

## RELEVANCE OF BREEDING AND MANAGEMENT FOR MORE OR BETTER STRAW IN DIFFERENT FARMING SYSTEMS

J. De Wit<sup>1</sup>, J.P. Dhaka<sup>2</sup> and A. Subba Rao<sup>3</sup>

### SUMMARY

Straw is becoming more important for ruminant feeding, although its relative importance differs per grain species. Breeding and/or management for better or more straw does not necessarily affect grain yield and therefore breeding or management for straw quality and quantity (the so-called "variability work") is highly relevant. This paper discusses relative importance of various straw characteristics, for different types of grain species, production goals and production circumstances. The variability work in India seems to be especially relevant for sorghum and millets because of the relatively low grain/straw price ratios. In these cases it is attractive to increase straw quantity. Increased straw quality is a priority when the objective is high milk production and when supplements are hardly available or expensive. Straw quantity is relevant where good quality supplementary fodder/feed is available and/or maintenance of animals is more important than high levels of milk production. Furthermore it is concluded that loss of quality during storage deserves priority attention.

### INTRODUCTION

Straw is becoming more and more valuable as animal feed. Some reasons for this are:

- reduction of common grazing land availability (Jodha, 1986);
- increased income for some people results in a relatively higher demand for animal products compared to staple food due to differences in price elasticity (Kelley et al., 1991).

The straw can be utilized in different manners:

- after grain harvest both straw and stubble can be fed or grazed;
- stripping or grazed immature leaves before grain harvest (Khazaal et al., 1991; Osafo et al., 1991);
- dense planting of coarse grains with subsequent thinning until ripening of the crop (Byerlee et al., 1989);
- grazing of a failed harvest or as a winter crop (Nordblom and Ceccarelli pers. comm.) with interesting work on optimization of harvest stage by Nordblom (1983);
- cutting of a green crop before flowering, as is done with winterwheat or oats but also in rice systems where the season

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<sup>1</sup> DTAP, Agricultural University Wageningen, PO Box 338, the Netherlands

<sup>2</sup> NDRI-ORP, Karnal 132001, Haryana, India

<sup>3</sup> NDRI/SRS, Adogadi, Bangalore-560030, Karnataka, India

is too long for one crop and too short for two crops (Robles *et al.*, 1991).

This paper discusses the choice between the need for quantity and/or quality of straw, assuming that grain yield remains unaffected by these choices. We also assume that "straw" is not used for fencing, roofing, fuel or other purposes.

### **BREEDING OR MANAGEMENT FOR MORE OR BETTER STRAW**

Straw quantity and quality can be increased without necessarily a major negative effect on grain production (Badve *et al.*, 1993; Capper *et al.*, 1989). Therefore the emphasis of plant breeders on grain yields alone, with neglect of straw quality and quantity, is increasingly criticised. Kelley *et al.* (1991) indicate that in some cases breeding programs on grain sorghum had resulted even in a negative impact on total value of production (being the sum of straw and grain value). The general conclusion is that straw quality and quantity characteristics should be considered in the plant breeding or management programs. In fact, the low straw quality or quantity of modern cultivars is sometimes a reason for the non-adoption of the "grain" variety (Seetharam *pers. comm.*, 1991). Decreased straw quality has been reported to be reflected in a 30 - 40% lower price for these straws (Kelley *et al.*, 1991).

Other papers in this workshop have shown that the development of research priorities and extension messages in the diversity of India requires definition of specific farming systems to provide specific answers (Jain and Dhaka, 1993; Patel *et al.*, 1993). The relative importance of straw quantity, straw quality or grain production in different circumstances (farming systems) is the central item of this paper. This question of quality versus quantity is important for breeding and management of crop (residues), but also an essential feature in optimizing feed production in general. See for example Belton and Michell (1989) for an analysis referring to fodder conservation and Zemmeling *et al.* (1992) for fodder selection in general. The issue will be dealt with by discussing differences in straw/grain price ratios, production goals and production circumstances.

### **FARMING SYSTEMS**

To analyse the effect of differences in agro-ecological circumstances on the relative importance of straw characteristics, a linear programming (LP) study was carried out for 3 hypothetical farming systems that reflect distinct but existing conditions in India (see Table 1). Assumptions are listed in Box 1.

