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Variation in chemical contents of seed, and foliage in *Albizia lebbek* (L.) Benth. of different provenances

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Abstract. Protein, oil, carbohydrate and starch contents of seed, which were collected from places with latitude 9° N to 32° N, longitude 72° E to 85° E and rainfall 40 to 400 cm, varied significantly ($P < 0.05$) among 12 provenances. Interestingly, seed protein was positively correlated ($r = 0.838$, $P < 0.05$), and on the contrary, carbohydrate and starch were negatively correlated ($r = -0.755$, $r = -0.623$, respectively, $P < 0.05$), with the latitude of the seed source. Significant variation for N, P, K, Ca and Mg in stems and leaves of one-year and three-year-old plants was also observed when these provenances were grown at Hisar (29°10′ N, 75°46′ E, 215 m alt.), an arid region in north India. In general, provenances from north India at the age of three years had greater chemical and mineral contents than those from south India. Chlorophyll content was highly correlated with the latitude of the seed source, at the ages of one and three years ($r = 0.742$, $r = 0.659$, $P < 0.05$, respectively), while crude protein of foliage at the age of three years was significantly correlated ($r = 0.673$) with latitude. Dehradun, Jammu and Hisar provenances, from the north had comparatively greater concentrations of N, P and K at the age of three years as compared to those from south India. The results are useful from the points of view of genetical variation, and selection of superior provenances for arid conditions in north India.

1. Introduction

Introduction and evaluation of provenances is an essential aspect in agroforestry research [von Maydell, 1986; Nair, 1989; Wood and Burley, 1991]. Considerable genetic variation in growth, chemical composition of seed and foliage at the level of provenance, variety or progeny can be expected particularly in outcrossing species such as many species of *Acacia*, *Albizia* and *Prosopis* which are widely used in agroforestry systems throughout arid and semi-arid regions. The variation would be useful as a source of future genetic selection provided the desired ideotypes for agroforestry systems are clearly defined [Cannel, 1982; Burley et al., 1984; von Carlowitz, 1986]. The greater contents of N, P, K, Ca, Mg, Fe, S and Na of seed enable the seedling to grow vigorously [Lee and Fenner, 1989], and also affect its frost tolerance capacity [Alberdi et al., 1989].

Albizia lebbek (L.) Benth. (family leguminosae, sub-family mimosoideae), commonly called 'black siris' is a robust tree that produces small timber and is a useful fuelwood; it fixes nitrogen; and it is an excellent species for reforestation of dry alkaline soils. It is native to the Indian sub-continent and has been cultivated in tropical and sub-tropical regions in the Americas and Caribbean and Southeast Asia. The tree coppices well. The young foliage is a good livestock feed and green manure.

In *Albizia lebbek*, maximum shoot growth occurs during dry period from March to April, compared to other semi-arid species where it occurs during rainy season from July to September [Bisht et al, 1992; Bisht and Toky, 1993]. Also this species allocates proportionally more biomass into roots as compared to other arid zone species such as *Prosopis cineraria, Acacia nilotica* and *A. catechu* [Toky and Bisht, 1992; Toky et al., 1992]. Due to these ecological features *A. lebbek* is an important component of traditional agroforestry systems in the dry parts of India.

Little work has been done sofar on germplasm collection and its evaluation for chemical composition of seed and foliage of India's arid and semi-arid species. The objective of the present study was to study variation in chemical contents of seed, and foliage of one year-old seedlings and three year-old trees of 12 provenances of *Albizia lebbek* collected from its entire range of distribution in India, and grown at Hisar, an arid region of India.

2. Study area

The work was carried out at Hisar (29°10′ N, 75°46′ E, 215 m elevation), in northwestern India, which is classified as an arid region with subtropical conditions (Fig. 1). The climate is dry monsoonic with mean humidity index less than 16.7%. Annual rainfall ranges from 50 to 1000 mm with most falling from July to September. The minimum and maximum temperatures vary from –3 °C in January to 48 °C in May–June. Hot winds blow throughout the summer from May to June. The soil is sandy-loam with an average pH of 8.5.

