Excess Feeding of Stovers from Sorghum and Maize for Small Ruminants and Cattle in Cereal-based Integrated Farming Systems in Africa

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Abstract
Surveys of small-scale farmers growing sorghum in Ethiopia and maize in Kenya showed that stover was used as livestock feed during the dry season. Feeding method generally involved offering crudely-chopped (i.e. machete), stover in large quantities, with refusals either re-offered to less valuable animals (eg. donkeys in Ethiopia), and/or used as fuel, mulch or compost with excreta. Experiments were undertaken to quantify the effect

of varying extents of excess feeding on stover intake and livestock production; cottonseed cake and minerals supplementation was provided. In Ethiopia, using machine-chopped sorghum stover, sheep offered 25, 50 or 75 g stover/kg live weight (M), daily (d), increased their intake and growth rate with increasing excess rate (intake, g DM/kg M.d: 22.1, 31.1 and 32.5; growth rate, g/d: 28.2, 54.1 and 62.2). With increasing excess rate, sheep consumed more leaf and less stem. Amount of stover refused also increased with excess rate (g/kg offered: 51, 318 and 526). Goats responded similarly. In another study, the effects of increasing the excess rate (25 vs 50 g/kg M.d) and chopping were additive in improving intake and growth rate of sheep. However, with cattle, chopping reduced intake of stover, but increasing the excess rate of unchopped stover improved performance. In a comparison of stover from a bird-resistant and non-bird-resistant variety, there was no difference in intake by sheep, but in the same trial, increasing the excess rate from 25 to 50 g/kg M.d increased intake. In Kenya, when mid-lactation, cross-bred cows were fed minerals and 3.2 kg DM/d cottonseed cake and offered 30, 60 or 90 g DM/kg M.d of unchopped maize stover, intake of stover (kg DM/d: 8.1, 11.3 and 13.2) and yield of milk (l/d: 10.0, 11.3 and 12.3) increased with increasing excess rate. The experiments demonstrate improved animal productivity from an excess feeding-rate strategy for sorghum and maize stovers. It is concluded that integrated farming systems involving excess feeding strategies now need to be modeled, so that interventions to improve the systems may be identified. However, to develop the models, it will be necessary to generate further input/output information, especially regarding strategies for utilising refused stover.

KEY WORDS: Excess feeding, straw, sorghum, maize, stover

Introduction

Farmer group surveys in sorghum-growing areas of Ethiopia (Nazret, Eastern Hararghe and Ada) showed farm sizes to range from 1.6 to 5 ha, with up to 54% of the cultivated area in sorghum (Osafo, 1993). Despite problems of grain damage by birds, farmers preferred local, non-bird-resistant varieties of sorghum to modern, bird-resistant ones, because of higher palatability of grain and more drought resistance. Sorghum stover and teff straw were major livestock feeds in the dry season, with draught oxen and milk cows having priority over small ruminants and donkeys, in access to crop residues. Stover feeding involved in situ grazing and stall feeding, the latter using either long stover, or crudely chopped (i.e. machete). Stems were used for fencing. Because of acute shortage of fuelwood, uneaten stover was used as fuel, often mixed with cow faeces and tree leaves (e.g. Eucalyptus). There was little use of residues for mulching or composting.

Surveys (Methu *et al*., 1996; Wais, 1996) showed that smallholder dairying in Central Kenya Highlands (Kiambu) based on cut-and-carry feeding with exotic dairy breeds (mainly Friesian and Ayrshire), is a major enterprise on small-scale (2 ha) farms. Crops grown involve Napier grass (0.8 ha), maize (0.36 ha, two crops per year) and horticultural crops. Except in the dry season, napier grass is the major basal component of dairy rations. Maize stover (approximately 2.6 t DM/ha.year) could play a larger role in dry-season feeding if problems of low intake and low nutritive value were alleviated. Omore (1996) reported milk yields averaging only 5.8 kg/d over lactations extending beyond 24 months. Concentrate feeds from commercial dairy meals, cereal brans and oilseed cakes were purchased by over 70% of farmers, but concentrates were fed at very low levels.

