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Genetic variation in minerals, crude protein and structural carbohydrates of foliage in provenances of young plants of *Prosopis cineraria* (L.) Druce in India

S. ARYA[1], R. P. BISHT[1], R. TOMAR[1], O. P. TOKY[2] and P. J. C. HARRIS[3]
[1] *Dayanand Post-Graduate College, Hisar, India, 125001;* [2] *Forestry Department, Haryana Agricultural University, Hisar, India, 125 004;* [3] *The Henry Doubleday Research Association, Coventry, CV8 3LG, UK*

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Abstract. *Prosopis cineraria* is an important species for aridzone agroforestry in India. Information on the chemical composition and nutritive value of the leaves of young trees that will be useful in screening the provenances, is lacking. Chemical composition (N, P, K, Ca, Mg, Na), crude protein, and structural carbohydrates (neutral detergent fibre, acid detergent fibre, cellulose, hemicellulose, and lignin) of the foliage of one-year-old plants of 31 provenances of *Prosopis cineraria* were determined. The seeds were collected from 16°50′ N to 29°55′ N latitude and 69°49′ E to 78°03′ E longitude in India, and grown at Hisar (29°10′ N latitude, 75°46′ E longitude and 215 m altitude). Mineral contents (except N and P), crude protein, and structural carbohydrates varied significantly ($p < 0.05$) between provenances, and the greatest amount of N, P, crude protein, NDF, ADF and lignin contents were found in Hisar provenance. The in vitro dry matter digestibility varied from 18.2% in Gandhinagar provenance to 34.0% in that of Barmer provenance.

1. Introduction

Prosopis cineraria (L.) Druce ‘Khejri’ plays a vital role in the development of arid and semi-arid regions of India. It is extensively used in agroforestry systems due to its deep root system [Toky and Bisht, 1992], monolayered canopy [Bisht and Toky, 1993], and because it has been shown to improve the nutrient status of soil [Arya et al., 1992a].

The branches of *P. cineraria* are frequently lopped during the winter, and the dried leaves (‘loong’ or ‘loom’) are used during summer when green fodder is scarce. A few studies are available on the general chemical composition and nutritive value of its leaves [Bhandari et al., 1979; Joshi et al., 1985], but little is known about variation among provenances.

The present study reports variation in mineral and biochemical contents in foliage of 31 provenances of *P. cineraria*. The seeds were collected from 16°50′ N to 29°55′ N latitude, 69°49′ E to 78°03′ E longitude throughout its distribution in India and grown in the nursery at Hisar (29°10′ N latitude, 75°46′ E longitude, 215 m altitude) in arid region of north-western India. The study was undertaken to screen provenances in order to select seed source for better forage quality.

2. Materials and methods

The climate of Hisar is sub-tropical monsoonic with an average rainfall of 350–400 mm, 70–80% of which occurs during July to September. The minimum and maximum temperatures vary from 3 °C during winter to 48 °C during summer.

Seeds were collected from 31 sites (provenances) from its entire range of distribution in India (Table 1). For each site, seeds were collected from 5 to 15 trees.

For each provenances, 300 polythene bags (18″ × 6″) containing soil and sand in equal proportions were arranged randomly in 3 blocks. Two seeds were sown in each bag in September 1991. The plants were watered weekly during summer and at fortnight interval during winter. After one year, 3 plants from each block (total 9 plants for each provenance) were randomly selected and all the leaves were harvested and dried at 70 °C for 48 h. The composite samples were ground in a willey mill to pass through a 2-mm sieve. The chemical analyses were done following standard procedures [Allen et al., 1974]. Nitrogen was determined by micro kjeldahl's method, sodium and potassium by flame photometry, calcium and magnesium by titrating with the EDTA, and phosphorus by the vandomolybde phosphoric colorimeteric method.

The nitrogen content was multiplied by the factor 6.25 to calculate crude protein. Standard procedures were followed for estimation of neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemi-cellulose, lignin and silica [Goering and Van Soest, 1970]. The in vitro dry matter digestibility was estimated by the methods of Tilley and Terry [1963] as modified by Barnes et al. [1971]. The results are presented on a dry weight basis.