Table 1 Description of three simplified farming systems used for the model

	Karnataka	West-Bengal	Haryana/Punjab
Crops/year	1 <sup>1</sup>	2 <sup>1</sup>	2 <sup>1</sup>
Irrigation	-	+	++
Major grains cultivated	fingermillet	rice	rice/wheat
Common grazing land availability	++	+/-	-
Ratoon (grazing)	300 kg/ha/year <sup>1</sup> (50% TDN, 10% CP)	0 <sup>1</sup>	0 <sup>1</sup>
Green fodder availability	0 <sup>1</sup>	0 <sup>1</sup>	2 crops/year, 20% of crop area <sup>1</sup> (8000 kg DM/ha, 70% TDN, 20% CP)
Relative animal density	++	+++	+
Production objective	draught/milk	draught/milk	milk/calves

Note: <sup>1</sup> - assumptions used in LP-model

### Box 1 Assumptions for the calculations of the model

The following assumptions are made to make a simplified estimate of the potential animal production per hectare:

- animal requirements are according to NRC (1988).
- DMI depends on quality of feed and production level of the animal and is predicted by the following equation (derived from Tolcamp and Ketelaars, 1992):

$$\text{DMI} = 1.3 * a * (-19.5 + 0.05979 * \text{CP(om)} + 92.46 * \text{TDN}/1.2148) * 1.05/\text{TDN}$$

where:

a = factor depending on level of production: 1.5 - 1.8 for 0 - 12 kg milk / day

DMI = g / kg<sup>0.75</sup>;

CP(om) = g CP/kg organic matter.

- For the (low) levels of animal production, which are the most relevant for management of straw, the predicted DMI is similar to the predictions that Joshi *et al.* (1993) have made.
- nutritive values for straw and bran are 45% TDN and 4% CP resp. 60% TDN and 12% CP;
- grain : straw : bran = 1 : 1 : 0.1; no concentrate is bought from outside. Grain production is 3000 kg/ha per season;
- bran is allowed to constitute not more than 60% of the total ration;
- storage losses of 1.5% in quantity and 0.75% of TDN in quality per month are included;
- the LP-model was allowed to choose between different types of cows (milkproduction ranging from 0 - 12 kg/day), but total number of cows was to remain equal over the different seasons only cows and no followers are considered;
- no supplementary feeds (either grass from common land or concentrates) from outside the farm are included;
- the matrix used is very similar to the one used by Patil *et al.* (1993). Details can be obtained from the authors.

## RESULTS

A comparison of the absolute level of milk production and the type of cow which the LP-model chooses for the three situations, is not so interesting. Because of the large amount of good quality fodder available in Haryana/Punjab, total potential production per hectare and per cow is considerably higher (Table 2). A comparison of the limiting factors is more interesting and shows that straw quality is the major limiting factor in all three situations. Straw availability (= quantity) becomes a major limiting factor when good quality fodder is available (Haryana/Punjab), though straw quality (= TDN value) still has a larger impact than quantity.

CP-content appears to be the most important limiting factor in West-Bengal, and to a lesser extent also in Karnataka. However breeding for CP-content is not advisable. Firstly, the CP-content of straw relates negatively with grain yield (Deinum, 1988), and secondly, because CP-deficiencies can easily be overcome by the addition of small quantities of protein-rich supplement or urea. If, for example, the CP-content of the straw was increased in the model only slightly from 4 to 5%, then TDN becomes the major limiting factor, more than straw availability. The important relations between CP and TDN are further elaborated by Walli et al. (1993)

An increase or decrease of nutritive values affects the results considerably (see Table 2). This underlines both the need for careful interpretation, but also the sensitivity of the system to small changes in quality and quantity of straw, obtained through breeding or management.

