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Observations on Livestock Productivity in Sheep Fed Exclusively on Haulms from Ten Different Genotypes of Groundnut

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ABSTRACT

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Haulms from 10 different genotypes of groundnut were tested with growing male sheep for digestibility, intake, nitrogen retention and live weight gains. Very high daily intake levels of > 4% of sheep bodyweight were observed in all haulms. Nitrogen retention (range: 6.7 to 11.4 g/d) and live weight gains (range: 65 to 137 g/d) varied about two fold among genotypes suggesting that the choice of groundnut genotype can have a very significant effect on livestock productivity in feeding systems based on groundnut haulms. Haulm fodder quality difference were well reflected by acid detergent lignin (ADL), which accounted for 58, 39 and 72% of the variation in haulm *in vivo* digestibility, nitrogen retention and live weight gains, respectively. Using stepwise multiple regression procedures, combinations of haulm ADL content and *in vitro* digestibility and of haulm ADL content and *in vitro* metabolisable energy content accounted for 84% and 92% of the variation in *in vivo* digestibility and live weight gain, respectively. The combination of haulm nitrogen and ADL content accounted for 80% of the variation in nitrogen retention. Among the genotypes, ICGV 89104), ICGV 91114), TMV 2 and ICGV 92093 promoted highest productivity in sheep.

Key words: Groundnut haulms, Livestock productivity, Genotypes of groundnut haulms

INTRODUCTION

Groundnut haulms provide important fodder resources for livestock in mixed crop-livestock systems in developing countries (Larbi *et al.*, 1999; Rama Devi *et al.*, 2000; Omokanye *et al.*, 2001). In India, groundnut haulms are the most available leguminous crop residues (NIANP, 2003; Garg *et al.*, 2009) providing - for a crop

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residue – fodder of high quality (Prasad *et al.*, 2000). It was shown that superior haulm fodder quality trait positively affected the adoption and spread of new groundnut cultivars (ICRISAT, 2008). Based on laboratory fodder quality assessments, Nigam and Blümmel (2009, this special issue) found considerable genetic variation for haulms fodder quality traits among groundnut genotypes/breeding lines suggesting that superior haulm fodder quality could be targeted in a systematic way. In support of this observation, the present work was initiated to learn how far haulm quality differences assessed by laboratory techniques translate into actual differences in livestock productivity and to identify the laboratory fodder quality traits that are closely related to actual livestock performance. A further objective was to search for variations in fodder quality in some popular released cultivars for preferential promotion of superior food-feed types.

MATERIALS AND METHODS

Haulms used and sheep experiments

Haulms from 10 groundnut genotypes (ICGV 89104, ICGV 91114, TMV 2, ICGV 92093, ICGV 92020, ICGV 86325, ICGS 76, ICGS 11, ICGS 44 and DRG 12) were harvested from seed multiplication plots at ICRISAT Center, Patancheru. Five genotypes (ICGV 89104, ICGV 91114, TMV 2, ICGS 76 and ICGS 11) in the 2003 post rainy season and another five (ICGV 92093, ICGV 92020, ICGV 86325, ICGS 44 and DRG 12) in the 2004 post rainy season. Of these genotypes, ICGV 91114, TMV 2, ICGS 76, ICGS 11, ICGS 44, DRG 12 and ICGV 86325 are released cultivars in India. ICGV 89104, ICGV 92093 and ICGV 92020 are advanced breeding lines developed at ICRISAT. The haulms were tested with sheep in two trials following their respective harvests in 2003 and 2004. In both trials, haulms were offered as sole feed *ad libitum* to growing *Deccani* sheep with a mean initial live weight of about 18 kg. *Ad libitum* feed intake was adjusted by allowing less then 10% of refused feed. Six sheep kept in metabolic cages were used per genotype. Sheep were adjusted to a genotype for at least 2 weeks, followed by a 10-day faeces and urine collection period. Sheep were weighted before the start of the experiments and before and after the 10-day collection periods each time on two consecutive days for which mean weights were calculated.

Haulm laboratory analysis and statistical evaluation

Groundnut haulms were analyzed in the laboratory for nitrogen content by Kjeldahl and for neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) by Goering and Van Soest (1970) and for *in vitro* organic matter digestibility (IVOMD) and metabolisable energy (ME) content by Menke and Steingass (1988). The SAS (1988) statistical software package was used for analysis of variance (SAS PROC GLM), simple correlations (SAS PROC CORR) and for stepwise multiple regressions (SAS PROC STEPWISE).