3. Results and discussion

Data were analysed by an analysis of variance. The coefficient of variation for mineral contents varied from 8.13 to 25.18% for N and Mg, respectively (Table 2). The concentration of N in the leaves varied from 17.2 to 25.4 mg/g and that of P from 1.1 to 1.8 mg/g with the greatest values in the Hisar provenance. The Sirsa and Ankleshwar provenances showed the greatest K and Na contents, respectively. The Ca and Mg contents varied from 21.0 (Bijapur provenance) to 38.0 mg/g (Sikar and Himmatnagar provenances) and 5.4 (Surat) to 16.8 mg/g (Churu provenance), respectively (Table 2). The analysis of variance showed that all the mineral contents except N and P varied significantly ($p < 0.05$) among the provenances.

Crude protein contents varied from a minimum of 10.7% in Aidlabad provenance to a maximum of 15.9% in the Hisar provenance (Table 3). The latter provenance also showed the highest NDF (59.6%), ADF (49.7%) and lignin (32.0%) contents, while the Jaisalmer provenance showed the lowest

Table 1. Description of seed collection sites.

Provenance	Acc. no.	Latitude (°) (′) N		Longitude (°) (′) E		Rainfall zone (mm)	Soil type
State Haryana							
Hisar	DPC-1	29	10	75	46	400–500	Old alluvium
Sirsa	DPC-2	29	23	75	07	400–500	Sandy clay
Bhiwani	DPC-3	28	46	76	18	400–500	"
State Raiasthan							
Ganganagar	DPC-4	29	55	73	50	200–300	Sandy Grey
Anupgarh	DPC-5	29	12	73	13	200–300	"
Suratgarh	DPC-6	29	20	73	52	200–300	"
Hanumangarh	DPC-7	29	25	74	20	200–300	"
Bikaner	DPC-8	28	00	73	22	150–200	"
Jaisalmer	DPC-9	26	55	70	53	150	"
Barmer	DPC-10	25	45	71	22	150	"
Jodhpur	DPC-11	26	17	73	03	150–200	"
Jalore	DPC-12	25	21	72	37	300–400	"
Sanchore	DPC-13	24	36	71	54	150–200	"
Sikar	DPC-14	28	05	75	00	300–400	"
Churu	DPC-15	28	17	74	57	300–400	"
Jhunjhunu	DPC-16	28	10	75	22	300–400	"
Nagaur	DPC-17	27	12	73	44	150–200	"
Nokha	DPC-18	26	00	73	22	150–200	"
Bidhasar	DPC-19	27	43	74	30	150–200	"
Jasrasar	DPC-20	26	05	73	24	150–200	"
State Gujarat							
Himmatnagar	DPC-22	23	37	72	59	500–700	Alluvial
Gandhinagar	DPC-23	23	15	72	17	500–750	"
Vishnagar	DPC-24	23	43	72	38	500–750	"
Bhuj	DPC-25	23	15	69	49	300–400	"
Bharuch	DPC-26	21	44	72	58	750–1000	"
Ankleshwar	DPC-27	21	38	78	03	750–1000	"
Surat	DPC-28	21	12	72	52	750–1000	" Coastal
State Karnataka							
Gulberga	DPC-29	17	19	76	54	600–750	Medium black
Bi japur	DPC-30	16	50	75	48	500–600	"
State Maharashtra							
Parola	DPC-31	20	33	75	48	600–750	"
Aidlabad	DPC-32	21	05	75	52	600–750	"

amount of these compounds. The cellulose and hemi-cellulose contents varied from 11.4–17.1% and 4.8–17.7%, respectively. The in vitro dry matter digestibility was the greatest in the Barmer provenance and least in the Gandhinagar provenance. The analysis of variance showed significant ($p < 0.05$) differences among provenances for all the characters. The coefficient of variation of structural carbohydrates, crude protein and in vitro dry matter

Table 2. Mineral contents (mg/g) in leaves of different provenances.