Table 2 Changes in potential milk yield (kg/ha/day) by changing different constraints for the hypothetical situations

	Karnataka	West Bengal	Haryana/Punjab
Total milkprod (kg/ha/d)	1.54	1.79	19.00
Straw availability			
-10% <sup>1</sup>	0	0	-1.5%
+10% <sup>1</sup>	0	0	1.5%
CP-content of straw			
-10% <sup>1</sup>	-4.2%	-3.4%	-1.0%
+10% <sup>1</sup>	6.2%	5.6%	1.0%
TDN-content of straw			
-10% <sup>1</sup>	-18.5%	0	-9.7%
+10% <sup>1</sup>	0.9%	0	6.9%
Storage losses			
Double of original (%)	-1.5%	-1.3%	-5.6%

Note: <sup>1</sup> - % of original value (see assumptions)

It is relevant to note that chopping of straw is practiced mainly in those farming systems where the model indicates the importance of straw quantity (= relative shortage of straw). Leaving aside the differences in straw type (coarse vs. slender), it can be observed that chopping is mainly practised in areas where supplementary feed is available (e.g. berseem in Haryana/Punjab), or other situations where straw quantity is the most important factor (drought prone areas or areas with relatively high animal densities). Chopping reduces the waste due to refusal (quantity!), while selective consumption (when no chopping is practised) results in an increased quantity and quality of the ingested feed, thereby increasing the production per animal (Zemmelink, 1980; Prabhu et al., 1988; Wahed et al., 1990).

The importance of storage losses as a limiting factor to animal production is another point revealed by the model-study, because even marginal losses as assumed in the model resulted in a considerable decrease in milk production. This will be worse if the indications are correct that the decrease in quality from just after harvest till 90 days can be upto 15 units of IVDMD (Subba Rao et al., 1993). The higher importance of the storage losses in Haryana/Punjab relative to the other FS's might explain the attention which is already given to the storage of straw in these areas.

### OBJECTIVE OF PRODUCTION

Different production objectives for various categories of farmers might also attribute to the wide variation in practices between farming systems. Milk production was the only objective in our model-study, but is only of secondary importance in systems like Karnataka and West-Bengal (Table 1). More in general, animal traction is the primary objective in most farming systems in India, although milk production gains importance due to factors like reduced landholding size and tractorization (Vaidyanathan, 1981; Dhas, 1990), often accompanied by cross-breeding programs. The different animal requirements due to different production objectives will affect the relative importance of straw quantity and quality.

The effect of increased quality (TDN) in the case of low and high producing animals is shown in Figure 1a and 1b respectively where the same assumptions as listed in Box 1 are made regarding animal requirements and DMI. In addition it is assumed that:

- the amount of biomass is kept constant for both situations, i.e. 2000 kg/ha,
- CP-content of the biomass is constant at 4%.

Not surprisingly, both the number of animals at maintenance and the milk production per hectare increases with an increasing TDN-value of the available biomass (the drawn lines). More interesting is the broken line (in both Figures), which expresses the amount of extra biomass with equal TDN needed to obtain a similar increase of milk production or animals per hectare as per the increase of one unit of TDN. This extra amount is expressed as percentage of the, assumed, original amount of straw per hectare, thereby making it independent of the original amount of biomass. This percentage serves as an indication whether higher increases in animal production (either number of animals or milk production) can be realized from either increasing the quantity or increasing the quality of the biomass. For example in Figure 1b, the increase of TDN from 50 to 51% (a relative increase of 2%) has the same effect as the increase in biomass of 10%.

Quantity is the most important factor in the case of low yielding animals (Figure 1a). If the quality of straw is sufficient for maintenance (TDN  $\approx$  42), the amount of straw necessary to achieve

Figure 1 Number of animals (1a) and milkproduction per hectare (1b) related to a stepwise increased TDN-value of the available biomass (-●-), and the additional quantity with equal TDN required for a same increase (-+-).

