Retour au menu

Contribution of crop residues to ruminant feeding in different agroecological zones of Burkina Faso

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Key words

Ruminants - Feed consumption - Cereals - Legumes - Crop residues - Carrying capacity - Agroclimatic regions - Burkina Faso.

Summary

A static model is used to evaluate the potential contribution of crop residues to ruminant feeding in the different agroecological zones of Burkina Faso. Residues of cereal crops including maize (*Zea mays* L.), millet (*Pennisetum glaucum* [L.] R.Br.), sorghum (*Sorghum bicolor* [L.] Moench) and rice (*Oryza sativa* L.) represent 90 to 98% of the total quantities of crop residues. These residues are characterized by low crude protein (CP) content (average 4.7%) and low digestibility of organic matter (OMD, average 49.2%). The best quality residues are haulms of cowpea (*Vigna unguiculata* [L.] Walp) and groundnut (*Arachis hypogaea* L.) with 12.6 to 15.6% CP and 57 to 61% OMD. Residues of bambara groundnut (*Voandzeia subterranea*) are of intermediate value: 6.4% CP and 55% OMD. With the current amounts of different residues, a maximum of 8, 54, 98 and 76% of the current ruminant stock, respectively in the Sahelian, Sub-Sahelian, North-Sudanian and South-Sudanian zones, could be fed at maintenance level during the dry season. Optimum utilization of crop residues in the Sudanian zones may contribute to intensify ruminant livestock production.

■ INTRODUCTION

Sub-Saharan livestock production is increasingly constrained by feed shortage, both quantitatively and qualitatively. Natural forage is not sufficient to satisfy animal requirements in the dry season when the quantity decreases by 25 to 50% of peak biomass and N content falls well below 1% (1, 3, 16, 23). In addition, industrial by-products are not available, or so expensive that farmers cannot afford them (8, 13). The human population increased by 77% in the last 30 years and crop areas followed the same trend (+120%) (29). In the region, animal feed in the dry season already consists mainly of crop residues (15, 16). Although this is increasingly the case in all Sahelian countries, reliance on crop residues to sustain animal production faces problems, because of the limited availability and low nutritive value. Nevertheless, many studies have shown scope for improvement of ruminant livestock production in systems based on crop residues, when appropriate feeding strategies are applied (4, 12).

Of the three major feed resources, i.e. natural or cultivated forage, industrial by-products and crop residues, only the latter is sure to increase in total production. Improving knowledge of their potential contribution to livestock feeding may therefore help in estimating the carrying capacity of different agroecological zones, and to examine the effect of possible changes in feeding systems on the productivity of livestock. The specific objective of this chapter was to quantify the potential contribution of crop residues to ruminant livestock feeding in the different agroecological zones of Burkina Faso, taking into account the combined effects of their quantities and nutritive value (digestibility and N content).

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■ MATERIALS AND METHODS

Study area

This study covered four agroecological zones: Sahelian, Sub-Sahelian, North-Sudanian and South-Sudanian. The Sahelian zone, located in the north of the country, is characterized by annual rainfall ranging from 200 to 400 mm, during 2-3 months; the Sub-

Sahelian zone receives 400 to 800 mm rain in about 4-5 months, the North-Sudanian zone 800 to 1000 mm and the South-Sudanian more than 1000 mm, in about 6 months (figure 1).

Estimation of crop residue availability

Estimates of the quantities of crop residues were based on crop areas and grain yields derived from the national agropastoral statistics (18). The ratios straw/grain were set to 3 for sorghum and millet, 2 for maize, 1.5 for cowpea and groundnut, 1.25 for rice, and 1 for bambara groundnut (34). The number of livestock was estimated on the basis of the national livestock census data of 1989 updated by an annual rate of increase of 2% for cattle, donkeys and horses, and 3% for small ruminant (17). Herd size was expressed in tropical livestock units (TLU), a hypothetical animal of 250 kg (3). The conversion factors used are 0.8 for cattle, 0.12 for sheep and goats, 0.6 for donkeys, and 1 for horses (17). Nutritive values of plant materials were taken from various relevant publications.