3. Material and methods

3.1. *Seed collection*

Seeds of 12 provenances from latitude ranging from 9°58′ N to 32°43′ N, longitude from 72°37′ E to 85°52′ E, and rainfall from 40 to 400 cm in India were collected (Table 1, Fig. 2). For each provenance mature pods from 20 healthy trees were collected during December, 1988, from south India, and during February–March, 1989 from north India. Each provenance consisted of 2 to 5 kg seed to provide potentially useful genetic variation. Bamboo pole with a hook attached to one end was used to harvest the pods from the trees. Pods were sun dried, and seeds were extracted through manual threshing to ensure the collection of sound seeds. The seeds were further cleaned through winnowing, fumigated with celphos, and stored at room temperature in air-tight aluminium canes.

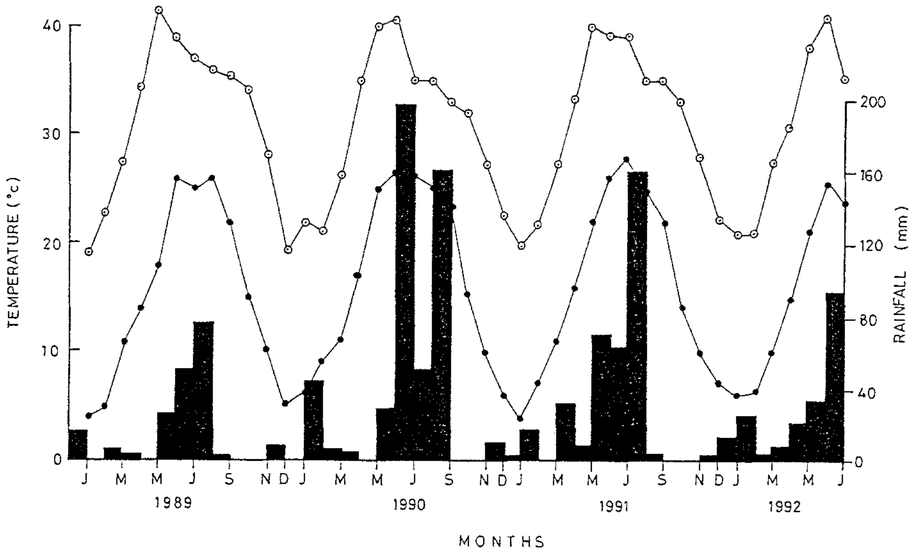

Fig. 1. Minimum temperature (●), maximum temperature (⊙) and rainfall (■) of the study site at Hisar, India.

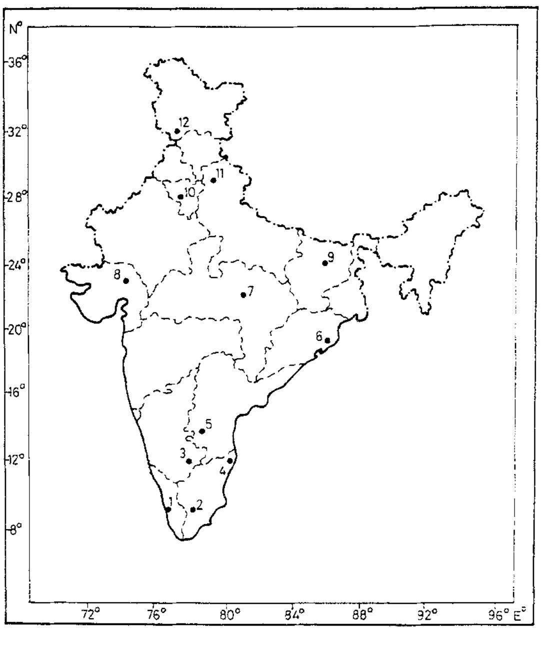

Fig. 2. Seed collection sites. 1, Cochin; 2, Madurai; 3, Bangalore; 4, Madras; 5, Anantpur; 6, Bhubaneshwar; 7, Jabalpur; 8, Mahesana; 9, Raniganj; 10, Hisar; 11, Dehradun; 12, Jammu.

