VARIATION IN FOLIAR BIOCHEMICAL AND NUTRIENT CONTENTS AMONG PROVENANCES OF *ACACIA NILOTICA* SSP. *INDICA*

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KRISHAN, B. & TOKY, O.P. 1995. Variation in foliar biochemical and nutrient contents among provenances of *Acacia nilotica* ssp. *indica*. The carbohydrate, starch, chlorophyll and N, P, K, Ca and Mg contents in leaf varied significantly ($p<0.05$) among 21 provenances of *Acacia nilotica* ssp. *indica*, collected from areas throughout its distribution range in India from latitude 11°N to 31°N and altitude from 19 to 650 m. The rankings of provenances for biochemical and nutrient assimilations were different at both 7- and 30-month ages. The greatest concentrations of carbohydrate and chlorophyll were noticed in Roorkee provenance at 7-month age, and in Hisar and Medinipur provenances at 30-month age respectively. The starch content was greatest in Medinipur provenance at both ages. In general, Hisar and Gurgaon provenances had higher contents of nutrients. These provenances also showed superior growth as compared to other provenances in the field. The provenance variations were random, and did not show a significant ($p > 0.05$) relationship with the latitude of the origin source. The observations are useful for selection of provenances for arid and semi-arid conditions.

Key words: *Acacia nilotica* - provenance - biochemical - nutrients

KRISHAN, B. & TOKY, O.P. 1995. Variasi di dalam biokimia daun dan kandungan nutrien pada provenans *Acacia nilotica* ssp. *indica*. Karbohidrat, kanji, klorofil dan kandungan kepekatan N, P, K, Ca dan Mg di dalam daun, adalah berbagai jenis ($p<0.05$) di kalangan 21 provenans *Acacia nilotica* ssp. *indica*, yang diambil daripada kawasan-kawasan di seluruh kawasan taburan di India daripada latitud 11°N kepada 31°N dan altitud daripada 19 kepada 650 m. Susunan provenans bagi biokimia dan asimilasi nutrien adalah berbeza pada umur 7 dan 30 bulan. Kepekatan karbohidrat dan klorofil yang paling tinggi didapati di dalam provenans Roorkee pada umur 7 bulan, dan di dalam provenans Hisar dan Medinipur masing-masing ketika berumur 30 bulan. Kandungan kanji paling tinggi didapati di dalam provenans Medinipur pada kedua-dua umur. Secara umumnya, provenans Hisar dan Gurgaon mempunyai kandungan nutrien tinggi. Provenans-provenans ini juga menunjukkan pertum-buhan yang terbaik dibandingkan dengan provenans-provenans lain di ladang. Variasi provenans adalah rawak, dan tidak menunjukkan perhubungan yang ketara ($p>0.05$) dengan latitud sumber-sumber asal. Pemerhatian ini adalah berguna untuk pemilihan provenans bagi keadaan-keadaan gersang dan separa-gersang.

Introduction

The potential of *Acacia nilotica* ssp. *indica* (Benth.) Brenan (Leguminosae, Mimosoideae) as a multipurpose tree has been recognised world-wide (National Academy of Sciences 1980). This species is widely distributed throughout the dry and hot regions of India ranging from 9°N to 34°N latitude and 72°E to 92°E longitude, and ascending to an altitude of 900 m. It experiences a maximum temperature of 40 to 50 °C, a minimum temperature of -5 to 15°C, and a mean annual rainfall of 75 to 1300 mm.

Acacia nilotica ssp. *indica* locally called as 'babul' is a big-sized nitrogen fixing tree, and forms an important source of small timber, fuelwood, fodder, tannin and gum. It has a strong vertical and horizontal root sytem (Toky & Bisht 1992), and a long growing period of more than 300 days with four peaks of leaf flush (Bisht & Toky 1993). Due to these ecological characteristics this species is exceedingly drought tolerant and survives on difficult sites, and it is largely preferred for reforestation of wastelands.

Considerable genetic variation in chemical composition of plants at the level of provenance with a variety of progeny can be expected particularly in many species of *Acacia, Albizia* and *Prosopis* which are out-crossed. The variation may be extremely useful as a basis for future genetic selection (Cannel 1982, Burley *et al.* 1984). No work has been reported on biochemical and nutrient concentrations among provenances of arid and semi-arid tree species in India. Further, in identification of natural populations, biochemicals can be a reliable source (Hanover 1974). The present paper reports the variation in biochemical and nutrient contents in plants at 7- and 30-month ages among 21 provenances.