Calculation procedure

All calculations were performed with the "Java" program developed at the Department of Animal Sciences, Animal Production Systems Group of Wageningen University (5, 32). "Java" was designed to estimate potential animal production for situations where feeds of different quality are available. It takes into account that intake of feed by animals depends on the quality (digestibility and N content) of the ration. This allows estimating the effect of selective utilization of feeds on animal production and hence to estimate optimum degrees of selection to attain maximum production or maximum number of animals that can be maintained during a given period of time. "Java" has been successfully used to determine optimum herd and to explore possibilities for increasing animal production in East Java (11), and to assess the balance of feed supply and animal production in Kenya (33). The program operates by first ranking the feeds according to their potential intake of metabolizable energy (IME) when fed *ad libitum*. IME is calculated from intake of organic matter (IOM in $g/kg^{-0.75}/d^{-1}$) according to the equation of Ketelaars and Tolkamp (14) for sheep:

$$IOM = - 42.78 + 2.3039*OMD - 0.0175*OMD^2 - 1.8872*N^2 + 0.2242*OMD*N$$

($rsd = 8.9$; $r^2 = 0.65$)

where OMD is organic matter digestibility and N is nitrogen concentration in the organic matter, both expressed as % (g/100 g).

This equation is obtained by regression analyses using data from feeding trials with 831 different roughage from various locations in subtropical and tropical zones. IOM calculated in this way for sheep was multiplied with 1.33 to account for the higher average metabolism level of cattle as compared to sheep (11). After this IOM is multiplied by OMD to arrive at IDOM (intake of digestible organic matter) and this is converted into IME, assuming that 1 g of digestible organic matter is equivalent to 15.8 kJ ME (20). The daily live weight gain per animal is calculated as $(IME - IME_m)/b$, where IME_m represents the maintenance requirements and b the amount of ME needed per unit live weight gain. In the present study values for Sahelian cattle breeds were used: 0.508 $MJ/kg^{-0.75}/d^{-1}$ for ME_m, and 31 MJ/kg for b (4).

After ranking the feeds according to their individual values of IME, the program starts a stepwise procedure to calculate the effect of varying degrees of inclusion of feed on ration quality and voluntary feed intake. In step 1, a certain fraction (e.g. 1%) of the total available feed DM is taken, in step 2 the next 1% is added, etc., until all feed is included. At each step, the program calculates the total amount of feed DM included and its quality (weighted mean of digestibility and N concentration), IOM, IDOM and IME. Using these values it calculates: (a) the number of animals units that can be fed *ad libitum* (herd size); (b) production (mean live weight gain per animal unit per day); and (c) total live weight production.

