The Role of Feeding System Based on Cereal Residues in Integrated Farming Systems in Sub-Saharan Africa

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Abstract
The traditional practice of transhumance in the African Sahelian countries has been severely hit by the droughts. The combined effects of recurrent droughts and declining pasture availability have both resulted in major changes in livestock ownership and production systems. Transhumant pastoralists are increasingly settling in cropping zones, growing mainly sorghum and millet as staple food grains. The rise in human population and livestock numbers, decline in pasture availability and the expansion of cultivated areas have greatly increased the pressure on available land resources and led to declining soil fertility which is already very fragile.

The above factors have inevitably accelerated the process of integrating livestock into crop production, as crop residues and manure are becoming increasingly valuable, the former for animal feed and the latter as fertilizer. However, the challenge of assuring the sustainability of the integrated farming system is how to integrate animal production with crop production so that it contributes to an intensification of both food production and cash income and encourages the maintenance of soil fertility in the Sahelian regions of Africa. These principles have been applied successfully in the FAO-UNDP project in Niger (FAO-PNUD/ NER/89/016: Extension de la Methode de Traitement a l'Uree des Fourrages Grossiers), where it has been shown that the improvement in

the ruminant feeding system based on urea treatment of crop residues is rapidly and enthusiastically received by resource-poor farmers. The technique of urea treatment is very simple, inexpensive and suitably adapted to Sahelian crop farmers. The advantages are undeniable greatest for feeding large and small ruminants during the dry season. The nutritive value of crop residues, namely sorghum and millet stovers, is greatly improved (nitrogen content, digestibility and consumption are significantly increased) and they are far better utilized since the edible proportion is increased.

This improvement of the animal feed, based on better utilization of crop residues not only led to better maintenance of live weight and other animal performance but extended to greater integration of crop and livestock production systems through improvements in draught animal power and increased availability of organic manure. Fields are ploughed more efficiently and rapidly. Nitrogen content in dung is sharply increased when animals are fed urea-treated forages compared to untreated forages (7 to 8.3 percent instead of 4.5 to 5.8 percent), which is extremely significant for soil fertility. As a result, yields of millet and sorghum are increased by roughly one-fifth to a third, improving the food security and income of farmers, decreasing the rural exodus and reducing the pressure on soils. The technique contributes also to reducing the animal pressure on the environment.

KEY WORDS: Feed, ruminant, Sahel, straw treatment, urea, millet, sorghum, soil fertility, integration

Introduction

The Sahel countries, which comprise Chad, Gambia, Mali, Mauritania, Niger, Senegal and Guinea Bissau, are characterized by their arid climate, low soil fertility, low annual rainfall (100 to 400 mm) with one long dry season of eight to nine months and recurrent droughts. This subject is introduced by reference to studies and observations mainly made in Niger.

Factors Changing Traditional Farming Systems and Their Consequences

The traditional farming systems in the Sahel have been based on an adaptation to low and variable rainfall, poor and fragile soils and widely available land (Speirs and Olsen, 1992). Over the past decades, the Sahel has had to face an increasingly difficult economic situation. Recurrent drought and temporal variation in rainfall are considerably changing farming systems and the socio-economic conditions of Sahelian farmers. For example, the practice of transhumance has been severely hit by the drought and many transhumant pastoralists were obliged to abandon their traditional dry season grazing areas and move to the south in higher rainfall zones where both pasture and crop residue outputs are greater (Dalibard, 1995). This phenomenon had resulted in major changes in production systems:

a. Transhumant pastoralists are increasingly settling and cultivating in cropping zones,
b. The high rate of population growth (average 3% per annum), the increasing settlement of nomads, the increase in the number of livestock in arable zones, the increase in cultivated area and the reduction of fallow periods have greatly augmented the pressure on available land resources and reduced soil fertility,
c. Land available for grazing animals is becoming increasingly scarce and of poor quality, as more and more is occupied by crop cultivation. In many zones, conflicts between crop farmers and pastoralists over access to land have therefore become more frequent and serious.
d. There have also been major changes in the pattern of livestock ownership: an increasing proportion of stock in the Sahel is now owned by crop farmers and many merchants have profited from low livestock prices during droughts to acquire more animals from poor farmers and pastoralists.

