OVERCOMING THE NUTRITIONAL LIMITATIONS OF RICE STRAW FOR RUMINANTS

4. UREA AMMONIA TREATMENT AND SUPPLEMENTATION WITH GLIRICIDIA MACULATA FOR GROWING SAHIWAL BULLS

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Summary

Forty bull calves of Sahiwal crosses were fed either urea treated or untreated rice straw with 4 levels of Gliricidia (0, 1, 2 and 4 kg fresh material). Dry matter intake (DMI) of straw and Gliricidia was measured during 2 periods. Straw intakes in period 1 and 2 were significantly different ($P < 0.001$). Supplementation of Gliricidia depressed the DMI of straw during the second period ($P < 0.01$), but not in the first period. Urea-ammonia treatment increased straw intake and total intake in both periods, but the increase in dry matter digestibility (DMD) of the ration was not significant ($P > 0.05$). Liveweight gain (LWG) was increased significantly, both by urea ammonia treatment ($P < 0.01$) and by supplementation with Gliricidia ($P < 0.001$). Animals on treated straw gained on an average 137 $g \cdot d^{-1}$ more than those on untreated straw.

(**Key Words:** Rice Straw, Urea Treatment, Supplementation, Gliricidia, Growing Bulls)

Introduction

Rice straw is a major feed resource for ruminants in many tropical countries, especially during the dry season. Despite frequently occurring shortages of roughage the straw is often burned in the field for disposal. Straw contains too little digestible energy, protein and certain minerals to sustain even maintenance of animals. (O'Donovan, 1983; Doyle et al., 1986; Schiere and Ibrahim, 1989).

Essentially 2 ways can be chosen to overcome this deficiency of nutrients. The first method is to improve the quality of the straw through treatment with several chemicals (Ibrahim, 1983) of which urea has been proven to be very practical (Perdok et al., 1982; Saadullah et al., 1982; Schiere et al., 1988).

Another method is to obtain the deficient nutrients from supplements, either concentrates or green feeds (Creek et al., 1984; Ghebrehiwet et al., 1988; Preston and Leng, 1984; Schiere et al., 1985). In order to quantify the effect of cheap green feeds as a supplement versus urea treatment of rice straw, an experiment was conducted using Gliricidia maculata, a common legume tree (Chadhokar, 1982; Smith and van Houtert, 1987), as a supplement at several levels to treated and to untreated rice straw. The highest level (4 kg fresh Gliricidia leaves) supplemented to untreated straw increases the crude protein content of the ration above 7-8%, which is the approximate crude protein level below which a decline in intake occurs (Milford and Minson, 1965; Van Soest, 1982).

Materials and Methods

Animals, diets and experimental design

Forty young bulls, crosses of Sahiwal, Sindhi, Jersey and local Sri Lankan cattle of 75-104 kg initial liveweight, were allocated to eight groups of five animals according to body weight. The animals were housed, tethered in two rows and equipped with individual feed troughs. The animals were fed unchopped untreated rice straw (US) or urea treated rice straw (TS), with a Gliricidia supplement at four levels (0, 1, 2 and 4 kg

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fresh material).

The straw consisted of a mixture of several varieties harvested at nearby government farms. The treated straw was prepared from the same batch as the untreated straw and according to Schiere and Ibrahim (1989), 100 kg of straw was sprayed with 100 l of water containing 4 kg of urea. After that, the straw was stored for treatment in three unsealed stacks (approx. 1.50 x 1.50 x 1.50 m^3) under a roof. After being left for eight days it was fed during four days. The straw was fed unchopped and *ad libitum*, i.e. the quantity offered was approximately 150% of the quantity consumed.

The Gliricidia was cut daily from trees around the experimental facility. Gliricidia was fed on top of the straw, half of it in the morning, half of it in the afternoon. Other supplements, minerals or salt were not fed. The animals had free access to water.

