Broad sense heritability for fodder traits estimated in 12 cultivars (that served as checks in the two consecutive growing seasons) grown in 2001/02 and 2002/03 postrainy seasons was 0.72 for nitrogen content, 0.72 for in vitro OMD and 0.67 for metabolizable energy content.

Relationship between pod yields and haulm quantity and quality. The relationships between haulm fodder quality traits and pod and haulm yield in 860 genotypes are reported in Table 3. It is encouraging to note that haulm fodder quality traits and pod and haulm yields were not inversely related. Even though highly significant, the relationships were generally weak (Table 3). The strongest relationship ($R^2 = 0.21$) was observed between pod and haulm yield, but even in this relationship most of the variation (79%) remained unaccounted for. The latter finding suggests that haulm yields should be recorded in its own right in groundnut improvement since a considerable degree of independence seems to exist between pod and haulm yields and high pod yield is not automatically associated with high haulm yield. To summarize, the relationships presented in Table 3 show that high pod yield and superior haulm quality and quantity are compatible traits.

References

Blümmel M, Vellaikumar S, Devulapalli R, Nigam SN, Upadhyaya HD and **Khan A.** 2005. Preliminary observations on livestock productivity in sheep fed exclusively on haulms from eleven cultivars of groundnut. International *Arachis* Newsletter 25:54–57.

Larbi A, Dung DD, Olorunju PE, Smith JW, Tanko RJ, Muhammad IR and **Adekunle IO.** 1999. Groundnut (*Arachis hypogaea*) for food and fodder in crop-livestock systems: forage and seed yields, chemical composition and rumen degradation of leaf and stem fractions of 38 cultivars. Animal Feed Science and Technology 77:33–47.

Menke KH and **Steingass H.** 1988. Estimation of the energy feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. Animal Research and Development 28:7–55.

Omokanye AT, Onifade OS, Olorunju PE, Adamu AM, Tanko RJ and **Balogun RO.** 2001. The evaluation of dual-purpose groundnut (*Arachis hypogaea*) varieties for fodder and seed production in Shika, Nigeria. Journal of Agricultural Science 136:75–79.

Rama Devi K, Bandyopadhyay R, Hall AJ, Indira S, Pande S and **Jaiswal P.** 2000. Farmers' perceptions of the effects of plant diseases on the yield and nutritive value of crop residues used for peri-urban dairy production on the Deccan Plateau: Findings from participatory rural appraisals. Information Bulletin no. 60. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 35 pp.

Van Soest PJ. 1994. Nutritional ecology of the ruminant. 2nd edition. Ithaca, New York, USA: Cornell University Press. 476 pp.

Preliminary Observations on Livestock Productivity in Sheep Fed Exclusively on Haulms from Eleven Cultivars of Groundnut

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Groundnut (*Arachis hypogaea*) haulms provide important fodder resources for livestock feeding in mixed crop-livestock systems in developing countries (Larbi et al. 1999, Rama Devi et al. 2000, Omokanye et al. 2001). In these systems fodder shortage is considered one of the major constraints to high livestock productivity and its corollary, high income from the marketing of livestock products. Shrinking common property resources and the little or no scope to expand arable land are further limiting the availability of fodder resources in the rainfed semi-arid tropics. These factors are increasing the value of groundnut as a food-feed crop for which both pod and haulm yields and quality traits are important. Improving the productivity of groundnut can address pod as well as haulm traits, but there is a lack of information on the variability amongst cultivars for the fodder quality of their haulms. This work reported here investigated the variability in cultivar-dependent fodder quality of groundnut haulms through measurement of productivity parameters of young sheep.

Materials and methods

Haulms from improved germplasm/released groundnut cultivars (ICGV 89104, ICGV 91114, TMV 2, ICGV 92093, ICGV 92020, ICGV 86325, ICGS 76, ICGS 11, ICGS 44, DRG 12 and ICGV 86590) were harvested at full pod maturity from seed multiplication trials at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. Four of the cultivars (DRG 12, ICGS 11, ICGS 44 and ICGV 86325) were harvested and fed in two different years. Haulms were fed ad libitum as sole feed to growing Deccani sheep which had a mean initial live weight of about 18 kg. Ad libitum feed intake was adjusted by allowing less than 10% of refused feed. The haulm of a cultivar was fed to six sheep kept in metabolic cages. The sheep were adapted to a cultivar for 3 weeks, following which feces were collected for 10 days. The sheep were weighed before the start of the trial and before and after the 10-day collection period on two consecutive days for which mean weights were calculated. The groundnut haulms were analyzed in the laboratory for nitrogen content by Kjeldahl method and for neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and for in vitro true organic matter digestibility (OMD) as described by Goering and Van Soest (1970).