Materials and methods

Seeds of *Acacia nilotica* ssp. *indica* from 21 provenances in India were collected from latitude 11°N to 31°23'N, and altitude 19 m to 650 m. (Table 1). For each provenance 10 to 16 good-looking trees of 15-20 years age were marked. The mature pods were collected during March - April from south India, and during May - June from north India. They were sun dried, and seeds were separated through manual threshing to ensure the collection of sound seeds. They were further cleaned though winnowing. Each provenance consisted of 2 to 5 kg seed to provide potentially useful genetic variation.

Eight hundred seeds of each provenance were sown in polypots (32 × 60 cm) arranged in five blocks, each having 160 polypots. The nursery was situated in the campus of Haryana Agricultural University (29°10'N, 75° 46'E, 215 m elevation), Hisar, in northwestern India. Hisar is classified as an arid region (Bishnoi 1988) with sub-tropical conditions. The detailed agro-climatic conditions that prevailed during the study period are given in Figure 1. In June 1989, 7-month old seedlings were transplanted to the field of about 1.5 ha at Hisar following randomized block design. There were 81 plants of each provenance split up into three blocks each having 27 plants with a uniform spacing of 3 × 3 m.

Table 1. Seed collection site data of 21 provenances of *Acacia nilotica* ssp. *indica*

Provenance	Latitude	Longitude	Altitude(m)
Coimbatore	11°00'N	77°00'E	409
Anantpur	14°41'N	77°39'E	350
Dharwad	15°27'N	75°05'E	650
Hyderabad	17°20'N	78°30'E	545
Aurangabad	19°53'N	75°23'E	581
Akola	20°42'N	77°02'E	282
Banaskantha	21°41'N	73°01'E	179
Medinipur	22°25'N	87°21'E	045
Ahmedabad	23°03'N	77°44'E	055
Bhopal	23°16'N	77°36'E	523
Beharampur	24°06'N	88°19'E	019
Satna	24°44'N	80°14'E	317
Varanasi	25°20'N	83°00'E	076
Patna	25°37'N	85°13'E	053
Jodhpur	26°18'N	73°04'E	224
Jaipur	26°55'N	75°22'E	390
Gurgaon	28°37'N	77°04'E	210
Hisar	29°10'N	75°46'E	221
Roorkee	30°19'N	78°04'E	274
Chandigarh	30°42'N	76°54'E	347
Jalandhar	31°23'N	75°25'E	228

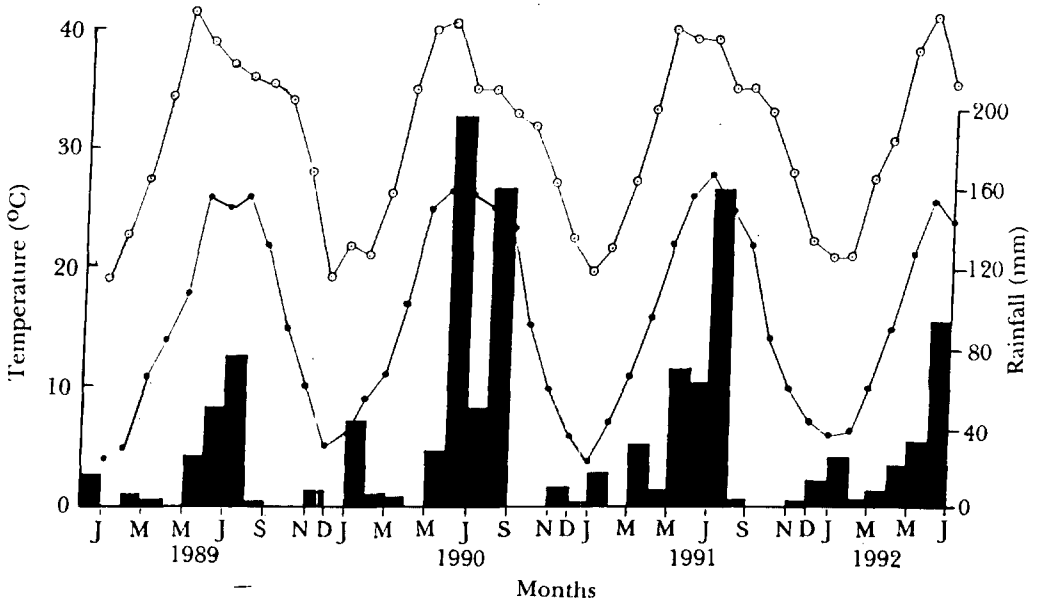

Figure 1. Minimum temperature (●), maximum temperature (⊙) and rainfall (■) of the study site

