ON-FARM TREATMENT OF STRAWS AND STOVERS WITH UREA

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Abstract

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The nutritional value of cereal crop residues to ruminants is constrained by low N and high fibre contents. These constraints can be alleviated by treatment with alkali, the most suitable of which, for smallholder use, is urea. However, it has not widely been used in Africa. Whilst in some areas, cost and availability of urea will be a factor, it may also be that the flexibility of the technique is not appreciated. The scope for adaptation at each stage of the procedure is reviewed, showing that the farmer does have options to develop a system suitable for a range of conditions.

1. INTRODUCTION

Farmers accept that fibrous straws and stovers from cereal grain crops are a poor feed resource because their crude protein (CP) content is low and fibre levels are high. When offered to livestock both dry matter intake and palatability are low. However, these residues are often the only livestock feed available in smallholder mixed crop and livestock systems, especially in areas characterised by a defined dry season or with high land pressure resulting from a high human population.

The total amount of fibrous residues available in Zambia has been estimated as 2–4 tons per livestock unit [1]. This suggests that if these materials were used optimally, so that a small improvement in the nutritive value was obtained, there would be a marked reduction in dry season feeding stress in livestock in developing countries [2].

2. WHAT CAN BE DONE TO IMPROVE THE NUTRITIVE VALUE OF THESE RESIDUES?

The answer to this question is addressed in other contributions to these proceedings. It is the on-farm application of one of these tools, treatment with urea, which needs further consideration.

3. WHY USE UREA?

Of the three chemicals (sodium hydroxide, ammonia, urea) most tested as improving agents for residues, urea is the best qualified for use in smallholder systems in the tropics because:

- It is usually available as a product (ammonium nitrate) with which farmers are familiar.
- Sufficient urease to ensure breakdown of urea to ammonia does not appear to be a problem in a warm climate.
- Urea breaks down the ligno-cellulose bonds of the residue, increasing rate and extent of rumen microbial digestion.
- It improves the nitrogen status of the residue.
- It is relatively safe and easy to use.

- It is easy to transport, if necessary in small quantities.
- There are no recorded social or cultural reasons (as could be a constraint to widespread use of urine) prohibiting its use.
- There is no damage to the environment

4. DIGESTIBILITY AND INTAKE

The objectives of treating residues are to increase the proportion of their gross energy available to the animal as metabolizable energy and to raise intake. Urea treatment has been found effective with all the major sources of crop residue (barley, rice and wheat straws; maize, millet and sorghum stover). Table I gives an indication of typical responses in nitrogen enrichment, digestibility and intake after urea treatment, for the major residues available in Africa.

TABLE I. EFFECT OF UREA TREATMENT ON NITROGEN CONTENT (N, g/kg DM), DRY MATTER DIGESTIBILITY (DMD, g/kg DM) AND DRY MATTER INTAKE (DMI, g/kg$^{0.75}$/DAY) (FALL ET AL. [3], FALL [4]).

Residue	N	DMD	DMI
Rice straw			
Urea (5%)	12.6	540 ± 40 (n=6)	61 ± 10 (n=6)
Control	7.2	430 ± 40 (n=6)	48 ± 3 (n=5)
Maize Stover			
Urea (5%)	23.8	570 ± 50 (n=6)	53 ± 10 (n=6)
Control	6.2	490 ± 20 (n=6)	40 ± 5 (n=5)
Millet stover			
Urea (5%)	22.6	490 ± 60 (n=5)	31 ± 7 (n=4)
Control	13.4	390 ± 60 (n=5)	31 ± 7 (n=4)
Sorghum stover			
Urea (5%)	23.4	650 ± 30 (n=6)	68 ± 3 (n=6)
Control	6.7	470 ± 50 (n=2)	50 ± 6 (n=5)

5. WHY IS UPTAKE, PARTICULARLY IN AFRICA, DISAPPOINTING?

The original work on treatment of residues was carried out in Northern Europe, based on the use of sodium hydroxide [5], as much to preserve straw, which was damp at the time of collection and storage, as to improve its value, the possibilities for which became apparent as the technology developed. This technology has been applied to tropical residues in laboratory conditions, but is not suited for use by resource poor farmers, who need an easy and safe treatment procedure which will both upgrade the residue and add N. The use of urea, already familiar to many farmers as a fertiliser and feed, is currently the most widely acceptable. Interest by farmers varies, but has been high, especially in some Provinces in China. In Africa uptake has been disappointing. However, the following points need considering [6].