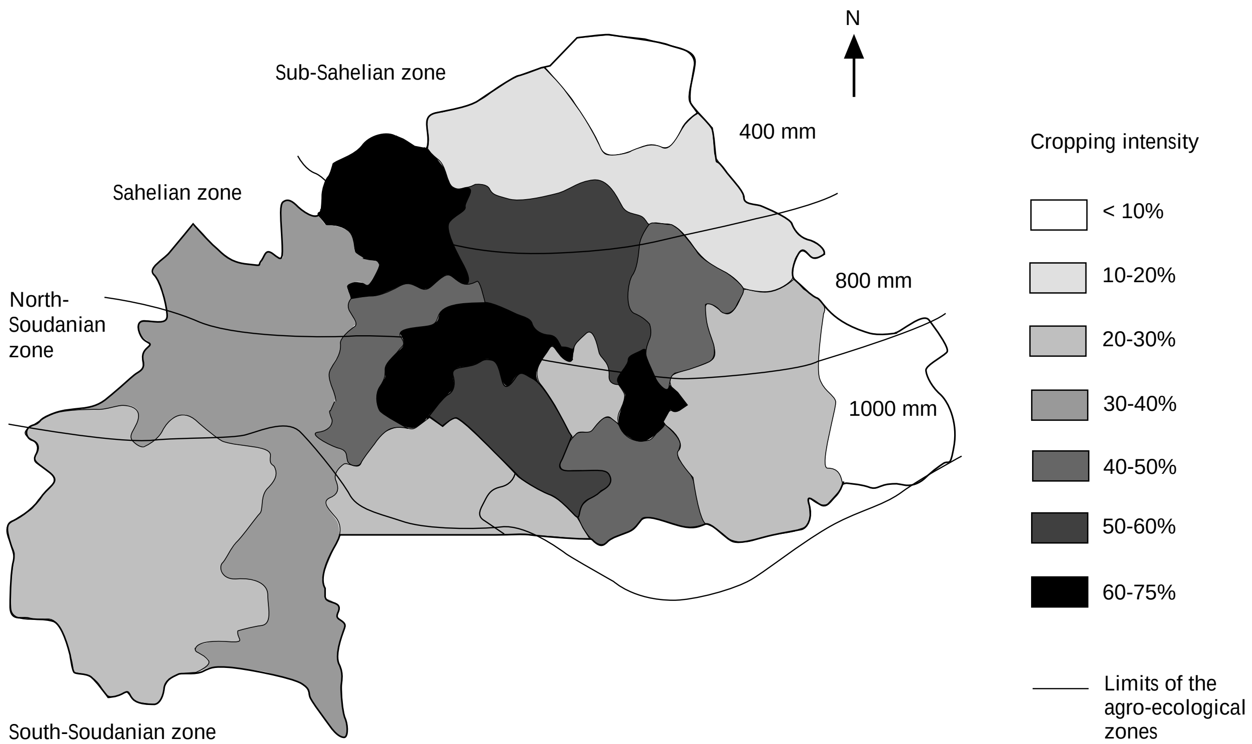

Figure 1: *Agroecological zones and cropping intensity in Burkina Faso. (Source : MET, 1991)*

Input data were the quantities of crop residues given in table I and their nutritive values (tables II and III). Four situations have been analyzed:

A: current quantity and average nutritive value of each crop residue were used. This reflects the utilization of crop residues in ruminant feeding without application of any special technology.

A-20: the quantities of cowpea and groundnut haulms were assumed 20% higher. This reflects the target of extension services for the Sudanian zones, mainly through the introduction of forage legumes, i.e. dolic (*Dolichos lablab*) and dual-purpose cowpea (9).

B: the effect of selective consumption on system productivity was examined by considering stems and leaves of cereal residues separately.

B-20: Scenario B with the quantities of cowpea and groundnut haulms assumed 20% higher.

All calculations were performed hypothesizing that the nutritive value of the crop residues was constant throughout the feeding period. The length of the period was set to 210 days, the average duration of the dry season.

■ RESULTS

Quantities of crop residues in the agroecological zones

Cereal crops, i.e. millet (*Pennisetum glaucum* [L.] R.Br.), sorghum (*Sorghum bicolor* [L.] Moench) and maize (*Zea mays* L.) are predominant in all four agro-ecological zones. Depending on the zone, these crops occupy 28 to 58%, 39 to 58%, and 0.4 to 17%, respectively, of the total cultivated land area (table I). Millet is the

Table I

Area, yields and total quantities of residues in the different agroecological zones of Burkina Faso

Crop residue	Sahelian zone			Sub-Sahelian zone			North-Sudanian zone			South-Sudanian zone		
	A	Y	Q	A	Y	Q	A	Y	Q	A	Y	Q
Legume residues												
Cowpea	9.4	747	7	65.0	939	61	168.5	1294	218	58.8	1123	66
Groundnut	2.6	775	2	26.7	1161	31	136.0	1434	195	66.2	1254	83
Bambara groundnut	2.3	864	2	7.9	880	7	18.9	951	18	22.6	931	21
Cereal residues												
Maize	2.2	928	2	12.1	1736	21	69.5	2130	148	162.3	2132	346
Millet	209.7	1416	297	205.0	1395	286	715.8	2094	1499	245.2	2349	76
Rice	0.7	1500	1	0.6	1687	1	14.4	2437	35	10.7	2531	27
Sorghum	138.2	1440	199	279.0	2025	565	836.7	2688	2249	359.0	2571	923

A: crop area (10^3 ha); Y: yield of crop residue (kg/ha^{-1}); Q: total amount crop residue (in dry matter, 10^6 kg)

Table II

Average, lowest and highest nutritive values of crop residues reported in consulted papers