The above factors have inevitably accelerated the gradual evolution from separate crop and livestock production systems in the Sahel towards integrated mixed farming systems (Speirs and Olsen, 1992; Lhoste,

1987). As land becomes ever more scarce, crop by-products (residues) and manure from livestock are becoming more valuable, the former for animal feed and the latter as fertilizer, and playing a key role in promoting a beneficial integrated farming system.

The Role of Feeding Systems Based on Cereal Residues in Integrated Farming Systems in the Sahel

Crop production is characterized by a few cash crops such as cotton and groundnuts, and cereal crops for domestic consumption. The main cereals grown are millet and sorghum, intercropped with cowpeas in some zones and, to a much lesser extent, paddy rice, mainly in irrigated areas. Millet and sorghum are the predominant staple food grains and there is little rotation of crops. Because of declining soil fertility, yields of millet and sorghum are extremely variable and generally low; 500 kg/ha is often recorded as an average yield. Many farmers do not produce enough cereals to meet their domestic requirements.

In addition to crop cultivation, farmers practise animal husbandry (cattle, small ruminants, draft animals, dromedaries) and the livestock contribution to household income is increasing with the deterioration in the terms of trade of agricultural products from the Sahel, notably groundnuts and cotton (Club du Sahel and CILSS, 1989). As pasture production has declined, ruminant animals in the Sahel have become more dependent on crop residues which assume a progressively greater proportion of the total diet, and have become the basic feeds for animals belonging to the traditional crop farmers, as well as to the newly settled pastoralists. They are mainly used during the dry season. The collection of crop residues from fields sown with millet, sorghum, rice, groundnuts, cowpeas and pigeon peas is increasing as a larger proportion of livestock is maintained near to the household and an intensive fattening system has been introduced in many projects.

Unfortunately the feeding system practised in the Sahel is based on cereal crop residues of poor quality with low nitrogen, energy and mineral contents. In addition, the edible proportion of sorghum and millet stovers is low and rarely exceeds one-third of the biomass. Therefore, most of animals lose weight, become weak and are more susceptible to

disease by the end of the dry season.

Effect of Improved Feeding Systems Based on Cereal Residues on Greater Integration of Livestock Into Crop Production Systems

The feeding of urea-treated cereal residues (sorghum and millet stovers, and rice straw) to large and small ruminants in Niger since 1991 (FAO-PNUD/ NER/89/016: Extension de la Methode de Traitement a l'Uree des Fourrages Grossiers) has greatly improved animal productivity and it has also been shown that this technique can be a way to strengthen the capability of farmers to run integrated crop-livestock systems while improving food security and the well-being of farmers.

Urea treatment is a simple method

Urea treatment of cereal residues, as developed in Niger, is a simple technique based on the use of locally available materials in villages. Sorghum and millet stovers, savannah grasses and rice straw are treated with urea (5 kg urea dissolved in 50 litres water to 100 kg dry residues) and made into a stack using the traditional storage method and locally available air-tight system in the village: silos made from sekos (Andropogon gayanus) or banco (briquettes made from clay and straw). Air-tightness was successfully ensured by tying with braids made from Andropogon gayanus and no plastic was used. Urea-treated forage was well preserved, showing a dark brown colour, with a strong smell of ammonia and a softer consistency. The treatment was effective and the nutritive value of poor quality forage was greatly improved, as confirmed by analysis (table 1): dry matter digestibility is significantly increased after treatment (an average increase of 20%) and the nitrogen content is more than doubled. In addition, most of the introduced urea is hydrolyzed (at least 78%) to ammonia gas which is the essential chemical product for upgrading cellulosic materials in forages.