Results and discussion

Significant differences amongst cultivars were observed for OMD, organic matter intake (OMI), digestible organic matter intake (DOMI) and live weight gains (LWG) in sheep (Table 1). Greatest differences amongst cultivars were observed for daily LWG. Live weight gains in the four cultivars (DRG 12, ICGS 11, ICGS 44 and ICGV 86325) that were harvested and fed in two different years did not differ significantly ($P > 0.05$) between the years. Therefore mean values over the two years are reported in Table 1. When fed haulms of cultivar ICGV 89104, sheep gained daily more than 150 g live weight, which was probably close to the growth potential of Deccani sheep (N Krishna, formerly at ANGRAU, Hyderabad, India, personal communication) while sheep gained only about 50 g on haulms of cultivar ICGV 86590. The cultivar-dependent variation in LWG varied by almost threefold. These observations confirm that groundnut haulms are excellent fodder for ruminant livestock, probably as good or better than most of the planted forages in the semi-arid tropics, and that livestock productivity can be increased through choice of groundnut cultivars.

The indirect haulm quality estimates, OMD, OMI and DOMI accounted for 0.71 ($P = 0.001$), 0.34 ($P = 0.06$) and 0.76 ($P = 0.0004$) of the variation in daily LWG, respectively. The strong positive relationship between OMI and LWG is encouraging because OMI can be estimated by simple laboratory techniques based on rumen microorganisms, ie, in vitro OMD. Established relationships between laboratory haulm quality traits and the productivity of livestock when fed the haulms are essential if haulm quality is to be effectively targeted in multidimensional crop improvement, since animal experimentation is unsuitable for routine screening work in crop improvement work.

Table 1. Organic matter digestibility (OMD), organic matter intake (OMI), digestible organic matter intake (DOMI) and live weight gain (LWG) estimated when haulms from 11 groundnut cultivars were fed to sheep.

Cultivar	OMD (%)	OMI ($g/kg^{0.75}$)[1]	DOMI ($g/kg^{0.75}$)[1]	LWG ($g\ day^{-1}$)
ICGV 89104	72.7	92.9	67.5	151
ICGV 91114	72.6	93.4	67.9	135
TMV 2	71.4	98.1	70.0	122
ICGV 92093	71.9	93.7	67.4	119
ICGV 92020	69.7	94.3	65.7	105
ICGV 86325	67.3	94.4	63.5	94
ICGS 76	66.4	100.1	66.4	100
ICGS 11	67.4	85.6	57.7	74
DRG 12	68.6	86.2	59.1	68
ICGS 44	65.6	87.7	57.5	69
ICGV 86590	67.0	89.9	60.0	51
LSD	2.2	11.3	8.9	41.4

1. Live weight was expressed as metabolic live weight, which is live weight to the power of 0.75 to account for possible absolute difference in live weight between groups.

Table 2. Content of nitrogen (N), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and in vitro organic matter digestibility (OMD) in haulms from 11 groundnut cultivars.

Cultivar	N (%)	NDF (%)	ADF (%)	ADL (%)	In vitro OMD (%)
ICGV 89104	1.8	42.1	25.0	3.8	88.0
ICGV 91114	1.8	38.5	25.6	3.9	87.9
TMV 2	1.8	43.7	29.8	5.2	83.5
ICGV 92093	3.1	33.0	25.6	5.3	86.0
ICGV 92020	2.6	36.6	27.0	5.1	80.5
ICGV 86325	2.4	39.2	25.9	5.1	80.5
ICGS 76	1.6	42.4	27.6	5.2	83.0
ICGS 11	2.0	39.6	25.7	5.8	82.9
DRG 12	2.2	37.8	26.6	5.7	82.2
ICGS 44	2.2	40.7	26.7	5.6	83.7
ICGV 86590	2.1	40.1	28.5	5.1	80.7

