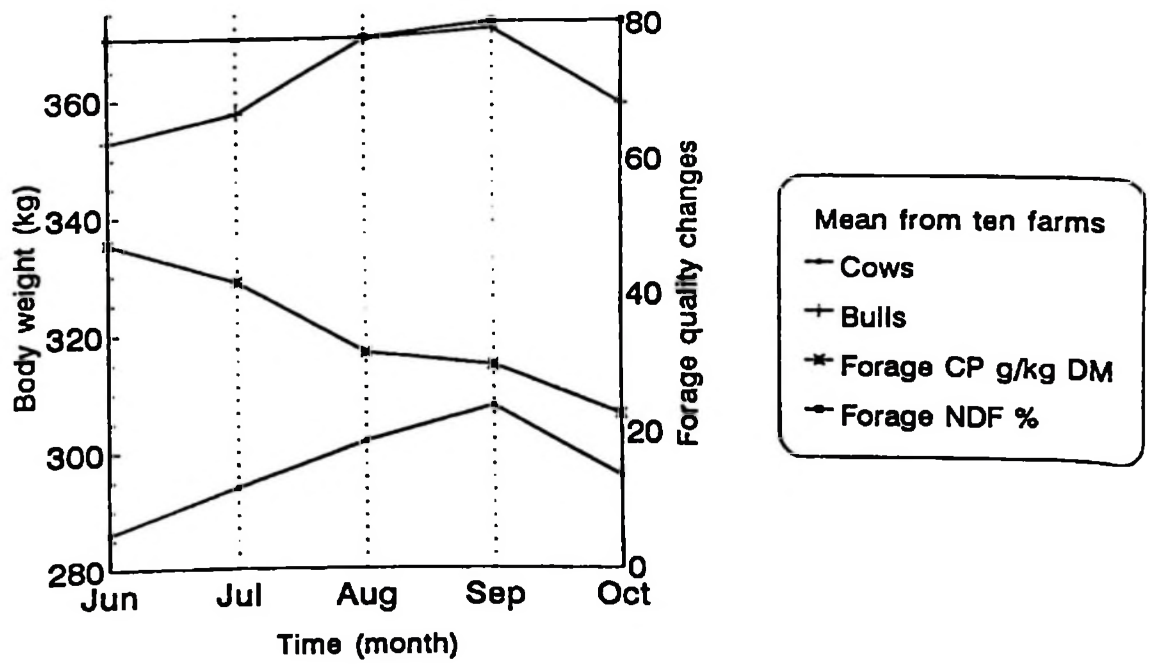


Figure 10: Cattle liveweight in adult animals and forage quality changes from early to mid-dry season in Berege village for 1993, cropping season

12.0 APPENDIX

12.1 Estimated costs of producing various fractions ofmaize

12.1.1 Stripping (SR)

a) Farm gate price
1 plot of 75.225 m^2 = 5 minutes to harvest all the 1st leaves
1 plot of 75.225 m^2 = 5 min. x 8 leaves = 40 minutes for all leaves
1 ha = 10000 m^2 x 40 min. / 75.225 m^2 = 5317.38/60 = 88.6 hours
1 day working hours in Tanzania = 8 hours/day
Days to strip = 88.6 hrs / 8 hrs = 11 effective days
Daily payment = 250.00 TSh/day
Cost of stripping 1 ha = 11 days x 250 TSh. = 2750.00 TSh.

b) Time spent to take 850 kg DM of fodder nearby home
Assumption made:
- -Minimum distance to and from crop field = 4 km
- -Time spent for covering 4 km = 2 hours
- -Drying is done in the field
- -Carriage capacity per adult person = 30 kg dry matter

Collection of fodder = 850 kg /30 kg = 28 trips @ 2 hrs = 56 hrs
Effective days = 56 days / 8 hrs /day = 7 days @ 250.00 TSh.= 1750
Overall costs of 1 kg. of strips = 4500.00 / 850 = **5.3 TSh / kg DM**