Provenance	N	P	K	Ca	Mg	Na
Hisar	25.4	1.8	9.4	28.0	9.8	0.5
Sirsa	22.8	1.5	10.1	28.0	9.6	1.1
Bhiwani	21.6	1.4	7.3	31.0	13.8	0.8
Ganganagar	22.6	1.6	7.8	33.0	9.0	0.9
Anupgarh	22.3	1.5	9.2	29.0	13.8	0.7
Suratgarh	23.9	1.1	7.2	24.0	11.4	0.5
Hanumangarh	25.0	1.8	9.1	31.0	10.8	0.7
Bikaner	18.0	1.3	7.5	37.0	7.2	0.6
Jaisalmer	18.5	1.4	7.8	28.0	9.0	0.6
Barmer	19.9	1.3	5.7	31.0	12.0	0.7
Jodhpur	19.3	1.5	7.3	28.0	7.2	0.6
Jalore	20.5	1.4	7.7	26.0	10.2	0.5
Sanchore	21.7	1.6	8.8	28.0	7.2	0.4
Sikar	19.6	1.4	7.8	38.0	3.6	0.6
Churu	21.0	1.6	9.8	32.0	16.8	0.4
Jhunjhunu	20.0	1.6	8.0	33.0	15.0	0.7
Nagaur	19.5	1.1	6.8	33.0	11.4	0.4
Nokha	18.7	1.5	7.5	36.0	8.4	0.5
Bidhasar	20.5	1.5	8.1	27.0	12.0	0.6
Jasrasar	20.5	1.6	7.8	29.0	12.6	0.6
Himmatnagar	21.7	1.5	8.3	38.0	6.6	0.6
Gandhinagar	24.2	1.6	8.1	32.0	9.6	0.4
Vishnagar	20.5	1.7	9.3	30.0	13.2	0.8
Bhuj	20.7	1.4	7.8	31.0	12.6	0.5
Bharuch	21.4	1.6	8.3	28.0	13.2	0.7
Ankleshwar	20.3	1.4	7.4	31.0	9.6	1.1
Surat	20.1	1.4	8.4	36.0	5.4	2.0
Gulberga	19.6	1.6	8.1	30.0	8.4	0.7
Bijapur	24.9	1.3	8.0	21.0	10.2	0.7
Parola	18.2	1.4	7.4	28.0	12.0	0.5
Aidlabad	17.2	1.5	7.2	31.0	9.6	0.8
F Value (d.f. 30)	1.5	0.5	3.2**	2.1*	2.7*	4.4*
LSD (5 %)	3.48	0.27	1.46	3.61	4.39	0.20
SEM	1.20	0.09	0.50	1.25	1.52	0.07
CV (%)	8.13	8.97	8.88	11.47	25.18	15.46

* $p < 0.05$; ** $p < 0.01$.

digestibility was low as compared to mineral contents, and it varied 1.15% for ADF to 10.88% for silica contents (Table 3).

In the present study large and statistically significant differences were observed in the mineral contents and structural carbohydrates between provenances. The Hisar provenance (local) showed the greatest concentrations of N, P, K, crude protein, ADF, NDF and lignin contents which may be due to the adaptability of this provenance to the local climate. Self-incompatibility in *Prosopis* species [Simpson, 1977] causes out-crossing so that the trees propagated from seeds are extremely variable within its population [Felker

Table 3. Variation in biochemical content (%) of different provenances.