Table 2 presents laboratory fodder quality traits, content of nitrogen (N × 6.25 is an estimate of crude protein content), NDF, ADF, ADL and in vitro OMD, which are often employed in roughage and forage analysis. From the perspective of ruminant nutrition, unsupplemented fodder should contain a minimum of 1.2% of nitrogen (Van Soest 1994) required as a critical basal nutrient for the rumen microbes to digest fodder efficiently. The results in Table 2 show that all haulms had nitrogen content well above this threshold level. Neutral detergent fiber is an approximation of total cell wall content (cellulose + hemicellulose + lignin) and the digestibility of NDF by rumen microbes depends on the chemical structure of NDF, particularly the degree of lignification. On the other hand cell contents (100 – NDF) are thought to be almost completely digestible and all haulms investigated consisted of more than 50% of cell content (Table 2). In vitro OMD varied amongst cultivars by 7.5 units, which is of similar magnitude to the range in OMD observed in sheep (7.1 percentage units, see Table 1). Mean in vitro OMD was 83.5% compared to 69.1% in sheep, which agrees well with the theoretical difference of 12.9 percentage units (Van Soest 1994) expected for the particular in vitro digestibility method employed, which was a "true" digestibility measurement, rather than the "apparent" digestibility measurement obtained in sheep.

The relationships between laboratory haulm quality estimates and digestibility, intake and LWG measurements in sheep fed on the haulms are reported in Table 3. Significant inverse relationships were observed between ADL and OMD, DOMI and LWG in sheep. Significant positive relationships were observed between in vitro OMD and OMD and LWG in sheep. Generally, the laboratory measurements accounted for approximately 50 to 58% of the variation in the measurements in sheep.

To conclude, substantial variation in fodder quality of groundnut haulm from this sample of cultivars was observed, such that the variability could be exploited through crop improvement for higher livestock productivity. From the laboratory measurements in vitro OMD and lignin content seem to be suitable for use in the initial screening of germplasm but further development of the laboratory quality traits is required.

References

Goering HK and **Van Soest PJ.** 1970. Forage fiber analyses (apparatus, reagents, procedures and some applications). Agricultural Handbook No. 379. Washington, DC, USA: USDA-ARS.

Larbi A, Dung DD, Olorunju PE, Smith JW, Tanko RJ, Muhammad IR and **Adekunle IO.** 1999. Groundnut (*Arachis hypogaea*) for food and fodder in crop-livestock systems: forage and seed yields, chemical composition and rumen

Table 3. Relationships between laboratory haulms quality measurements (as in Table 2) and digestibility, intake and live weight gain (LWG) measurement in sheep fed haulms from 11 cultivars of groundnut[1].

Variable	OMD	OMI	DOMI	LWG
Nitrogen	0.06 (P = 0.86)	–0.18 (P = 0.57)	–0.09 (P = 0.80)	–0.11 (P = 0.75)
NDF	–0.17 (P = 0.62)	0.25 (P = 0.45)	0.08 (P = 0.81)	0.04 (P = 0.90)
ADF	–0.22 (P = 0.52)	0.35 (P = 0.29)	0.12 (P = 0.72)	–0.29 (P = 0.40)
ADL	–0.70 (P = 0.02)	–0.36 (P = 0.27)	–0.62 (P = 0.04)	–0.76 (P = 0.007)
In vitro OMD	0.72 (P = 0.01)	0.10 (P = 0.77)	0.45 (P = 0.17)	0.74 (P = 0.01)

1. OMD = Organic matter digestibility; OMI = Organic matter intake; DOMI = Digestible organic matter intake; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin.

degradation of leaf and stem fractions of 38 cultivars. Animal Feed Science and Technology 77:33–47.

Omokanye AT, Onifade OS, Olorunju PE, Adamu AM, Tanko RJ and **Balogun RO.** 2001. The evaluation of dual-purpose groundnut (*Arachis hypogaea*) varieties for fodder and seed production in Shika, Nigeria. Journal of Agricultural Science 136:75–79.

Rama Devi K, Bandyopadhyay R, Hall AJ, Indira S, Pande S and **Jaiswal P.** 2000. Farmers' perceptions of the effects of plant diseases on the yield and nutritive value of crop residues used for peri-urban dairy production on the Deccan Plateau: Findings from participatory rural appraisals. Information Bulletin no. 60. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 35 pp.

Van Soest PJ. 1994. Nutritional ecology of the ruminant. 2nd edition. Ithaca, New York, USA: Cornell University Press. 476 pp.