In both Ethiopia and Kenya, there was no evidence of farmers adopting technologies such as urea-ammonia treatment of sorghum and maize stovers to improve intake and nutritive value. Farmers surveyed in Kenya were unaware of residue upgrading technologies (Methu *et al*., 1996). This confirms the earlier findings of Owen and Jayasuriya (1989) and the recent conclusions of Devendra (1996).

Research by Wahed *et al*.(1990) using barley straw, and Zemmelink

(1980) using tropical grasses and legumes, showed that an `excess feeding' strategy resulted in increased intake of digestible organic matter. In view of this, a series of experiments was conducted with sorghum and maize stovers to investigate whether excess feeding would increase intake and productivity of ruminants. It was hypothesised that this approach would provide an adoptable and sustainable strategy for alleviating the problem of low nutritive value of stovers.

Experiments Undertaken

The Excess Feeding Approach

The method involved offering differing amounts of stover, on the basis of the live weight (M) of animals, such that the proportion refused increased dramatically above the conventional *ad libitum* rate of 0.15 kg refused/kg offered. Except for one experiment (Osafo *et al*., 1993a), supplements of cottonseed cake and minerals were provided. Measurements were made of the quantity and quality (botanical fractions) of stover offered and refused.

Three experiments with sorghum stover were conducted at the International Livestock Research Institute (ILRI), Debre Zeit, Ethiopia and one with maize stover at the Kenya Agricultural Research Institute (KARI), Muguga, Nairobi.

Experiment 1: Effects of Amount of Chopped Sorghum Stover Offered in Goats and Sheep

The stover used (Seredo, bird-resistant variety) was coarsely chopped using a tractor-driven chopper (Alvan-Blanch Maxi chaff cutter). Both goats and sheep increased their intake of stover with increasing amounts of stover offered, and this was reflected in increasing growth rates (Table 1). As the amount offered increased, the content of leaf and sheath in the stover consumed increased and that of stem decreased, indicating selection for the more nutritious leaf and sheath components. Also clearly evident, was the increasing proportion of refused stover as the amount offered increased (Table 1).

Table 1: Effects of amount of chopped sorghum stover offered, in goats and sheep in Ethiopia (Aboud *et al*., 1993)

	Goat			Sheep		
Amount offered (g/kg M.d)	25	50	75	25	50	75
Number/treatment	7	7	7	8	8	7
Initial weight (M) (kg)	15.4	16.3	16.3	14.7	16.3	16.5
Stover refused (kg/kg offered)	0.15	0.43	0.57	0.05	0.32	0.53
Stover intake (1) (g DM/kg M.d)	19.9	26.3	29.1	22.1	31.1	32.5
Growth rate (1) (g/d)	9.4	23.4	31.6	28.2	54.1	62.2

(1) Measurements over 75 d following a 21-d preliminary period, supplements given: 150 g/d cottonseed cake and mineral licks; s.e.d. for stover intake, 1.09; s.e.d. for growth rate, 8.70

Experiment 2: Effects of Amount of Stover Offered and Chopping in Sheep and Cattle

The stover used was a non-bird-resistant variety (Dinkamash). Both sheep and cattle showed greater intakes when the amount of stover offered was doubled, and this was reflected in increased growth rates (Table 2). However, chopping increased intake in sheep, but decreased intake in cattle. This result has an important practical implication in view of the fact that chopping (albeit ill-defined) is widely advocated when feeding sorghum and maize stovers.

Experiment 3: Effects of Amount of Chopped Stover Offered and Variety of Stover in Sheep

Experiment 3 tested the hypothesis that stover from bird-resistant sorghum would be less nutritious than stover from non-bird-resistant sorghum because of the higher anti-nutritive factors in bird-resistant varieties (Reed *et al*., 1987). Table 3 shows that although digestibility was lower in the bird-resistant stover, intake was unaffected. This was probably due to the higher leaf-plus-sheath to stem ratio in the bird-resistant stover used.