Crop residue	OM (% DM)			CP (% in OM)			ME (MJ kg^{-1} OM)			OMD (%)		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Legume residues												
Cowpea	89	88	92	15.6	13.9	21.7	9.7	9.2	11.7	61	58	74
Groundnut	88	85	90	12.6	8.5	25.3	9.0	8.7	10.8	57	55	68
Bambara groundnut	88	84	92	6.4	5.5	10.1	8.7	7.9	9.5	55	50	60
Cereal residues												
Maize	91	87	95	4.8	4.6	6.5	7.1	6.3	8.7	45	40	55
Millet	90	89	93	5.2	4.8	9.3	7.5	4.6	10.0	47	29	63
Rice	83	77	86	5.4	2.3	8.6	7.5	6.7	9.0	47	42	57
Sorghum	91	90	94	4.4	2.8	7.0	8.1	6.8	10.3	51	43	65
Weighted mean (cereals)	90			4.7			7.8			49.2		

OM: organic matter; CP: crude protein

ME: metabolizable energy estimated from digestible organic matter (1 g DOM equivalent to 15.8 kJ ME); OMD: organic matter digestibility

Avg: average; Min: minimum; Max: maximum

Sources: 4, 6, 13, 21, 24

Table III

Proportions and nutritive values of stems and leaves of cereal stovers used in the calculations

Crop residue	Stem					Leaf				
	P	OM	CP	OMD	ME	P	OM	CP	OMD	ME
Millet	70	93	3.8	38	6.0	30	86	6.6	59	9.4
Sorghum	71	95	2.6	41	6.5	29	87	5.4	46	7.3
Maize	65	95	4.0	40	6.3	35	85	5.0	52	8.3
Rice	40	82	3.7	40	6.3	60	75	4.8	55	8.7
Weighted mean	70	94	3.1	40	6.3	30	86	5.8	52	8.2

P: proportion (% of OM); OM: organic matter (% in DM); CP: crude protein (% in OM)
OMD: organic matter digestibility (%); ME: metabolizable energy (MJ kg^{-1} OM) estimated from digestible organic matter (1 g OM equivalent to 15.8 kJ ME)
Sources: 1, Savadogo (unpl.)

Table IV

Proportion of feeds included in the ration when feeding aims at maintaining the maximum number of animals (HS) or maximum total live weight gain (TP). Cowpea and groundnut haulms are fully used in all rations

Crop residue	Sahelian zone		Sub-Sahelian zone		North-Sudanian zone		South-Sudanian zone	
	HS	TP	HS	TP	HS	TP	HS	TP
Situation A								
Total feed	7	2	37	10	35	11	27	10
Bambara groundnut haulms	100	60	100	74	100	100	100	100
Cereal stovers	5	0	30	0	28	1	20	0
Situation A-20								
Total feed	9	2	43	15	41	12	32	12
Bambara groundnut haulms	100	77	100	100	100	100	100	100
Cereal stovers	7	0	35	3	33	0	25	2
Situation B								
Total feed	32	11	43	22	43	29	41	17
Bambara groundnut haulms	100	100	100	100	100	100	100	100
Cereal leaves	100	30	100	45	100	71	100	31
Cereal stems	1	0	10	0	10	0	7	0
Situation B-20								
Total feed	33	13	46	21	46	33	43	26
Bambara groundnut haulms	100	100	100	100	100	100	100	100
Cereal leaves	100	36	100	35	100	81	100	58
Cereal stems	2	0	14	0	13	0	9	0

A: current quantities of feed, no distinction between leaves and stems of cereal residues; A-20: as A with legume residue assumed 20% higher
B: current quantities of feed with distinction between leaves and stems of cereal residues; B-20: as B with legume residues assumed 20% higher

principal crop in the Sahelian zone, but somewhat less important further south. Maize as % of the total area is most important in the South-Sudanian zone and sorghum in the intermediate zones. The legume crops, i.e. cowpea (*Vigna unguiculata* [L.] Walp), groundnut (*Arachis hypogaea* L.) and bambara groundnut (*Voandzeia subterranea*) occupy in all zones less than 15% of the crop area. Cowpea is often intercropped with sorghum or millet. The intercropping consists of various spatial arrangements of millet/sorghum and cowpea. The yields of the residues in t/ha^{-1} range from 1.4 to 2.3 for millet, 1.4 to 2.7 for sorghum, 0.9 to 2.1 for maize, 0.7 to 1.3 for cowpea, 0.7 to 1.4 for groundnut, and 0.8 to 0.9 for bambara groundnut.