Measurement

The experiment lasted for 14 weeks, consisting of a four week adaptation period and a ten week measurement period. Daily individual dry matter intake (DMI) was estimated during two periods of eight days and ten days, respectively. During these two periods samples of the offered straw were collected from the troughs at the time of feeding. The refusals were collected daily in the morning before feeding. Samples of the refused feed were collected from a mixed bulk. Dry matter digestibility (DMD) was measured during the second intake period by total collection. Faeces was collected for 24 hours a day during five days. The faeces was sampled daily and of composite samples dry matter content was determined. Liveweight gain (LWG) was measured during a period of ten weeks, in which the animals were weighed weekly in the morning before feeding.

Statistical analysis

Dry matter intake, dry matter digestibility and liveweight gain were tested using analysis of variance (Snedecor and Cochran, 1980). The period effect on dry matter intake was also tested. Initial liveweight was included as a covariable in all analyses. The Student-Newman-Keuls' test was used to check differences between treatment groups (Steel and Torrie, 1980). The liveweight gain values as well as the relationship between gliricidia intake and liveweight gain were obtained by means of linear regression analysis (Snedecor and Cochran, 1980).

Results

The dry matter intakes of straw in the two periods were significantly ($P < 0.001$) different (see box 1 for analyses of variance), so the results are presented for each period separately (table 1).

The intake of straw was increased in both periods by treating the straw (table 2), in the first period with 31% ($P < 0.001$), in the second period with 13% ($P < 0.01$). Consequently, total intake was also increased by straw treatment, in the first period with 24% ($P < 0.001$), in the second period with 8% ($P < 0.05$).

In the first period straw was replaced with Gliricidia ($P < 0.01$) at a substitution rate of 53%, while the substitution rate in the second period was still considerable (31%), but statistically not significant ($P > 0.05$). As a consequence, Gliricidia supplementation increased total intake only slightly in the first period ($P < 0.05$), while in the second period supplementation with Gliricidia at a level of 2 kg fresh matter or more increased total intake ($P < 0.001$).

The gliricidia intake was lower for the animals on treated straw than for the animals on untreated straw ($P < 0.05$, both periods). At the highest Gliricidia levels (2 and 4 kg fresh matter$\cdot d^{-1}$), the animals on treated straw tended to refuse some Gliricidia. This indicates an interaction straw treatment x Gliricidia level, which was significant in the second period ($P < 0.01$). Initial liveweight (as a covariable) affected Gliricidia intake slightly ($P < 0.05$) in the first period.

The dry matter digestibility (table 3) was not affected by Gliricidia addition ($P > 0.05$). The digestibility was increased by urea treatment (55.1% for TS versus 50.9% for US), however, not significantly ($P > 0.05$).

The increase in total dry matter intake due to urea treatment and Gliricidia supplementation was associated with an increase in liveweight gain due to straw treatment ($P < 0.01$) and level of Gliricidia ($P < 0.001$). The regressions of liveweight gain (LWG) on Gliricidia intake (Glir DMI) for untreated straw and treated straw shown in figure 1 are represented by the following re-

BOX 1. RESULTS OF THE ANALYSES OF VARIANCE ON INTAKE DATA

A. OVER BOTH PERIODS (Incl. Period effect and effect of initial liveweight)

Dependent Variable: Intake of Straw

SOURCE	DF	SS	F value	PROB > F
Period	1	0.00511	40.05	0.0001
Straw Treatment	1	0.00577	45.24	0.0001
Gliricidia	3	0.0026	97.03	0.0003
Straw * Glir	3	0.00059	1.54	0.21
Initial Weight	1	0.00008	0.65	0.42

Dependent Variable: Total Intake

SOURCE	DF	SS	F value	PROB > F
Period	1	0.00541	42.86	0.0001
Straw Treatment	1	0.00454	35.99	0.0001
Gliricidia	3	0.00376	9.93	0.0001
Straw * Glir	3	0.00055	1.45	0.24
Initial Weight	1	0.00024	1.89	0.17

B. OVER SEPARATE PERIODS

PERIOD 1. Dependent Variable: Intake of Straw

SOURCE	DF	SS	F value	PROB > F
Straw Treatment	1	0.00596	47.27	0.0001
Gliricidia	3	0.00240	6.35	0.002
Interaction	3	0.00031	0.80	0.50