RESULTS AND DISCUSSION

Table 1 presents laboratory fodder quality traits such as content of nitrogen (N x 6.25 is an estimate of crude protein content), NDF, ADF, ADL, *in vitro* organic matter

Table 1. Content of nitrogen (N), neutral detergent fiber (NDF) and acid detergent fiber (ADF), acid detergent lignin (ADL), *in vitro* organic matter digestibility (IVOMD) and metabolisable energy content in haulms from 10 different groundnut genotypes *(pod and haulm yield may be included)*

Genotype	N %	NDF	ADF	ADL	IVOMD	ME MJ/kg
ICGV 89104	2.2	43.4	25.0	3.8	62.0	8.90
ICGV 91114	2.1	39.9	25.6	3.9	60.7	8.74
TMV 2	2.0	45.6	29.8	5.2	62.1	8.98
ICGS 76	1.9	42.1	27.6	5.2	58.2	8.25
ICGS 11	2.0	41.1	25.0	5.2	55.5	7.78
DRG 12	2.2	38.4	25.8	6.4	62.2	8.75
ICGS 44	2.3	38.6	24.1	5.7	59.6	8.38
ICGV 86325	2.6	41.2	24.7	5.3	61.1	8.45
ICGV 92020	2.6	39.9	27.0	5.1	65.1	9.15
ICGV 92093	3.1	35.5	25.6	5.4	67.1	9.34

digestibility (IVOMD) and metabolisable energy (ME) content. The ranges in key laboratory fodder quality traits observed generally agreed with, and in some cases exceeded, the ranges reported by Nigam and Blümmel (2009, this special issues) in more than 800 groundnut cultivars, suggesting that haulm fodder quality variations in released cultivars can reflect both the positive and negative genetic variability of the gene-pool of the species. In other words, unless fodder quality traits are considered in cultivars breeding and release, cultivars with very poor and very good haulm quality might reach farmers with a similar probability.

When haulms of the 10 groundnut genotypes were fed to sheep as sole feed, significant genotypic differences were observed for organic matter digestibility (OMD), digestible organic matter intake (DOMI), nitrogen retention and live weight gains (LWG) but not for organic matter intake (OMI), see Table 2. The daily OMI ranged from 811 to 1017 g/d which was more than 4% of the sheep body weight. This level of intake in non-lactating livestock is remarkable (Forbes, 1995), underlining that groundnut haulms provide a highly palatable feed resource. Still, choice of genotypes will substantially affect the returns from livestock fed on the haulms, since cultivars-dependent daily nitrogen retention in the sheep – ideally a reflection of protein tissue gains - ranged from 6.7 to 11.4 g/day with differences of a similar order observed for daily live weight gains which ranged from 65 to 137 g (Table 2). In other words livestock productivity varied by about two fold depending upon the genotype from which the haulms were derived. The haulms were obtained from two different cropping seasons in 2003 and 2004 respectively and environmental factors might have contributed to variations in haulm fodder quality. Still ranges in nitrogen balances and live weight gains were similar in both cropping seasons (ranges in nitrogen retentions: 7.2 to 11.3 g/d in 2003 and 6.7 to 11.4 g/d in 2004; ranges in live weight gains: 76 to 137 g/d in 2003 and 66 to 109 g/d in 2004).

Table 2. Organic matter digestibility (OMD), organic matter intake (OMI), digestible organic matter intake (DOMI), nitrogen retention and live weight gain (LWG) in sheep fed haulms from 10 different groundnut genotypes

Genotype	OMD	OMI		DOMI	Nitrogen retention		LWG
	%	g/d	g/kg $LW^{0.75}$/d	g/d	g/kg $LW^{0.75}$/d	g/d	g
ICGV 89104	72.7	935	92.0	66.9	11.3	1.11	137
ICGV 91114	72.6	938	93.2	67.8	9.3	0.92	123
TMV 2	71.4	991	97.5	69.6	8.8	0.88	111
ICGS 76	66.4	1005	99.6	66.1	8.0	0.79	76
ICGS 11	67.4	852	85.8	57.7	7.2	0.72	76
DRG 12	65.5	811	83.7	55.0	6.7	0.70	66
ICGS 44	67.2	917	93.1	62.5	8.5	0.87	65
ICGV 86325	69.6	1017	100.7	70.4	10.4	1.05	83
ICGV 92020	69.7	954	94.4	65.7	9.0	0.89	95
ICGV 92093	71.9	938	93.7	67.4	11.4	1.14	109
Prob > F	<0.0001	0.64	0.20	0.04	0.004	0.002	0.02

However, the experiments were relatively short-term and daily live weight gains might have been affected by incremental gut fill, particularly in light of the very high intakes. On the other hand, nitrogen retentions varied by a similar order than live weight gains and both were reasonably well correlated (live weight gain = -6.5 + 11.1 nitrogen retention; $R^2 = 0.50$; $P = 0.02$) suggesting that the cultivar-dependent ranges observed in live weight gains were real. The finding reported here do also agree with work by Garg *et al*. (2009) who fed groundnut haulm based (60%) complete feed blocks to sheep and observed a mean daily live weight gains over 120 days of 84 g, associated with a nitrogen retention of 5.7 g/d. These observations further corroborate that groundnut haulms can provide excellent livestock fodder, probably on par or even better than many of the planted forages in the semi-arid tropics, which often have high water requirements (Singh *et al*., 2004).