Better quality residues are those of cowpea and groundnut, with 15.6 and 12.6% crude protein (CP), 61 and 57% digestibility of organic matter (OMD), and 9.7 and 9.0 MJ metabolizable energy (ME) per kg OM, respectively (table II). Cereal residues that represent more than 85% of all residues in all agroecological zones are lowest in nutritive value, i.e. 4.4 to 5.4% CP, 45 to 51% DOM and 7.1 to 8.1 MJ ME per kg OM. Residues of bambara groundnut are of intermediate nutritive value, i.e. 6.4% CP, 55% DOM and 7.9 MJ per kg OM. For situations A and A-20 the weighted mean nutritive value of cereal residues given in table II was used in the calculations. For situations B and B-20, where leaves and stems of cereal residues are distinguished, weighted mean values of stems and leaves were used (table III).

Retour au menu

Composition of rations

When the objective is to maintain the maximum number of animals, i.e. provide a ration meeting the requirements for maintenance only, 7% of the total amount of crop residues available in the Sahelian zone could be used in the current situation (A). This consists of all legume haulms (cowpea, groundnut and bambara groundnut) combined with 5% of the cereal stovers (table IV). Due to the larger quantities of haulms, a larger fraction of the cereal stovers could be used in the other zones: 30, 28 and 20%, respectively, while 37, 35 and 27% of the total feed could be used in the Sub-Sahelian, North-Sudanian and South-Sudanian zones, respectively. The assumed nutritive value of cereal stovers is below maintenance requirements and due to their large quantities, only a small proportion could be combined with the small quantities of haulms. Even when the amount of haulms was increased by 20% (situation A-20), only 9% of the total amount of feed in the Sahelian zone can be used and 32 to 43% in the other zones. The distinction between leaves and stems of stovers allows inclusion of a higher proportion of the stovers, and hence a higher proportion of the total amounts of feed. The increase in proportion of total feed that could be used was more important in the Sahelian zone (by a factor 4.6) than in the Sub-Sahelian and Sudanian zones. In the Sub-Sahelian and Sudanian zones, 7 to 10% of the cereal stems could be used. Under situation B-20 (selective utilization of cereal leaves and 20% increase in the quantity of haulms), only a slightly larger proportion of the stems could be used.

When the objective is to maximize animal production, even smaller proportions of cereal residues can be used. Under the current situation (A) in the Sahelian zone, the total proportion of bambara groundnut was less than 1% of the total residues and only 60% of that could be used. Also in the Sub-Sahelian zone, only 74% of the bambara groundnut haulms could be included and only 10% of the total feeds were used. When availability of haulms was assumed 20% higher, only slight changes resulted. Distinction between leaves and stems in stovers led to an increased contribution of cereal residues to the diets. Up to 71 and 81% of stover leaves could be used in situations B and B-20, respectively, in the North-Sudanian zone, and 30 to 58% in the other zones.

Carrying capacity of the different zones

Sahelian zone

When maximizing total production, a maximum of 64 10^3 livestock units could be fed in the Sahelian zone in situation B (table V), corresponding to 12% of the current livestock population (550 10^3 TLU). The associated daily weight gain was 97 g per TLU. It would be possible to feed a higher number of animals (76 10^3) for similar daily weight gain when the quantities of haulms were increased by 20% and leaves and stems of cereal residues distinguished. Under situation A, 9 10^3 TLU could be fed to gain 526 g per TLU per day for maximum total production or a maximum of 43 10^3 TLU at maintenance level. Allowing selective consumption of stover leaves (situation B) results in an increase in this maximum herd size by a factor 4.6. Increasing haulms availability by 20% (situation A-20) results in a 33% increase in herd size. Up to 37% of the current ruminant stock in this zone could be fed at maintenance level if the amounts of haulms could be increased by 20% and selective consumption of the stover leaves were allowed. In this zone, only a small total production could be derived from the available crop residues.