Table 1: Effect of urea treatment on improving the nutritive value of sorghum stovers, rice straw and savannah grasses in Niger (treated forage is stored according to the traditional storage system using local covering materials) (5 percent urea in 50 litres water to 100 kg dry residues)

Forage		N x 6.25	*In sacco* digest-ibility	Residual urea
Sorghum stover	untreated	5 ± 2	38 ± 7	
N=18	treated	10 ± 4	47 ± 4	0.78
Rice straw	untreated	4 ± 2	39 ± 5	
N=28	treated	11 ± 3	50 ± 6	0.92
Savannah grasses	untreated	4 ± 2	36 ± 3	
N=20	treated	10 ± 3	45 ± 2	0.86

Positive Results Are Obtained in Animals

a. Urea-treated forage is appetizing. The intake is much increased and refusals decreased considerably, especially in the case of millet and sorghum stovers. Quantities distributed to animals can be reduced by a third when the forage is treated. About 70 per cent of treated stovers is edible while the usual edible proportion is only 30 to 40 per cent with untreated stovers. Their is therefore less wastage. Water intake is also increased (by about 30 per cent) as a consequence of higher dry matter intake (Table 2).
b. Improvement of animal performance: The consumption of treated forages during the dry season is often accompanied by an improvement in body condition of the animals and maintenance of live weight; they are also more resistant to disease and their coat is

improved (brighter hair). Thin and weak animals recuperate rapidly. Farmers have noted a positive effect on animal fattening. The fattening period is reduced with a consequent saving in concentrates. Furthermore, selling of fattened animals is made easier, especially at the end of dry season when there is a shortage of animals with good conformation. Finally milk from dairy cows is significantly increased, allowing a better growth of the suckled calf, an increased amount for household consumption and the sale of the remainder. Dairy recording, undertaken over 4 months, confirmed this important increase (280-350 litres instead of 150).

c. Improvement in the capacity of draught animal power and the improvement in the quantity and quality of dung have been noted by the majority of peasants as the two essential points of the technique. Farmers in Niger have given priority to feeding treated forages to draught animals during working periods, as well as at the end of their working cycle when animals are fattened and sold.

The Role of the Improved Feeding System in Strengthening the Integration of Draught Cattle Power Into Crop Production Systems

The use of draught cattle (oxen) is common and increases in the Sahel because of the extension of the cropping zones and settlement of the pastoralists, and this plays a major role in the development of integrated systems. In addition, they have a key socio-economic function in the Sahel by increasing the opportunities to earn non-farm income with the use of animals in the transport sector to carry a variety of goods such as wood, water, building materials, crop residues, manure to the fields, products and farmers to and from markets and so on. Draught animals also make a significant contribution to household income, mainly through the end value after their working life when they are sold for meat production.

Almost all farmers who fed urea-treated forages to oxen had carefully observed that, during the dry season, animal body condition was improved and they did not lose live weight during the ploughing period. In addition, animals work harder and longer, compared to those fed on

untreated straw and stovers. It is often reported that animals plough 1.5 to 2 hours more per day. Some on-farm trials undertaken in Cambodia and Laos are closely comparable with these results (table 2). This is particularly crucial, since field ploughing is undertaken at the end of the dry season and beginning of the rainy season, when feed resources are scarce and of low quality. Draught animal power is therefore weakened, even before starting work, compromising the sowing of crops. However, when draft animals are fed treated forages, fields are ploughed efficiently and rapidly, more land can be cultivated and crop yields are greatly improved. Because ploughing is more rapidly completed, several peasants have rented their animals to neighbours and raised their cash income.

Table 2: Effect of feeding urea-treated straw on straw intake, water consumption and thoracic perimeter measures in Laos (February, Mars and April 1996) (Kayouli, 1996)

Animals	Intake /head /day				Thoracic perimeter	
	Untreated straw kg	Water litres	Urea-treated straw kg	Water litres	initial cm	final cm
Cattle						
1	3.5	25	3.5	35	149	151
2	3	22	4	31	137	140
3	3	25	4.5	32	130	132
Buffalo						
1	3.5	28	5	38	165	166
2	4	30	6	40	168	172
3	4	31	6	42	160	163
4	3	20	4	30	91	95
5	3	25	4	34	105	107
6	4.5	35	6	42	182	186

Role of the Improved Feeding System in Integrating Livestock Into Crop Production Systems Through Better Manuring of Fields

Draught animals are often constantly maintained at or near the households or the settlement, where they are fed on crop residues and collected savannah grasses. These animals are the basic producers of manure, which is increasingly used as fertilizer on crop fields prior to sowing (Orskov, 1995; Powell and Mohamed-Saleem, 1987). Farmers in the Sahel are aware that the main limiting factor responsible for the lower crop yields is the quality of soils: organic matter is reducing and the fertility of soils is continually declining as a results of the reduction or abandonment of fallow periods. The key problem of maintaining or improving crop productivity per unit area in the Sahel is how to enrich the soil. The quantity of manure produced per household is often insufficient to sustain soil fertility (Speirs and Olsen, 1992). This issue is further accelerated since the manuring of fields practised in the past by transhumant herds in exchange for crop products (manuring contracts) is diminishing because crop residues are increasingly collected by crop farmers to feed their own animals or for sale.