- Cost and availability of urea (conflict in using resources to treat residues or as a fertilizer?). In some countries urea has to be imported, thus having to compete for limited availability of foreign currency.
- Cost and availability of sealing materials (e.g. plastic sheeting or bags) and stores.
- Labour constraints. In many areas it is normal to leave residues *in situ,* for grazing, rather than gather and store them.
- Seasonal variation in feed supply.
- Benefits are not always obvious.
- Residues produced some distance from livestock, necessitating the use of transport (expensive with bulky feeds).
- Lack of knowledge and training. Both farmers and extension workers need practical demonstrations and appropriate fact sheets to assist with the treatment procedure.
- Rigid procedures for applying treatment.

In summary, it is predictable that use of urea for treating crop residues will be most acceptable where urea is cheap and can be purchased locally. The cost of sealing can be reduced, but labour may be needed to dig pits. The technique will probably not be attractive following good rains, when there is a carry over of alternative feeds. The process costs time and money, for which the farmer needs to see some reward, suggesting that strategic feeding (e.g. draught, pregnant and milking animals) of treated residues should be encouraged. Adequate explanation and demonstration is necessary, together with help in adaptation to local conditions.

6. ARE TREATMENT PROCEDURES TOO RIGID?

To assess the benefits of urea treatment, loss of urea/ammonia, through extraneous factors must be eliminated. This necessitates guidelines for mixing the urea solution, method of sealing for incubation (this must be as tight as possible so that ammonia is not lost, thereby reducing the effects of treatment) and the time of incubation (the aim is usually to obtain the full benefit of the urea). However, is simplification of the system to promote adoption by farmer's possible, especially in Africa. Is there any scope to produce a system, which meets technical requirements and is 'farmer-friendly' in its application.

7. IS THERE SUFFICIENT FLEXIBILITY TO MAKE UREA TREATMENT WORK IN PRACTICE?

7.1. Economics

Economics of purchasing urea to treat residues or use as fertiliser will depend on the unit cost, expected returns, severity of the season/other available feed resources and the farmer's access to financial support. Intensive land pressure and a poor growing season will always increase the dependence of livestock on crop residues. Orskov [6] suggested an economic price for one kg of urea as costing no more than two kg of high quality concentrates. The cost of extra nutrients derived from processing must be compared with the cost of nutrients from other sources [7].

7.2. Labour requirements

It can be managed by varying the size of batch to be treated, from a daily task to one which is undertaken once or twice during the season. This requires forward planning.

Convenience will depend in part on treatment time, availability of resources and the number of animals to be fed.

7.3. Storage before treatment

Residues destined for treatment need collecting and storing as soon after grain harvest as possible to reduce leaf-loss: however, in the semi-arid areas of Central and Southern Africa there is increasing interest in conserving them (S. Ncube, personal communication). Methods of collection and storage of residues vary [8]. Local materials are being used to build structures to prevent post-harvest losses, through the effects of weathering, in a semi-arid environment [9].