Table 1. Seed collection sites.

Provenance	Latitude	Longitude	Rainfall (cm)	Soil type
Cochin	9° 58′	76° 17′	200–400	Coastal alluvium
Madurai	9° 58′	78° 10′	40–100	Red loam soil
Bangalore	12° 58′	77° 38′	40–100	Red gravelly soil
Madras	13° 04′	80° 17′	100–200	Coastal alluvium
Anantpur	14° 41′	77° 39′	40–100	Medium black
Bhubaneshwar	20° 15′	85° 52′	100–200	Red loam
Jabalpur	23° 10′	79° 59′	40–100	Medium black
Mahesana	23° 42′	72° 37′	40–100	Alluvial
Raniganj	25° 52′	85° 52′	100–200	Red Loam
Hisar	29° 10′	75° 46′	40–100	Alluvial
Dehradun	30° 19′	78° 04′	100–200	Red loam
Jammu	32° 43′	74° 54′	100–200	Red loam

3.2. *Plantation establishment*

In the nursery, 600 seeds of each provenance distributed randomly into three blocks, were sown in the polypots (32 × 60 cm) containing soil, sand and manure in equal proportions. In October, 1989, six-month-old seedlings were transplanted into a rectangular size field of about 2.5 acres with plant spacing of 3 × 3 m at Hisar (India). Planting was done following a randomized block design (RBD) with 75 plants for each provenance, split up into three blocks. No fertilizer was added to the soil. The plants were not watered except during the first year.

3.3. *Chemical analyses*

The crude protein, oil, carbohydrate and starch of seeds, and crude protein, carbohydrate, starch, chlorophyll, N, P, K, Ca and Mg of one- and three-year-old plants were analysed following the standard procedures [Allen et al., 1974]. Composite samples for stems and leaves from five plants collected in October after the rainy season and 100 seeds for each provenance were oven dried at 70 °C and ground with Willey Mill to pass through a 0.5 mm mesh. Analyses were carried out with five sub-samples drawn from a composite sample. Chlorophyll was estimated from leaf samples taken from five replicate plants by using the DMSO method [Hiscox and Israelstam, 1979]. The total nitrogen was determined by the micro-Kjeldehl method. Crude protein was then estimated by the multiplication of factor 6.25 with N concentration. Carbohydrate was determined colorimetrically by using anthrone regeant and starch with Cleg method [Cleg, 1956]. Phosphorous was determined by the phosphomolybdic blue method and potassium by flame photometry while calcium and magnesium were estimated by the EDTA rapid titration method. Oil content of seeds were determined by wide-line NMR [Gupta et al., 1985].

The data were subjected to analysis of variance [Panse and Sukhatme, 1978]. Linear correlation coefficients were calculated for various biochemicals or nutrients in seed or plants against latitudes of the provenances.

4. Results

4.1. *Seed*

Crude protein, oil, carbohydrate and starch contents varied significantly ($P < 0.05$) among most of the provenances (Table 2). Crude protein was the greatest in Dehradun provenance (31.4%), closely followed by Raniganj (30.8%) and least in Madurai provenance (26.5%). Oil content ranged from 5.6% in Madurai to 8.6% in Madras provenance. In general, high concentration of carbohydrate was observed in provenances having low crude protein, and it ranged from 3.1% in Bhubaneshwar, a eastern provenance to 3.7% in Cochin, southern provenance. Starch content followed the same trend as that of carbohydrate.

Table 2. Chemical content (%) of seeds.