PERIOD 1. Dependent Variable: Total Intake

SOURCE	DF	SS	F value	PROB > F
Straw Treatment	1	0.00533	40.57	0.0001
Gliricidia	3	0.00126	3.19	0.036
Interaction	3	0.00031	0.80	0.50

PERIOD 2. Dependent Variable: Intake of Straw

SOURCE	DF	SS	F value	PROB > F
Straw Treatment	1	0.00091	8.85	0.0055
Gliricidia	3	0.00062	2.00	0.13
Interaction	3	0.00052	1.69	0.19

PERIOD 2. Dependent Variable: Total Intake

SOURCE	DF	SS	F value	PROB > F
Straw Treatment	1	0.00050	5.11	0.031
Gliricidia	3	0.00276	9.45	0.0001
Interaction	3	0.00045	1.52	0.23

TABLE 1. DRY MATTER INTAKES AS AFFECTED BY PERIOD OF MEASURING, STRAW TREATMENT AND LEVEL OF GLIRICIDIA SUPPLEMENTATION[1]

Level of	Untreated straw				Treated straw			
Gliricidia(kg)	0	1	2	4	0	1	2	4
Period 1								
Dry matter intake ($g/kg^{.75}$ BW)								
Straw	87.7^{bc}	83.4^{bc}	78.8^{c}	69.6^{d}	116.1^{a}	100.4^{ab}	109.8^{a}	91.0^{bc}
Gliricidia	0.0	8.0	16.8	35.0	0.0	8.2	14.7	31.4
Total	87.7^{y}	91.4^{y}	95.6^{y}	104.6^{xy}	116.1^{x}	108.6^{xy}	124.6^{x}	122.4^{x}
Period 2								
Dry matter intake ($g/kg^{.75}$ BW)								
Straw	79.0^{ab}	73.5^{ab}	68.0^{b}	64.8^{b}	80.6^{ab}	79.6^{ab}	89.1^{a}	74.3^{ab}
Gliricidia	0.0	8.1	16.9	35.2	0.0	8.1	14.0	28.1
Total	79.0^{z}	81.7^{z}	84.9^{yz}	100.1^{xy}	80.6^{z}	87.7^{yz}	103.1^{x}	102.5^{x}

[1] Values within the same line with the same superscripts are not significantly different ($p > 0.05$).

TABLE 2. PERCENTAGE INCREASE IN INTAKE DUE TO STRAW TREATMENT FOR EACH LEVEL OF GLIRICIDIA SUPPLEMENTATION (0, 1, 2 AND 4 KG)

Comparative groups	Percentage increase in dry matter intake (%)			
	First period		Second period	
	Straw	Total	Straw	Total
$TS_0 > US_0$	32	32	2	2
$TS_1 > US_1$	20	19	8	7
$TS_2 > US_2$	39	30	31	21
$TS_4 > US_4$	31	17	15	2
$TS > US$	31	24	13	8

TABLE 3. DRY MATTER DIGESTIBILITY (%) AS AFFECTED BY STRAW TREATMENT AND LEVEL OF GLIRICIDIA SUPPLEMENTATION (IN FRESH MATTER)[1]

Type of straw	Level of Gliricidia supplementation (kg/day)				
	0	1	2	4	Mean
Untreated	51.2	51.7	49.0	51.7	50.9[a]
Treated	55.6	52.2	55.1	57.2	55.1[a]
Mean	53.1[a]	51.9[a]	52.1[a]	56.0[a]	

[1]These differences are not significant ($P > 0.05$).