7.4. Urea requirement

It is accepted that crop residues need to be offered with supplementary nitrogen to improve their fermentation in the rumen. Urea is often the cheapest source and can either be added at the point of feeding (often in conjunction with a soluble energy source such as molasses) or used as a treatment agent. Saadullah et al. [2] noted that DRY MATTER DIGESTIBILITY (DMD) was increased by six units when urea was added as a supplement at the point of feeding but by 11% units when it was added to the straw 10 days previously. The amount of urea added, as a percentage of the weight of residue, has varied between three and five (see review; [10]). Smith et al. [11] found no advantage in treating maize stover with 7% urea, compared to 5%, although 2% was insufficient to prevent moulding in wheat straw when added with 20% (w/w) water (Manyuchi and Smith unpublished data). Results similar to those of Smith et al. [11] were obtained for wheat straw by Singh and Makkar [12]. Orskov [6] recommended 'around' five per cent urea (w/w basis).

Once the amount of urea has been determined for a given amount of residue, it can be measured using a container of known volume. Residues will probably also be ‘measured’ (e.g. a known number of armfuls). Check weighings should be done when possible.

7.5. Amount of solution (water)

The amount of water used has also varied. Munthali et al. [13] used 1.5 litres of solution per kg maize stover, as in earlier work [14] they found inadequate wetting when one litre of solution per kg stover was applied. However, in Bangladesh, Dolberg et al. [15] found one litre of solution adequate when treating dry rice straw. This is the amount recommended by Fall [4]. Orskov [6] recommended 40–50% solution (w/w basis), but also pointed out that in dry areas water supply (both flow rate and total supply) can be a major problem. This could result in the quantity of solution being reduced or the size of individual treatment batches being reduced. Smith et al. [11] added 20% solution when treating maize stover. For relatively small batches the solution is best applied using a watering can with a rose.

7.6. Preventing loss of ammonia from freshly treated material

Ammonia loss can be prevented by wrapping the treated material in plastic sheeting. The disadvantages with this are, assuming the plastic is available, cost and damage from birds and animals. Disposal of torn plastic sheeting may cause a pollution problem. Cheaper, readily available materials are needed to create the airtight conditions needed. Ibrahim et al. [16] (quoted by Sundstol and Coxworth, [10]) stored urea-treated rice straw in earthen pits, polyethylene bags, coconut leaves, urea bags, ‘big bags’ and in an open stack. The most efficient, measured by the lowest incidence of mould and increased digestibility and intake, were earthen pits and polyethylene bags. Saadullah et al. [17] found similar improvements in urea-treated rice straw, either stored in earthen pits lined with a mixture of soil and cattle dung with a covering of banana leaves, or bamboo baskets. Dolberg et al. [15] lined the sides of pits with banana and coconut leaves and covered them with the same materials topped with 30 cm of soil. In one village the authors observed treated straw stacked and covered with the leaves, which were tied to keep them in place. Where earthen pits have been used a variety of materials have been employed to seal the tops, including plastic sheeting; plastic and jute bags; soil; cow dung. Plastic (sheet or bags), when available, is usually laid between the residue and other materials to avoid contamination.

7.7. Length of incubation period

Oji and Mowat [18] found that treatment of maize stoker with ammonia resulted in a higher intake and digestibility after 12 hours incubation at 90°C, compared to 30 days at 60°C. As ammonia is the treatment agent released from the breakdown of urea by urease of microbes which are present as contaminant in straw [19], it is reasonable to assume that ambient temperature will be an important factor in the process. However, whilst some manipulation of temperature may be possible (e.g. selecting site for incubation, storage under a metal roof), supplying heat to speed up the process is not feasible. The same workers, Oji and Mowat [20], found that urea treated maize stover, with a dry matter content of 55–65% stored in polythene bags and kept at room temperature, 70% of the urea was decomposed after two days. All the urea had disappeared after 20 days. Temperature dependent hydrolysis of urea and increase in dry matter digestibility of wheat straw have also been observed by Makkar and Singh [19] and Singh and Makkar [12]. Saadullah et al. [17] found that the N content of rice straw was similar after 20 or 40 days incubation. In another trial an 11% unit increase in the digestibility of rice straw was noted after 10 days incubation [2]. Smith et al. [11] found that *in vitro* digestibility was unimproved after seven days incubation, but was improved after 21 or 35 days. Ambient temperatures ranged from a minimum of 4°C to a maximum of 31°C over the treatment period. Orskov [6] suggested 14–28 days incubation time, depending on ambient temperature, whilst Fall (1990) recommended 14 days in a tropical environment and up to 42 days in cooler regions.