Sub-Sahelian zone

Maximum potential live weight gain was estimated at 10 10^6 kg in situation A, 12 10^6 kg in situations A-20 and B, and 14 10^6 kg for B-20. This production was obtained with 90, 148, 225 and 213 10^3 TLU, respectively, corresponding to 11, 18, 27 and 26% of the current ruminant population in this zone (817 10^3 TLU). These optimum herd sizes were associated with daily weight gains per animal of 302 to 526 g. When the quantity of haulms was increased by 20% or leaves of the cereal stovers were distinguished from stems, or both, the number of animals that give maximum production increased by a factor 1.64 to 2.50, but the associated daily weight gain per animal decreased so that the total production increased by only a factor 1.17 to 1.36. A maximum of 54% of the current population could be fed at maintenance level in situation A. Situation B-20 allowed maintenance of 67% of the current livestock population. The current availability of crop residues cannot maintain the current livestock population in the dry season in this zone with the assumed nutritive value, even when selective consumption is allowed.

Table V

Potentials of crop residues as ruminant feed in the different agroecological zones

Agroecological zone	At maximum TP			Maximum HS fed at maintenance
	HS	DWG	TP	
Sahelian zone				
A	9	526	1	43
A-20	9	583	1	57
B	64	97	1	198
B-20	76	98	2	206
Sub-Sahelian zone				
A	90	526	10	441
A-20	148	374	12	522
B	225	246	12	503
B-20	213	302	14	551
North-Sudanian zone				
A	464	427	42	1872
A-20	505	478	51	2235
B	1386	174	51	2259
B-20	1602	180	61	2476
South-Sudanian zone				
A	205	342	15	675
A-20	252	333	18	814
B	370	213	18	1009
B-20	592	173	22	1075

A: current quantities of feed, no distinction between leaves and stems of cereal residues

A-20: as A with legume residues assumed 20% higher

B: current quantities of feed with distinction between leaves and stems of cereal residues

B-20: as B with legume residues assumed 20% higher

HS: Herd size in 10^3 TLU (an hypothetical animal of 250 kg body weight)

DWG: daily weight gain in g d^{-1} per TLU

TP: total production in 10^6 kg

North-Sudanian zone

This zone has the highest potential. In situation A, 98% of the current 1 901 10^3 livestock units could be fed at maintenance level. If 20% more cowpea and groundnut haulms would be available, or when selective consumption of cereal stover is assumed, or both, it would be possible to maintain all the current ruminants in this zone. Total potential production varied between 42 and 61 10^6 kg. Optimum herd size associated with the highest potential production ranged from 464 to 1602 10^3 TLU.

South-Sudanian zone

In situation A, maximum production was attained with 205 10^3 TLU, associated with 342 g daily weight gain per animal. If 20% more legume haulms would be available (A-20), the optimum herd size would increase to 252 10^3 TLU. Similar trends were observed when selective consumption was assumed. When the target was to maximize herd size fed at maintenance, 76, 92, 114 and 121% of the current livestock population (887 10^3 TLU) could be maintained in situations A, A-20, B and B-20, respectively. Optimum herd sizes for maximum regional production, however, would be 205, 252, 370 and 592 10^3 TLU, respectively, corresponding to 23 to 67% of the current population. These herd sizes were associated with daily weight gains of 342, 333, 213 and 173 g per animal, giving 15 10^6 kg total production from 210 days feeding in situation A, 18 10^6 kg in A-20 and B, and 22 10^6 kg in B-20.

■ DISCUSSION

Potential of crop residues as ruminant feeds in the different agroecological zones

Crop residue yields per ha estimated in this study, are slightly lower than those reported by Van Duivenbooden (30) and Camara (6), because different straw/grain ratios have been used. Yields of crop residues are quite substantial compared to the average yields of natural forages in the same period. Winrock International (31) estimates the latter at 0.2 to 0.5 t ha^{-1} in the arid and semi-arid zones, and 0.72 to 0.76 t ha^{-1} in the subhumid and highland zones. Leloup (11) reported a forage yield of 2.3 t per ha natural grassland in Southern Mali at peak biomass. Cowpea and groundnut haulms are of reasonable quality, both in terms of digestibility and protein content, allowing acceptable levels of animal production when fed alone. However, the quantities available are insufficient to compensate for the low nutritional value of the cereal crop residues.