Provenance	Crude protein	Oil	Carbohydrate	Starch
Cochin	28.9	7.6	3.7	1.3
Madurai	26.5	5.6	3.7	1.1
Bangalore	28.8	6.1	3.6	1.2
Madras	28.5	8.6	3.7	1.1
Anantpur	29.7	6.5	3.3	1.1
Bhubaneshwar	30.2	7.4	3.1	0.9
Jabalpur	29.5	7.5	3.4	1.1
Mahesana	30.6	6.7	3.4	1.1
Raniganj	30.8	6.7	3.2	1.0
Hisar	30.6	7.7	3.3	0.9
Dehradun	31.4	7.0	3.3	0.9
Jammu	30.6	7.3	3.2	1.1
LSD at 5% level	0.50	0.71	0.16	0.29

It was interesting to note that crude protein of seed was significantly and positively correlated with the latitude of the provenance origins ($r = 0.838$, $P < 0.05$). The carbohydrate and starch were, however, negatively correlated ($r = -0.755$, $r = -0.623$, respectively; $P < 0.05$) with the latitude.

4.2. *One- and three-year-old plants*

Crude protein, carbohydrate, starch and chlorophyll contents in leaf varied significantly ($P < 0.05$) among most of the provenances. The provenance with greater chemical contents at the age of one year did not maintain their ranking at the age of three years. Crude protein at the age of one year varied from 15.2% in Madras to 20.5% in Dehradun provenance; while at the age of three years it was from 15.2% in Cochin to 21.3% in Dehradun provenance. The concentrations of carbohydrate, starch and chlorophyll were significantly greater in Jammu, Jabalpur and Raniganj provenances. Only the average values for north, middle and south provenance, respectively, have been given in the Table 3.

Chlorophyll content in different provenances was highly correlated with the latitude; at the ages of one and three years ($r = 0.742$, $r = 0.659$, respectively, $P < 0.05$) while crude protein at the age of three years was significantly correlated ($r = 0.673$, $P < 0.05$) with latitude of origin source.

The concentrations of N, P, K, Ca and Mg in stems and leaves varied significantly among most of the provenances at the ages of one and three years. Provenances with greater concentrations at the age of one year, however, did not maintain their ranking at the age of three years. Concentrations of stem nitrogen varied significantly from 1.2% in Madurai to 1.7% in Hisar provenance, and for leaf from 2.5% in Cochin to 3.3% in Dehradun provenance at the age of one year. At the age of three years comparatively lesser concentrations were observed in most of the provenances, and the ranking of provenance with respect to concentration also changed. Only the average values of leaves for north, middle and south provenances, respectively, have been given in Table 3.

Concentration of stem N at the age of one year and that of leaf at the age of three years were highly correlated with the latitude ($r = 0.798$, 0.674, respectively, $P < 0.05$) of the origin site. The interesting observations was

Table 3. Percentage mean values of groups of south, north and middle India provenances.

Content (%)	Age (year)	South	North	Middle	LSD
Crude protein	1	17.1	18.4	17.1	0.20
	3	16.4	19.7	17.0	1.16
Carbohydrate	1	0.15	0.16	0.12	0.04
	3	0.21	0.22	0.22	0.06
Starch	1	0.036	0.025	0.042	0.009
	3	0.033	0.033	0.022	0.041
Chlorophyll	1	0.238	0.268	0.254	0.072
	3	0.255	0.283	0.273	0.069
N	1	2.8	3.0	2.7	0.57
	3	2.6	3.2	2.7	0.39
P	1	0.27	0.23	0.26	0.32
	3	0.29	0.25	0.27	0.14
K	1	0.69	1.08	0.91	0.18
	3	1.33	1.12	1.19	0.16
Ca	1	0.90	0.86	0.92	0.30
	3	0.96	0.91	0.95	0.24
Mg	1	0.30	0.28	0.33	0.40
	3	0.33	0.28	0.29	0.51

that in contrast to the trend of N concentration, there was a strong negative correlation of leaf P at the ages of one year ($r = -0.568$, $P < 0.05$) and three years ($r = -0.606$, $P < 0.05$) age with latitude of provenance origins.