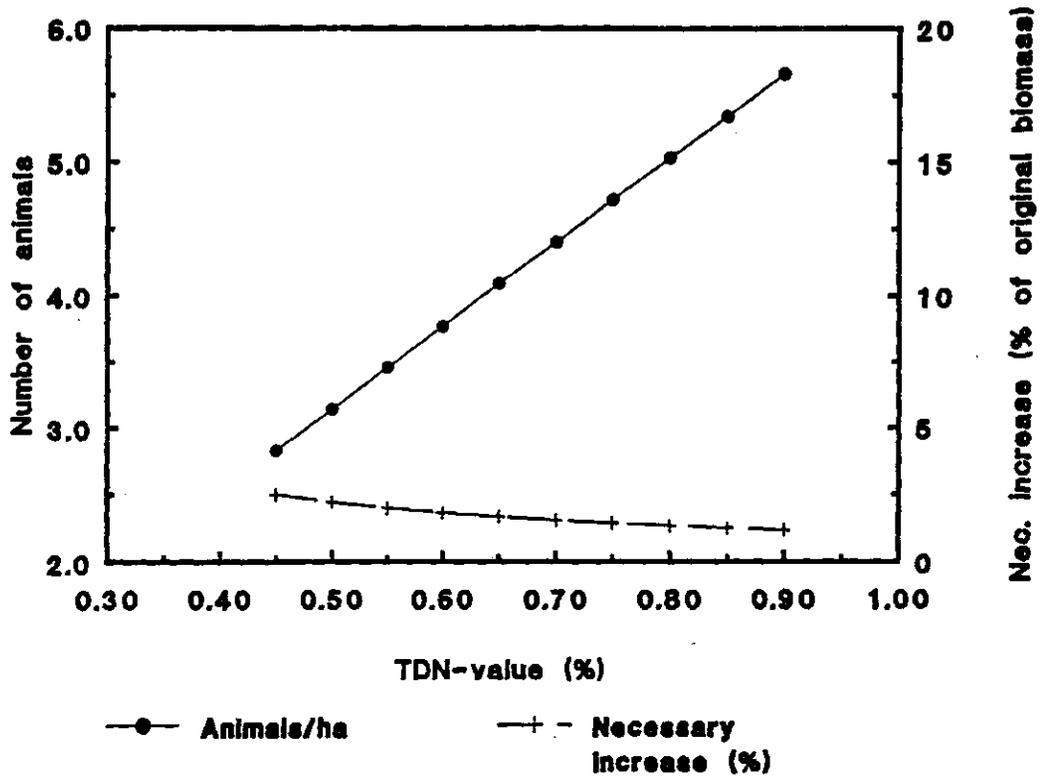
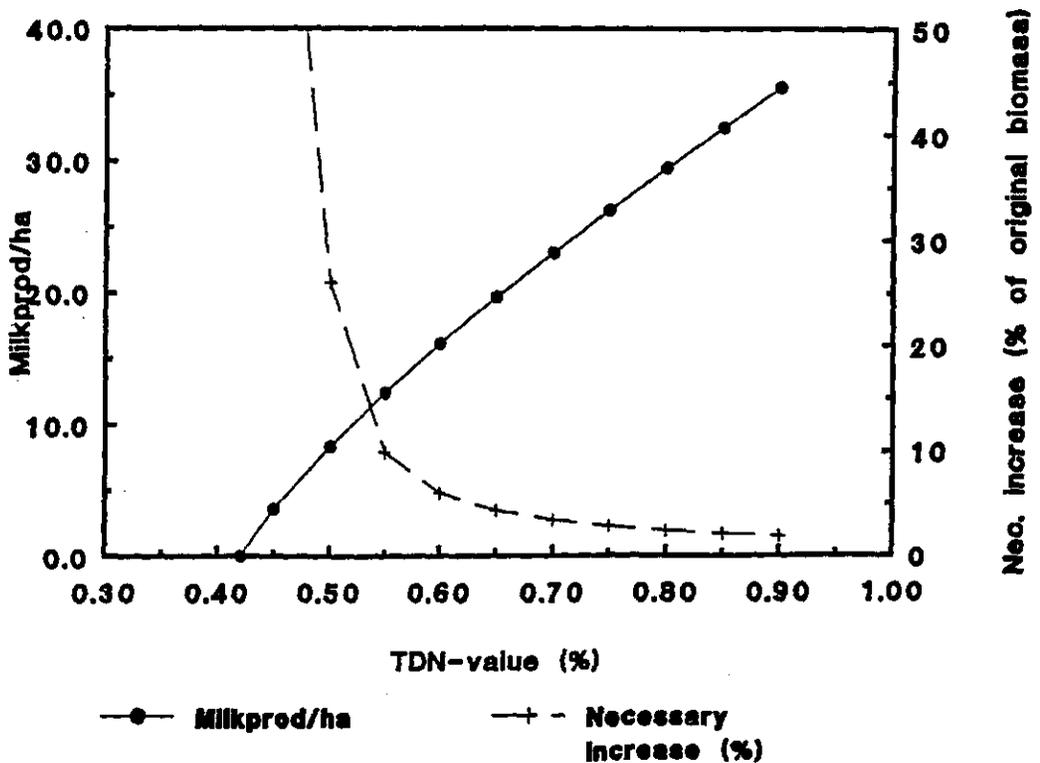