To increase the possibilities of using crop residues for ruminant feeding, physical, chemical and biological treatments have been tested in many developing countries (22). Chopping increases dry matter intake, but has a variable effect on digestibility and weight gain; the effectiveness of treatment with urea in terms of increased digestibility is variable (21, 27) and does not always result in increased weight gain, due to the interactions with nutrient availability. Urea treatment improves the availability of energy, but the low level of true protein may hamper the conversion of this energy into animal products. As urea treatment is also expensive, it is not widely used (7). Other treatments such as grounding, soaking, wetting, addition of NaOH, KOH, urine, composting and ensiling have been developed (27), but these are often unknown by smallholders and/or impractical and costly.

Results of the present analyzes suggest that the North and South-Sudanian zones are well endowed with crop residues that may allow meeting the feed requirements of the current ruminant population in the dry season, even without application of any of these technologies. This requires that animals be allowed to eat leaves of stovers selectively. In that situation, between 31 and 81% of the leaves would be included in the diet when maximizing animal production. When the feeding system aims at maximizing the number of animals fed at maintenance level, for which rations of lower quality can be used, even some of the stems can be included in the diets (maximum about 10%). A substantial part of the cereal residues is of such inferior quality that it does not contribute to the possibilities for maintaining animals. In these zones, intensive management of crop residues can contribute to intensified ruminant livestock production, which may lead to increased recycling of nutrients, if all nutrients in animal excreta could be returned to the crop land. Recycling, however, is associated with unavoidable losses. Hence, more intense recycling also leads to greater losses in absolute terms. Therefore, this recycling may lead to higher nutrient availability for crops in the short run, but contributes to more efficient mining in the long run. The degree to which more intensive management of crop residues will be adopted depends on possibilities to collect and transport residues, conservation techniques and the value attached by farmers to the different alternative uses of these residues.

Practical implications

Optimizing use of crop residues has for a long time been a major concern in the semi-arid West African Research and Development programs. Based on the results of this study, the following measures can be suggested that can help to improve the contribution of crop residues to ruminant feeding:

- the first step towards improved utilization of crop residues would be to improve residue collection and conservation techniques that minimize the reduction in nutritive value, especially of the scarce highest quality residues. Collected and conserved under good conditions, the nutritive value of cowpea and groundnut haulms can be quite high (> 20% crude protein and 60 to 70% OMD). Also appropriate collection and storage minimizes losses of cereal leaves;

- improvement of animal production in systems based on crop residues during the dry season requires an increase in the availability of better quality feed (residues of leguminous crops). In the Sahelian and Sub-Sahelian zones, very little scope seems to exist for such an improvement because of unfavorable climatic conditions. In the other zones, some possibilities may exist although availability of soil nutrients may be a major limiting factor. Introduction of cultivated forages as single crop meets difficulties related to the shortage of suitable land and labor, but legume-cereal intercropping as already applied by farmers, could be successfully used (25, 26). In addition to taking advantage of N fixation by legumes, intercropping of cereals and legumes reduces the competition for land. Intercropping of maize and *Dolichos lablab* for example has attracted great interest in South Mali (10). The utilization of dual-purpose varieties (cultivated for both grain and forage), i.e. *Vigna unguiculata* types Vita1, Vita3, and 58-74 selected in Burkina Faso (9), reduces the land area and labor needed. Moreover, the lower cereal yields that may result from intercropping are compensated by higher animal production. Increasing the amount of legume haulms is an alternative for using concentrate, which requires much working capital;

- in the Sudanian zones, where availability of cereal stover is higher, it may be profitable to take advantage of the capacity of animals to use feeds selectively by excess feeding, to increase

Retour au menu

quantity and quality of intake by allowing animals to consume only leaves. Subba Rao *et al.* (28) have shown that selective consumption of the better part of millet stover by sheep allows energy intake levels close to their maintenance requirements. Bhargava *et al.* (2) indicated that intake of digestible organic matter by sheep fed excess barley straw, so that animals can select, is comparable to that realized after treating straw with alkali. This feeding technique should be combined with improved refusal management so that refused organic matter can be effectively returned to cropland.