Provenance	Crude protein	NDF	ADF	Cellulose	Hemi-cellullose	Lignin	Silica	IVDMD
Hisar	15.9	59.6	49.7	16.6	9.8	32.0	1.1	22.2
Sirsa	13.2	48.4	37.5	14.4	10.9	21.1	1.1	25.4
Bhiwani	13.5	54.7	37.5	12.1	17.2	24.8	0.6	20.0
Ganganagar	14.1	51.0	37.2	11.4	13.8	24.1	0.7	25.8
Anupgarh	13.9	49.9	38.2	12.2	11.7	25.6	0.4	24.4
Suratgarh	14.9	49.2	32.0	12.2	17.3	19.0	0.8	28.0
Hanumangarh	15.6	56.1	41.5	16.1	14.6	24.2	1.3	27.6
Bikaner	11.3	46.9	34.9	11.9	12.0	22.4	0.6	25.8
Jaisalmer	11.4	45.9	30.4	11.8	15.5	17.6	1.0	28.2
Barmer	12.5	46.6	30.1	11.5	16.6	18.1	0.5	34.0
Jodhpur	12.0	49.9	32.2	11.9	17.7	19.5	0.8	25.6
Jalore	12.8	53.8	38.1	11.8	15.8	26.0	0.3	26.8
Sanchore	13.6	52.2	37.0	13.6	15.2	22.6	0.7	22.2
Sikar	12.3	51.0	38.2	14.9	12.8	22.9	0.5	27.4
Churu	13.1	49.2	33.7	13.3	15.5	23.8	0.6	29.6
Jhunjhunu	12.5	49.7	36.0	13.3	13.7	22.0	0.7	21.2
Nagaur	12.2	54.2	44.0	16.1	10.2	27.0	0.9	19.4
Nokha	11.7	47.2	38.6	15.0	8.6	22.8	0.7	18.4
Bidhasar	12.8	47.6	37.8	14.3	9.8	22.0	1.6	27.8
Jasrasar	12.8	54.0	45.7	17.1	8.3	27.9	0.8	25.6
Himmatnagar	13.6	49.2	40.2	16.1	9.0	23.4	0.7	22.6
Gandhinagar	15.1	54.8	40.6	16.3	14.1	24.0	0.4	18.2
Vishnagar	12.8	55.0	43.4	16.1	11.5	26.8	0.5	22.8
Bhuj	12.9	49.9	39.8	15.7	10.1	23.7	0.4	22.4
Bharuch	13.3	53.1	41.0	15.3	12.1	24.7	1.1	24.8
Ankleshwar	12.7	55.4	43.8	16.3	11.6	26.4	1.1	23.4
Surat	13.9	56.5	43.0	13.7	13.5	27.6	1.6	26.6
Gulberga	12.3	50.2	43.2	16.1	7.0	26.1	1.0	32.2
Bijapur	15.6	51.5	46.7	16.7	4.8	29.4	0.7	19.2
Parola	11.4	55.5	45.2	15.8	10.3	27.9	1.5	24.0
Aidlabad	10.7	53.2	41.5	14.8	11.7	26.0	0.7	28.0
F value (d.f. 30)	1.9*	27.9**	44.2**	11.2**	26.6**	43.6**	9.0**	2.5**
LSD (5 %)	1.54	1.08	1.17	1.19	1.59	0.979	1.16	4.53
SEM	0.53	0.37	0.40	0.41	0.55	0.34	0.40	1.57
CV (5 %)	3.58	1.15	1.47	2.62	3.84	1.62	10.88	7.45

* $p < 0.05$; ** $p < 0.01$.

et al., 1981]. We had also observed a wide variation in seed and pod morphology [Arya et al., 1992b], seed germination and seedling growth (our unpublished data).

Continuous supply of protein is required by ruminant animals if they have to maintain a normal metabolism. Rumin bacteria require a minimum of 6–8% crude protein for efficient fermentation of plant tissue [NAS, 1981; Van Soest, 1982]. Considering this, all the provenances provide at least the minimum required amount of protein although the leaves are less palatable. The crude protein contents of this species are reported to vary with season [Gupta and Mathur, 1974] and age of the leaves and trees [Joshi et al., 1985].

In vitro dry matter digestibility (IVDMD) was only up to 34%. The lower digestibility may be due to the presence of higher lignin contents caused by the high temperature of the area and also, to the presence of tannins and silica. Lignin has been found to be the single component most widely correlated with depressing digestibility [Van Soest, 1982]. It apparently inhibits the effect of enzymes on cellulose catabolism and may also have an antibacterial function.

Further more, the leaves of *P. cineraria* are reported to contain 11.6% [Bohra and Ghosh, 1980] to 25.3% [Joshi et al., 1985] tannins. High tannin contents decreases the palatibility and digestibility of protein and cellulose by forming insoluble complexes as well as inhibiting digestive enzymes [McLeod, 1974]. For example, the increase of 1% of tannic acid, decreased the IVDMD by up to 7% in sorghum [Arora and Luthra, 1974]. Bohra and Ghosh [1980] reported that the digestibility of crude protein and cellulose was up to 5.5% and 23.0%, respectively, in sheep and goats. Further, the digestibility of the cellulosic fraction of *P. cineraria* feed was less than half of that of *Cenchrus ciliaris* in sheep [Bohra and Ghosh, 1977]. The values estimated for young plants, however, may not follow the same trends in the old trees, but they certainly provide useful information for the selection of provenance at the early stage of plant growth.

Despite the relatively poor quality, dried fodder from *P. cineraria* has its part to play in animal nutrition of arid and semiarid dry regions. Our findings suggested that screening seed sources for high protein contents and digestibility and low lignin contents has great potential.

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