The feeding system based on urea-treated stovers and straw in Niger and elsewhere has been accompanied by positive, and sometimes unexpected, effects. Dung is more abundant: a higher output of faeces which was of a wetter consistency and darker colour, and of high quality as fertilizer. These results emerge from numerous on-farm trials and findings of farmers. Laboratory analysis indicated that nitrogen content in dung is sharply increased when animals are fed urea-treated forage compared to untreated forages (7-8.3 per cent instead of 4.5-5.8 per cent; Sourabie *et al*., 1995; Sansoucy, 1995). Similar results have also been recorded elsewhere with animals fed urea-treated rice straw (table 3). The urea or ammonia treatment generates an increase in the nitrogen excreted in the dung. This increase results from: (I) nitrogen fixed to indigestible cell walls ,(ii) microbial nitrogen coming from fermentation in the large intestine and not able to be digested (Chenost and Besle, 1993); (iii) it is also expected that the microbial protein in the rumen, which contain about 20% indigestible nucleic acids, is significantly increased after intake of urea-treated forages since there is more energy and nitrogen in treated forages which stimulate rumen microbial growth.

Table 3: Influence of alkaline treatment on nitrogen content of dung of ruminants (mean values ± standard deviation; as per cent of faeces dry matter)

Cereal residues	n	N x 6.25	Reference
Wheat straw			
Treated (3.5% NH3)	7	15.6 ± 2.6	Chenost & Dulphy, 1987
Treated (5% urea)	4	13.8 ± 0.9	France.
Control	7	9.5 ± 0.6	
Millet stover			
Treated (5% urea)	5	9.4 ± 2.1	Kayouli, 1994. Niger.
Control	9	5.9 ± 1.1	
Rice straw			
Treated (5% urea)	10	8.5 ± 2,4	Kayouli, 1996. Laos.
Control	10	6.3 ± 0.9	

Comparison between fields fertilized with dung produced by animals fed treated forage with those fertilized with traditional dung shows that the former improves soil texture fertility and crops are greener, more productive and more vigorous. Crop yields are therefore significantly increased. This improvement is highly significant in Niger where soils are naturally poor, with very low organic matter content. For example, some peasants have reported increases of 40 to 50% in the production of cereals, despite a reduction of half of the quantity of urea used on the fields. Farmers in Laos, who traditionally use dung as fertilizer in paddy fields, have also perceived with much interest that the best quality of manure is produced by animals fed urea-treated rice straw, improving soil fertility and thereby rice yield. Table 4 shows a significant increase of production per hectare varying from 15 to 24 percent.

Table 4: Effect of dung (as a fertilizer) produced by animals fed urea-treated rice straw (UTRS) on the paddy rice yield in Laos (Kayouli, 1996).

Province	Paddy production (sacks*) Before feeding	After UTRS**	Observations
Vientiane	60	70	3 ha. 4 t UTRS. 15 animals
Pakse	28	32	1 ha. 1 t UTRS. 2 animals
Saravanne	50	62	4 ha. 3 t UTRS. 5 animals

* 1 sack = 75 kg.
** UTRS = urea-treated rice straw

Conclusion

The improvement of animal feeding based on better utilization of crop residues not only led to better maintenance of live weight and improved animal performance but led to greater integration of crop and livestock production systems through improvements in draught animal power and increased availability of organic manure. The use of crop residues is indeed enhanced after urea treatment. Yields of millet and sorghum, which are the staple foodgrain, are increased by one-fifth to a third, improving the food security and income of farmers, decreasing the rural exodus and reducing the pressure on soils. The technique contributes also to reducing the animal pressure on the environment as reported by Dalibard, 1995.

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