Table 2: Effects of amount of stover offered and chopping, in sheep and cattle in Ethiopia (Osafo *et al*., 1993b)

Form of stover	UNCHOPPED		CHOPPED	
Amount offered (g/kg M.d)	25	50	25	50
SHEEP (1)				
No. of pens (2)	4	4	4	4
Initial weight (M) (kg/pen)	51.8	51.0	50.4	51.2
Growth rate (3) (g/animal.d)	30.5	56.0	45.8	70.5
Stover offered (kg DM/pen.d)	1.25	2.56	1.23	2.60
Stover refused (kg/kg offered)	0.21	0.52	0.11	0.38
Stover intake (4) (kg DM/pen.d)	0.98	1.24	1.08	1.60
Stover intake (g DM/kg M.d)	18.9	24.3	21.4	31.3
CATTLE (5)				
No. of steers	8	8	7	8
Initial weight (M), kg	204	204	200	203
Growth rate (6) (kg/d)	0.25	0.43	0.36	0.44
Stover offered (kg DM/d)	4.9	9.5	5.1	9.9
Stover refused (kg/kg offered)	0.24	0.51	0.29	0.62
Stover intake (7) (kg DM/d)	3.7	4.7	3.6	3.9
Stover intake (g DM/kg M.d)	18.1	23.0	18.0	19.2

(1) Measurements over 56 d, supplements given: 310 g/d cottonseed cake and mineral licks;
(2) 3 rams/pen;
(3) s.e.d. 4.86;
(4) s.e.d. 0.100;
(5) measurements over 49 d, supplements given: 800 g/d cottonseed cake and mineral licks;
(6) s.e.d. 0.083;
(7) s.e.d. 0.22

Osafo (1993) found large variation in the leaf-plus-sheath:stem ratios between varieties of both bird-resistant and non-bird-resistant sorghums. Experiment 3 involved offering stover without supplementation to simulate farmer practice. It is notable that sheep offered the higher rate of stover maintained weight.

Table 3: Effects of amount of chopped sorghum stover offered and variety of stover, in sheep in Ethiopia (Osafo *et al*., 1993a)

Variety	Non-bird resistant (1)		Bird resistant (2)	
Amount offered (g DM/kg M.d)	25	50	25	50
INTAKE TRIAL (3)				
No. of rams	12	12	12	12
Initial weight (M) (kg)	20.0	20.1	20.1	19.9
Growth rate (4) (g/d)	-25.3	3.5	-16.1	-4.0
Stover offered (g DM/d)	548	1019	537	1011
Stover refused (kg DM/kg DM offered)	0.13	0.38	0.11	0.38
Stover intake (5) (g DM/d)	474	633	478	628
DIGESTIBILITY TRIAL (6)				
No. of rams	4	4	4	4
Live weight (M) (kg)	17.8	18.2	17.8	17.0
Stover offered (g DM/d)	622	1093	619	1067
Stover refused (kg DM/kg DM offered)	0.13	0.39	0.10	0.37
Stover intake (g DM/d)	544	670	558	676
OM digestibility (7)	0.58	0.56	0.53	0.54
NDF digestibility (8)	0.61	0.57	0.55	0.55

(1) Mixture of Dinkamash and 76T123 varieties), leaf-plus-sheath:stem, 0.82;
(2) Seredo, leaf-plus-sheath:stem, 1.25;
(3) measurements over 42 d, supplement given: mineral licks only;
(4) s.e.d 6.2;
(5) s.e.d. 16.0;
(6) measurements over 7 d, supplement given: mineral licks only;
(7) s.e.d. 0.024;
(8) s.e.d. 0.029

Experiment 4: Effects of Amount of Maize Stover Offered in Milk Cows

In both Latin squares, intake of maize increased as the amount offered increased, and this was reflected in greater milk production, though responses were non-significant (Table 4). The proportions of leaves and husks in the stover consumed were greater than in the stover offered, suggesting selection for these components as opposed to selection against stems and sheaths. As in Experiments 1 to 3, the proportion of stover refused increased markedly with increasing offer rate. The milk yields achieved in this experiment, from mid-lactation cows on a basal diet of maize stover, were substantial, although it is acknowledged that 3.2 kg DM/d cottonseed cake was fed.