The relationship between laboratory haulm quality traits and OMD, OMI, DOMI, nitrogen retention and live weight gains are reported in Table 3. Generally OMI (and by extension DOMI) were not well correlated to any of the laboratory haulm quality traits but significant relationships were observed between the latter and OMD, nitrogen retention and live weight gain. From these correlations ADL appears to be a good choice for the ranking of groundnut haulms for fodder quality. Interestingly haulm nitrogen content was significantly related only to nitrogen retention, and this relationship may have been affected by inter-correlations because haulm nitrogen content was used in the calculation of nitrogen retention. All haulms had nitrogen content well above the minimum requirements for ruminants of 1 to 1.2% (Van Soest *et al*., 1994) and haulm nitrogen content apparently presented no limiting factor. However, groundnut haulms in the present work were fed as sole feed while under on-farm conditions they will often be used as a supplement to lower quality crop residues from cereals. High haulm nitrogen

Table 3. Relationships between laboratory haulms quality measurements (as in Table 1) and digestibility, intake and live weight gain measurement in sheep fed haulms from 10 different genotypes of groundnut

Parameters	OMD	OMI	DOMI	Nitrogen retention	LWG
N	0.28 (0.43)	0.08 (0.83)	0.20 (0.58)	0.64 (0.05)	0.09 (0.79)
NDF	0.17 (0.63)	0.34 (0.34)	0.33 (0.35)	-0.11 (0.77)	0.30 (0.40)
ADF	0.11 (0.77)	0.35 (0.32)	0.31 (0.39)	-0.21 (0.56)	0.18 (0.61)
ADL	-0.76 (0.01)	-0.24 (0.51)	-0.54 (0.11)	-0.49 (0.15)	-0.85 (0.002)
IVOMD	0.49 (0.15)	0.16 (0.67)	0.35 (0.32)	0.60 (0.07)	0.41 (0.23)
ME	0.60 (0.07)	0.18 (0.61)	0.41 (0.23)	0.57 (0.08)	0.57 (0.08)

content will then be beneficial, since cereal crop residues do rarely provide for minimum nitrogen requirements. High haulm nitrogen content should, therefore, be a breeding and selection criteria in multidimensional groundnut improvement.

When combining ADL with other laboratory haulm quality traits in stepwise multiple regressions, predictions of OMD, nitrogen retention and live weight gains were significantly improved (Table 4). Thus, ADL and IVOMD together accounted for 84% of the variation in OMD and ADL and ME together accounted for 92% of the variation in live weight gains, while nitrogen and ADL together accounted for 84% of the variation in nitrogen retention. These observations suggest that potential livestock productivity and ultimately economic benefit from feeding different haulms can be predicted with reasonable accuracy thereby supporting multidimensional groundnut improvement targeting optimization of the whole groundnut plant.

Among the genotypes, ICGV 89104 (137 g/d), ICGV 91114 (123 g/d), TMV 2 (111 g/d) and ICGV 92093 (109 g/d) gave higher live weight gains than other genotypes. ICGV 89104, a Spanish bunch genotype originating from J 11 x U 4-7-5 cross, is

Table 4. Stepwise multiple regression between laboratory haulms quality measurements *in vivo* and chemistry and organic matter digestibility (OMD), organic matter intake (OMI), digestible organic matter intake (DOMI), nitrogen retention (NR) and live weight gain (LWG)

Trait & Model	Y-Variable	R^2	Probability
Model: ADL+IVOMD	OMD	0.84	0.002
Step 1: ADL		0.58	0.01
Step 2: IVOMD		0.26	0.01
Model: Nitrogen + ADL	NR	0.80	0.003
Step 1: Nitrogen		0.41	0.04
Step 2: ADL		0.39	0.007
Model: ADL + ME	LWG	0.92	0.0001
Step 1: ADL		0.72	0.002
Step 2: ME		0.21	0.002

tolerant of aflatoxin contamination. ICGV 91114 is also a Spanish bunch genotype and originates from (72-R x Chico) x (Robut 33-1 x NC Ac 1705) cross. It can withstand long dry spells. ICGV 92093 is a Virginia bunch genotype and has tolerance to foliar diseases (late leaf spot and rust) of groundnut. It originates from (72-R x Chico) x CS 29/1. CS 29/1 is an interspecific derivative. Both, ICGV 91114 and ICGV 92093, have a common parent (72-R x Chico). These genotypes will make good donors for increasing haulm feeding quality traits through multidimensional groundnut improvement. In addition, the findings of the present work suggest the need to screen more aflatoxin, drought and foliar diseases resistant groundnut breeding lines for haulm feeding quality traits to see if these traits have any direct influence on the latter.

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