■ CONCLUSION

From the above results we conclude that crop residues can improve significantly animal production in the Sudanian zones, if suitable feeding strategies are applied. The possibility for selective consumption of cereal stover leaves and availability of legume haulms determine the level of production that can be achieved, depending on the production objectives. In low external input systems, crop residues represent a strategic organic matter and nutrient resource for soil and animals. Their optimum utilization implies thus a choice or compromise between maximizing animal production and maintaining maximum number of animals. The model used in this study allows assessment of the potential of a total package of tropical feed resources, as a basis for identification of relevant feeding strategies.

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Résumé

Savadogo M., Zemmelink G., Van Keulen H., Nianogo A. J. Contribution des résidus de récoltes à l'alimentation des ruminants dans differentes zones agro-écologiques du Burkina Faso

Un modèle statique a été utilisé pour évaluer la contribution potentielle des résidus de récoltes à l'alimentation des ruminants dans différentes zones agro-écologiques du Burkina Faso. Les résidus de céréales, comprenant le maïs (*Zea mays* L.), le mil (*Pennisetum glaucum* [L.] R.Br.), le sorgho (*Sorghum bicolor* [L.] Moench) et le riz (*Oryza sativa* L.) représentent 90 à 98 % des quantités totales de résidus de récoltes. Ils présentent de faibles taux de protéine brute (Pb : 4,7 % en moyenne) et une faible digestibilité de la matière organique (dMO : 49,2 % en moyenne). Le reste est constitué des résidus de fanes de niébé (*Vigna unguiculata* [L.] Walp) et d'arachide (*Arachis hypogaea* L.) qui sont de meilleure qualité (Pb : 12,6 à 15,6 %, dMO : 57 à 61 %) ; ceux du voandzou (*Voandzeia subterranea*) sont de valeur intermédiaire (Pb : 6,4 %, dMO : 55 %). Avec les quantités de résidus de récoltes disponibles, un maximum de 8, 54, 98 et 76 % des ruminants, respectivement dans les zones sahélienne, sub-sahélienne, nord et sud-soudanienne, pourraient être entretenus pendant toute la saison sèche. Une utilisation optimale des résidus de récoltes pourrait contribuer de manière significative à l'intensification des productions animales, spécialement dans les zones soudaniennes.

Mots-clés : Ruminants - Consommation alimentaire - Céréale - Légumineuse - Résidu de récolte - Capacité de charge - Zone agroclimatique - Burkina Faso.

Resumen

Savadogo M., Zemmelink G., Van Keulen H., Nianogo A. J. Contribución de los residuos de cosechas en la alimentación de los rumiantes en diferentes zonas agroecológicas de Burkina Faso

Se utiliza un modelo estático para evaluar el potencial de la contribución de los residuos de cosechas en la alimentación de los rumiantes, en diferentes zonas agroecológicas de Burkina Faso. Los residuos de las cosechas de cereales, incluyendo maíz (*Zea mays* L.), millo (*Pennisetum glaucum* [L]R.Br.), sorgo (*Sorghum bicolor* [L] Moench) y arroz (*Oryza sativa* L.) representan 90 a 98% de la cantidad total de residuos de cosechas. Estos residuos se caracterizan por un bajo contenido de proteína cruda (CP) (4,7% en promedio) y una baja digestibilidad de materia orgánica (OMD promedio de 49,2%). Los residuos de mejor calidad son los tallos de *Vigna unguiculata* ([L] Walp) y cacahuete (*Arachis hypogaea* L.) con 12,6 a 15,6% CP y 57 a 61% OMD. Los residuos de cacahuete bambara (*Voandzeia subterranea*) tienen un valor intermedio: 6,4% de CP y 55% de OMD. Con las cantidades actuales de los diferentes residuos, se podría alimentar un máximo de 8, 54, 98 y 76% del hato rumiante, a nivel de mantenimiento durante la estación seca, en las zonas Sahelina, sub-Sahelina, Sur-Sudanesa y Norte-Sudanesa, respectivamente. La optimización del uso de los residuos de cosechas en las zonas sudanesas puede contribuir a la intensificación de la producción animal.

Palabras clave: Rumiante - Consumo de piensos - Cereales - Leguminosas - Residuos de cosechas - Capacidad de carga - Regiones agroclimaticas - Burkina Faso.