Figure 1b



a similar increase as could be obtained per unit TDN, is relatively small: around 2% of extra biomass is needed to obtain the same number of animals per hectare as is possible by an increase of one unit of TDN.

In case high milk production per hectare is the objective, this picture changes considerably (Figure 1b). In that case quality is the most overruling factor. At a TDN-level of 50%, one would need around 10% more straw to achieve a same increase as could be obtained per unit TDN.

Concluding it can be said that the objective of production influences the relative importance of straw quality and quantity and thereby the adoption rate of new cultivars. This is supported by the work of Janssen et al. (1990), who suggest that modern cultivars of sorghum and millet have been less adopted in important milk producing areas because of their low nutritive quality of their straws. It would be interesting to see if a similar trend can be distinguished with other types of straws. Gowda (1988) and Nygaard (1983) also relate instances where higher grain yield of a new variety does not compensate the loss in straw quality and quantity, but their observations do not specify the production objectives of the farmers, nor the availability of other feeds.

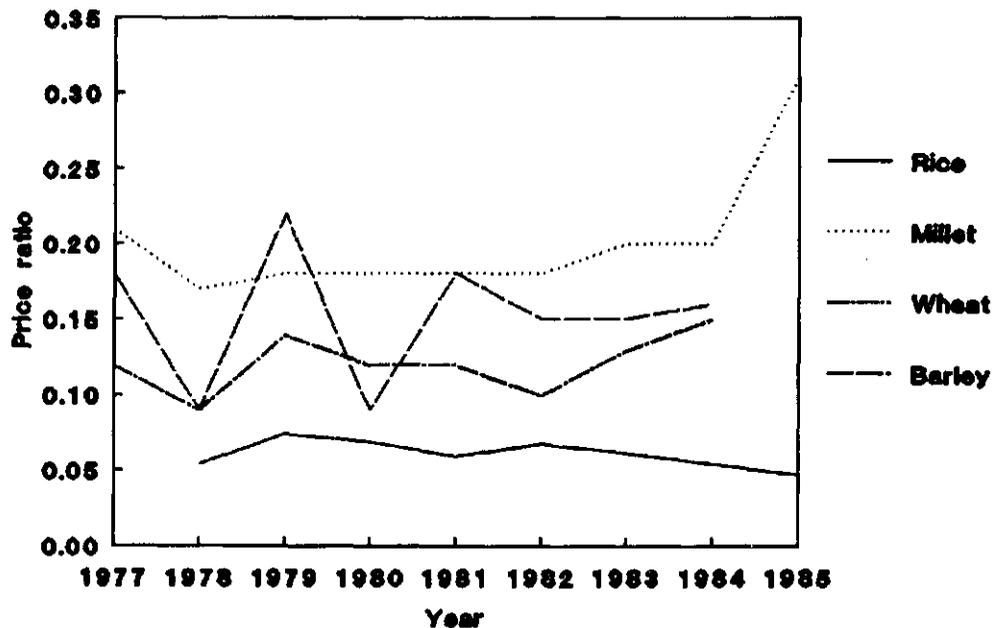
#### RELATIVE PRICES OF STRAW AND GRAIN

The scarcity of straw and thereby the importance of straw is (partly) reflected in the economic value of the straw. Although in general straw is becoming more valuable, the magnitude of change differs between regions and types of straws. The price ratios of straw to grain in Haryana declines from coarse straws via slender straws to rice straws (Figure 2). Depending on prevailing feeding practices per region, price ratios will be different. In Haryana for example wheat straw is preferred over rice straw but in Gujarat, rice straw is more preferred than wheat straw. This can be due to the Degnala disease occurring on rice straw in Northern India and Pakistan (Rangnekar et al., 1993) or differences in the varieties grown. It indicates the need for studies of price ratios in other areas and to understand the importance of straw quality and quantity relative to grain. Price ratios at the farmgate level may be quite different from market prices, because transport cost is relatively high for (bulky) straws. It would be worthwhile to verify through field studies whether the adoption of varieties with less (valuable) straw, is lower in areas and/or for grain species having a high straw/grain price ratio, compared with opposite situation.