Dolberg et al. [15] noted that treated straw absorbed more moisture than the same straw untreated, with the result that it may have a reduced shelf-life when atmospheric humidity is high.

8. ADAPTATION OF PROCEDURES FOR THE LITTLE FLOWER LEPROSY WELFARE ASSOCIATION FARM IN NORTHERN BIHAR

A herd of 25 milking cows and their followers were considered to be under-performing, with poor nutrition as a major factor. Roughage, largely from wheat and rice straw, was in short supply (each cow received about 6 kg straw per day) and budgetary constraints limited the amount of concentrates which could be purchased.

Chopped straw was delivered in daily. This suited the transport (ox cart) and also the limited storage space. Regular labour was available, with routine work relatively easy to fit into the system. Urea was readily available in 50 kg bags, at 4 rupee/kg (milk retailing at 17 rupee/litre). It was decided to store the treated material in woven plastic meal bags (available on the farm) and measure the response, before purchasing plastic bags. Initially it was decided to treat 25% of the total straw intake with 5% urea. Bags held about 7.5 kg straw and this was treated with 3 litre of solution, which was added as the straw was packed into the bag. Bags were stored in a low building with an asbestos roof for 10 days (warm season).

To allow a sample to be brought to UK for analysis, the first bag was opened after only eight days. The colour had changed from dull brown to bright yellow and there was a lingering smell of ammonia (this was present in the storage shed, indicating that the woven bags were allowing some ammonia to escape). Gas production [21] from the two straws showed that the treated material produced more gas in the first 48 hours than the untreated, although total production at 96 hours was similar. *In vitro* organic matter digestibility [21] was increased from 41 to 48% at 48 hours. The increase in N was disappointing, up from 0.64 to 0.78%, possibly reflecting the short incubation time and relatively open weave of the bags.

9. CONCLUSIONS

Saadullah et al. [2] concluded that for Bangladesh the attractions of treating residues with urea are the relative simplicity of the process and the competitive price of urea. Both these aspects are essential for widespread adoption in Africa. Fall [2] suggested on-farm research to devise suitable practical procedures for urea treatment. The evidence presented here suggests that farmers do have choices. They need to be made aware of them and the potential benefits that could be realised.

At every stage of the process of treating residues with urea there has been variation in the procedures used. Farmers should select the options that will best suit their particular circumstances (size of individual batches; amount of water to use; method of storage; time of incubation, etc.) (Table II). There is little the farmer can do about the cost of urea, but whatever the cost the outlay is best justified when there is a production objective (e.g. milk or draught power)

TABLE II. SUMMARY OF OPTIONS FOR APPLYING UREA TREATMENT TO CROP RESIDUES.

	Range	Recommendation	Comment
Pre-treatment Storage		Covered store with air circulation	Prevent mould formation and leaf loss
Batch size	Daily or less often (e.g. once /season)	Depends on labour, urea and water supply, place/room available for storage of treated material	With high relative humidity a short storage period indicated
Incubation period	2–40 days	10–30 days in tropical regions.	Higher the ambient temperature, quicker the reaction
Urea requirement	3–7%	5%	Costs money: weigh or measure known volume
Amount of solution	20–150%	40–50% up to 100%	Water availability; thorough wetting, with residue 'holding water'
Storage/ Covering	Pits/bags/baskets	Cheap, locally available materials	If covering with soil, put leaves/bags between residue and soil
Tools	Depends on scale of operation	Water drum/bucket/ watering can/scales (or appropriate measures)	Elaborate equipment unnecessary. If measuring volumetrically, check weigh when possible.

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