In general, K concentration was greater at the age of three years than at the age of one year. The concentration in stem was significantly ($P < 0.05$) greater in Dehradun and Mehasana provenances at the ages of one and three years. Concentration of calcium in stem varied from 1.08% in Dehradun, a northern provenance to 1.34% in Madras and Madurai, two south provenances, at the ages of one and three years. Leaf Ca was significantly greater ($P < 0.05$) in Jabalpur provenance at the ages of one and three years. Interestingly, Mg concentration in stems was the greatest in Jabalpur provenance, and least in Hisar, at both ages of growth. In leaves, however, there was no clear trend. Only the average values of leaves for north, middle and south provenances, respectively, have been given in Table 3.

Strong negative correlations were established between K concentrations of stems at the ages of one year ($r = -0.559$, $P < 0.05$) and three years ($r = -0.627$, $P < 0.05$) with latitude. High rank negative correlations were established between Ca concentration of stem at the ages of one ($r = -0.917$, $P < 0.05$) and three years ($r = -0.590$, $P < 0.05$) with latitude. Regression equations showed significant negative correlations of Mg concentrations (stem, $r = -0.567$, leaf, $r = -0.455$; $P < 0.05$) and Ca concentrations (stem, $r = -0.590$; $P < 0.05$) in plants at the age of three years with latitude.

5. Discussion

Crude protein, carbohydrate and starch contents of the seeds of 12 provenances of *Albizia lebbek* showed significant variation. The seeds of Cochin, Madurai, Bangalore and Madras provenances, from south India that were having greater contents of carbohydrate and starch, also showed better seedling growth. Such a relationship of starch and carbohydrate of seed with plant growth had also been reported in *Chionochloa* species [Lee and Fenner, 1989]. Variation in protein content of seed among different provenances of *Sasa senanensis* were also reported in the USSR [Semikhov, 1978]; however, the author did not relate it to the growth of the seedling.

The superiority in growth up to the age of one year was presumably based on high seed contents in southern provenances, and also due to high chlorophyll contents, however, the superiority was not maintained at the age of three years. There was no other report available on *Albizia lebbek*. Nevertheless, there are studies on seed contents of *Acacia nilotica*. In this species, a range of crude protein from 13.9% in Jodhpur provenance in western India [Ganguli et al., 1964] to 22.4% in Anantpur provenance in south India [O. P. Toky and B. Krishan, unpublished] has been reported. Such variation is primarily due to genotype [Lunder Stadt, 1980].

The site of testing in the present study experiences frost and drought alternatively which might have affected the survival and growth of plants, and the effect varied among genotypes. Cochin and Madurai provenances which had the greatest carbohydrate in the seed showed greater survival percentage at the age of one year.

In general, Dehradun, Jammu and Hisar provenances, all three from north India, had comparatively greater concentrations of N, P, and K at the age of three years than provenances from south India. These three provenances were much superior in diameter and height growth also [O. P. Toky and N. Kumar, unpublished]. It suggests that these provenances may be genetically superior for northern India.

Similar variation in nutrient contents of plants among provenances were observed in *Picea abies* seedlings [Fobee and Giertych, 1970], *Pinus sylvestris* [Bopp, 1971], *Pseudotsuga menziesii* [Driessche, 1973] and *Acacia albida* [Sniezko and Stewart, 1989]. Greater concentration of N in superior provenance has been reported for *Quercus robur* in the USSR [Lukyanetes, 1980]. A detailed study [Khosla et al., 1992] on six fodder trees of the Himalaya revealed that early successional fast growing tree species, e.g., *Grewia optiva*, *Celtis australis* and *Robinia pseudoacacia* have much greater content of protein in leaves (20 to 30%) than late successional slow growing species e.g. *Quercus leucotrichophora*, *Q. glauca* and *Ilex odorata* (8 to 10% protein).

The results are important from the points of view of genetical variation in chemical of seed and leaves of *Albizia lebbek*, and for selection of superior provenances for semi-arid north India.

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