Conclusions

The experiments confirmed the hypothesis that excess feeding of sorghum or maize stover is a method of increasing intake and productivity of small ruminants and cattle, thus alleviating the problem of low nutritive value of stovers.

At first sight, the large amount of refused stover generated by excess feeding would be conceived as unsustainably wasteful. However, as indicated by surveys in Ethiopia, residues uneaten by ruminants have a value as feed for donkeys or substitute for fuelwood.

Stovers refused in an in situ grazing system would be available for soil incorporation to increase organic matter (Powell *et al.*, 1995). However, refused stovers, which would tend to be dominated by the stem fraction, would contain high C:N ratios. Not only are such residues slow to decompose under field conditions, but may also immobilise mineral nitrogen making it unavailable for plant growth.

In Kenya refused maize stover is used as bedding in zero grazing units. Farmers combine urine-soaked stover with cattle faeces in heaps or pits for composting prior to application to crops. Collaborative research being conducted by KARI and ILRI is currently examining how interactions between the quality of diets based on maize stover, bedding, manure management and composting techniques influence the quality of organic fertilizers produced.

Table 4: Effects of amount of maize stover offered, in lactating cows in Kenya (Methu *et al*., 1996)

	1994 stover (1)			1995 stover (2)		
Amount offered						
(g DM/kg M.d)	29	57	87	33	60	87
Live weight (M) (kg)	425	436	439	424	438	437
Stover offered (kg DM/d)	12.3	24.7	38.2	13.8	26.5	38.0
Stover intake (3) (kg DM/d)	8.3	11.5	13.2	7.9	11.0	13.2
Stover refused						
(kg DM/kg DM offered)	0.32	0.54	0.65	0.41	0.58	0.65
Milk yield (4) (kg/d)	11.2	11.3	13.0	8.8	11.2	11.5
Stover Offered (%)						
Stem	42	42	42	50	50	50
Leaf	17	17	17	12	12	12
Sheath	15	15	15	13	13	13
Husk	25	25	25	24	24	24
Stover Consumed (%)						
Stem	19	21	31	20	12	20
Leaf	24	28	29	18	19	17
Sheath	23	12	6	22	20	9
Husk	34	39	34	40	49	54

(1) 3 Ayrshire cows in 3x3 Latin square, 24 d/period, supplements given: 3.2 kg DM/d cottonseed cake and 150 g/d mineral premix;
(2) 3 Friesian cows in 3x3 Latin square, 24 d/period, supplements given: 3.2 kg DM/d cottonseed cake and 150 g/d mineral premix;
(3) s.e.d. for Ayrshires, 1.12, s.e.d. for Friesians, 0.46;
(4) s.e.d. for Ayrshires, 1.54, s.e.d. for Friesians, 0.71

Under the intensive farming systems practised in the highlands of East and Central Africa, excreta is a highly valued output of the livestock sub-system.

In Indonesia, excess feeding of indigenous forages is already practised by farmers with the main intention of maximising yield of manure-compost production made from refused forage and excreta (Tanner *et al.*, 1996). In Indonesia, excess feeding therefore not only increases animal productivity per se, but also maximises outputs from the livestock enterprise which are of benefit to crops.

There is a need to model input-output relationships concerning the excess feeding approach and the use of supplements in order to optimise the sustainable use of sorghum and maize stovers in cereal-based integrated farming systems in Africa and elsewhere.

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