#### HARVEST INDEX

The harvest index, however, influences the value of straw. Table 3 gives an indication of straw relative to the total value of

Figure 2 Change in straw/grain price ratio (Haryana state 1977-1985)



relative prices of straw and grain, and the harvest index). The preliminary conclusion is that the scope for breeding and management of straw for quantity and/or quality is less for slender species and rice than for coarse straws, due to:

- the higher harvest index for slender and rice grains,
- the lower quality of slender and rice straws (Prasad et al., 1993) reflected in a low straw price compared with the price of their grains.

Therefore, for slender straws the primary objective of the variability work should be an increase in straw quality. Especially for rice straw, however, simple physiological parameters which might be used as indicators for straw quality still do not have sufficient predictive value (Soebarinoto et al., 1993).

Table 3 Estimates of relative economic importance of straws

	Straw/grain ratio	Straw/grain price ratio	Straw as percentage of the total value
Coarse straw	4.0	0.36	69%
Slender straw	1.5	0.15	21%
Rice straw	1.5	0.06	9%

Note: - Slender straws include barley, oats and wheat; coarse straws include sorghum, millet, maize, etc.; rice can be considered as a separate category (see Prasad et al., 1993).

### POTENTIAL GAINS

The final choice of breeding or management for straw quantity or quality does not only depend on their relative importance for enhancing animal production, but also on the relative ease of improving the characteristics. When it is easier to increase the straw quantity than the straw quality (which seems to be true), it might become attractive to focus on straw quantity rather than on straw quality, even when quality is the most important factor influencing animal production. Quality constraints can then be overcome by supplementation. Increased quantity can also indirectly increase straw quality via increased possibilities for selection by the animals. Information on whether higher and faster gains in straw quantity can be obtained compared with gains in straw quality is deficient but some preliminary information is given for fingermillet straw by Seetharam et al. (1993) and for rice/wheat by Mahendra Singh et al. (1993).

### IDEOTYPING PER FARMING SYSTEM

Specification of ideotype of cultivars (Jansen et al., 1989) for different farming systems is possible on the factors discussed above in relation to the characteristics of the farming systems as described in Table 1. The value of straw as proportion of the total value can be used as indicator for the importance of the variability work, while the availability of straw relative to the availability of other feeds, production objectives and animal densities influences to a large extent the relative importance of quantity versus quality of the straw (see Table 4).

Table 4 Importance of variability work and relative importance of straw quantity and quality for three simplified farming systems

	Karnataka	West-Bengal	Haryana/Punjab
Importance of:			
-straw breeding and management	+++	++	+/-
-straw quantity	+++	++	+
-straw quality	-	++	+

### CONCLUSIONS

The relative importance of straw quantity or quality depends on factors such as the availability of straw and other feeds and the objective of animal production, which are partly reflected in the relative prices of straw and grain. Breeding and management for straw quantity is especially relevant for:

- coarse straws because of their reasonable quality and, partly relate to that, their higher straw/grain price ratio;

- more remote areas with a less developed milk market and therefore a lower production per animal which allows the inclusion of straws as major proportion of the ration;
- farming systems where good quality supplements are available, or feed quantity as such is the most limiting factor (e.g. areas with relatively high animal densities).

Improvement of straw quality (here mainly expressed as TDN) is especially important for:

- rice straws, and to a lesser extent slender straws, because of their low price ratio;
- in situations where good quality supplements are scarce and where milk production is the primary objective.

The ideotype of different cultivars therefore needs to be specified per farming system. On the basis of these hypotheses, it would be possible to develop clear objectives for future work. But it is essential to verify these hypotheses by studies of characteristics of cultivars grown in different farming systems by different categories of farmers. Finally it is suggested that storage losses, deserve more attention because of their potential effect on animal production and the results which might be obtained easily and with less expense than through breeding programs.

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