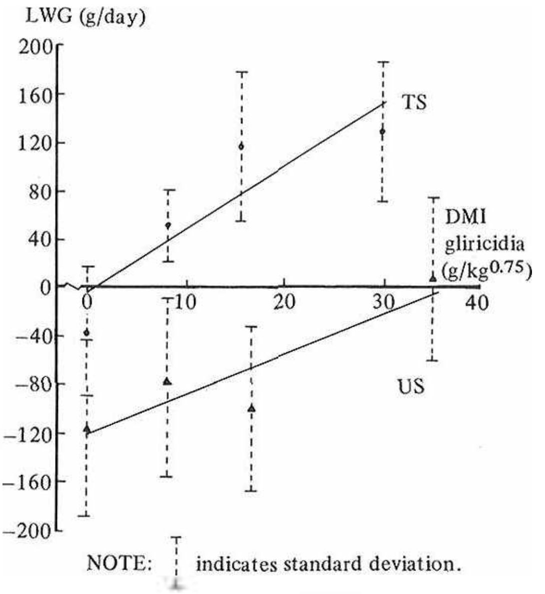

Figure 1. Liveweight gain (LWG) as affected by Gliricidia intake (DMI Gliricidia) of animals given untreated rice straw (US) or treated rice straw (TS).

gression equations:

$$LWG_{US} = -121 + 3.3 \text{ Glir DMI } (r^2 = 0.83, n = 4)$$
$$LWG_{TS} = -4 + 5.3 \text{ Glir DMI } (r^2 = 0.78, n = 4)$$

No interactive effect of urea treatment and Gliricidia supplementation on liveweight gain was present ($P > 0.05$), which is visualized in figure 1 by the non-converging response curves.

Discussion

Gliricidia maculata contains approximately 22-23% crude protein (Chadhokar, 1982; Smith and van Houtert, 1987). One might expect that addition of such a protein supplement to untreated straw would have a larger effect on liveweight gain than addition of the supplement to urea treated straw, which already has a higher crude protein content (Jayasuriya and Perera, 1983). The absence of this kind of interaction agrees with Creek et al. (1984) and with Gebrehiwet et al. (1988), who found no interaction between urea treatment and rice bran supplementation when animals were fed untreated or treated straw with several levels of rice bran. Data of Perdok et al. (1982) on lactating cows supplemented with Gliricidia suggest converging liveweight gain response curves, but non-converging milk production response curves.

Although Gliricidia addition to both untreated and treated rice straw improved LWG, it did not stimulate straw intake or digestibility. This may be due to the presence of tannins in Gliricidia, which lowers the level of soluble protein (Marshall et al., 1979). Protein digestibility is depressed in the presence of tannins by the formation of complexes with dietary protein and the inhibition of proteolytic enzyme activity (D'Mello, 1982). Many studies have reported partial substitution of the basal rations by legume supplement (Moran et al., 1983; Mosi and Butterworth, 1983). The merit of including a legume supplement is the increase in total dry matter intake, which is generally also reflected in improved animal performance (Elliott, 1987), like was also shown in this study.

Evaporation of ammonia from the open treatment heaps may have caused the low response in terms of digestibility and LWG at zero supplement. Generally, digestibility of the ration increases some 5 to 8 points by airtight urea treatment (Jayasuriya and Perera, 1983; Doyle et al., 1986; Ghebrehiwet et al., 1988; Schiere et al. 1989). Whether the use of open treatment systems affects the efficiency of urea treatment, depends on the size of the open heap and the compactibility of the straw.

The intake levels of untreated and treated straw as estimated in the second period of this experiment correspond with recent work of Schiere et al. (1989), who reported intakes of untreated straw and treated straw (closed heaps) around 80 and 100 $g \cdot kg^{-0.75}$, d^{-1}, respectively. During the first intake measurement period the animals consumed considerably more straw, which may have been caused by compensatory intake, although the animals had been given their respective rations for four weeks. Differences in straw intake between periods were also observed by Ghebrehiwet et al. (1988) and can probably be attributed to differences in straw quality.

Conclusion

Urea treatment increased dry matter intake of straw, total dry matter intake and liveweight gain, but did not significantly increase digestibility. Gliricidia addition depressed straw intake, but increased total dry matter intake and liveweight gain, but did not have effect on digestibility. The nutritional limitations in rice straw can be overcome both by treatment, supplementation or their combination. No major interactions are likely to disturb this general pattern. The decisions on which approach to take, depend on cost and economics of treatment and of supplementation as worked out by Nell et al. (1986) and Pannell and Bennett (1987).

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