12.1.2 Topping (TP):

a) Farm gate price:
Plot size = 75.225 m^2 = 20 minutes
10000 m^2 = 2658.70 minutes = 44.3 hours = 5.5 days
The estimated costs = 5. 5 x 250 TSh / day = 1375.00 TSh.

b) Costs of taking 1830 kg DM home (Assumptions as in SR):
Transportation of fodder = 1830 kg / 30 kg = 61 trips @ 2 hrs = 122 hrs = 15.25 working days
Payment of 15.25 days @ 250 TSh. = 3812.50 TSh.
Overall costs of 1 kg of green tops = 5187.50 TSh. / 1830 kg = **2.83 TSh / kg DM.**

12.1.3 Stripping + topping (STP):

a) Farm gate price:
Days in SR + TP = 11 + 5.5 = 16.5 effective days
Cost for STP = 16.5 days x 250 TSh / day = 4125.00 TSh./ha

b) Cost of taking the fodder (2350 kg DM STP) from 1 hectare:
(Assumptions as in SR and TP above)
Transportation = 2350 kg / 30 kg = 78 trips @ 2 hrs = 156 hrs
Effective days = 156 hrs / 8 hrs / day = 20 days @ 250 TSh.
Sub-costs = 5000 TSh.
Overall cost of 1 kg of STP = 9125 TSh. / 2350 kg = 3.88
~4.00 TSh. / kg DM.

12.1.4 Stover (WPL):

a) Farm gate price

1 plot of 75.225 m^2 = 15 minutes
10000 m^2 = 1994.02 minutes = 33.23 hours = 4.15 working days
Cost of WPL = 4.15 x 250.00 TSh. = 1037.50 TSh / ha

b) Transportation of 4230 kg DM / ha (Assumptions as in SR, TP, STP)
Trips to be made = 4230 kg / 30 = 141 trips @ 2 hrs = 282 hrs
Effective days = 282 hrs / 8 hrs = 35 days @ 250.00 TSh.= 8750.00
Overall cost of 1 kg of stover = 9787.50 TSh. / 4230 kg DM = **2.31 TSh kg DM.**

12.2 Estimated cost of producing various fractions of sorghum plant
12.2.1 Cost of producing sorghum green leaves

a) Farm gate price
Area = 71.4 m^2
Stripping time @ leaf = 5 minutes x 10 leaves = 50 min./plot
1 hectare = 10000 m^2 x 50 min/71.4 m^2 = 7002.80 min.= 116.71 hours
Working hours in Tanzania = 8 hours/day
Daily payment = 250 TSh.
Total payment 116.71 hrs /8 hrs= 14.6 days @ 250 TSh.= **3650.00**

b) Transportation
Assumption:
-Minimum distance to and from crop fields = 4 km
-Maximum time spent for walking 4 km = 2 hours
-Maximum load carrying capacity = 30 kg dry fodder/adult person
Trips to collect 720 kg DM produced
=720 kg/30kg= 24 trips @ 2 hours = 48 hours/8 hrs = 6 effective days
Payment of days 6 @ 250 = 1500.00 TSh.
Overall cost of producing green leaves (720 kg)
3650 + 1500 = 5150/720 = **7.15 TSh./ kg** DM of green leaves

12.2.2 Cost of producing sorghum straw
a) Farm gate price
Area = 71.4 m^2
Collection time = 30 minutes
1 ha = 10000 m^2 x 30 min/71.4 m^2 = 4201.68 min. = 70.03 hrs
Payment = 70.03 hrs / 8 hrs = 8.75 = 9 days @ 250 TSh. = 2250.00

b) Transportation
Assumption as in b) above
Total straw = 1840 kg Dry matter
Trips to field = 1840 kg/ 30 kg = 61.33 trips @ 2 hrs =122.67 hrs
Payment = 122. 67 /8 hrs = 15.33 days @ 250 = 3833.00 TSh.
Overall cost of straw production = 2250 + 3833 = 6083.00/1840 = 3.3
TSh./kg DM of straw