The contents of carbohydrate, starch, chlorophyll and N, P, K,Ca and Mg in the leaf of 7-month old seedlings in the nursery and 30-month old trees in the field were analysed. The plant samples for analyses were colleced from 10 randomly marked

seedlings or trees. The plant materials were oven dried at 70 °C and ground with a Wiley mill to pass through 0.5 mm mesh. Analyses were carried out with five sub-samples from a composite sample.

Chlorophyll content was determined by the DMSO method (Hiscox & Israelstam 1979), and calculated by the procedure given by Arnon (1949). Carbohydrate and starch contents were estimated by the colorimetric method given by Dubois *et al.* (1951) and Cleg (1956) respectively. Nitrogen was estimated by the Kjeldahl method (Kjeldahl 1883), phosphorus colorimetrically following Koening and Johnson (1942), potassium by the flame emission method, and calcium and magnesium by the EDTA method (Allen *et al.*1974).

Results

Biochemicals

Starch and chlorophyll contents in the leaf varied significantly ($p < 0.05$) among most of the provenances (Tables 2 & 3). The provenances with greater biochemical contents at seedlings stage did not maintain their ranking at the 30-month age in the field. The greatest concentrations of carbohydrate and starch of seedlings were in Roorkee and Medinipur provenances respectively, while of the 30-month-old trees, the greatest concentration of carbohydrate was in Hisar provenance, and that of starch in Medinipur provenance (Table 2).

The variations in carbohydrate, starch and chlorophyll contents of leaves were random and they did not reveal any significant correlation with latitude ($p < 0.05$, $r = 0.19, 0.22, 0.21$ respectively). The greatest or least values were observed in contrasting latitude or altitude.

Nutrients

The N, P, K, Ca and Mg concentrations in leaf varied significantly ($p < 0.05$) among provenances. In general, greater nutrient concentrations were observed for seedlings at the 7-month age as compared to trees at the 30-month age. Provenance ranking also changed at tree stage (Table 3).

Leaf N concentration of seedling ranged from 3.6% in Anantpur to 4.4% in Patna. The ranking of provenances changed at the 30-month age, and the greatest concentration of 3.9% was noticed in Satna and Hyderabad. Similiar significant variation in P concentration among provenances was observed. At the 7-month age, the concentration varied from 0.26% in Jodhpur to 0.48% in Beharampur. Interestingly, comparatively lower concentration up to 0.27% in Hyderabad was noticed at the 30-month age. K concentration was greatest in Hisar at the 7-month age, replaced by Beharampur provenance at the 30-month age.

Table 2. Carbohydrate, starch and chlorophyll contents in the leaves of 7-month (A) and 30-month (B) plants of *Acacia nilotica* ssp. *indica* (figure in parenthesis denotes ranking)

Provenance	Carbohydrate (%)		Starch(%)		Chlorophyll (%)	
	A	B	A	B	A	B
Coimbatore	0.13(6)	0.20(6)	0.052(4)	0.058(4)	0.079(17)	0.136(2)
Anantpur	0.16(3)	0.21(5)	0.013(15)	0.017(15)	0.128(4)	0.132(6)
Dharwad	0.15(4)	0.20(6)	0.026(10)	0.033(9)	0.114(11)	0.123(10)
Hyderabad	0.13(6)	0.21(5)	0.014(14)	0.019(13)	0.108(13)	0.135(3)
Aurangabad	0.14(5)	0.23(3)	0.046(5)	0.033(9)	0.107(14)	0.132(6)
Akola	0.16(3)	0.20(6)	0.034(7)	0.041(7)	0.119(8)	0.124(9)
Banaskantha	0.17(2)	0.20(6)	0.019(11)	0.022(12)	0.122(7)	0.133(5)
Medinipur	0.13(6)	0.20(6)	0.079(1)	0.095(1)	0.107(14)	0.149(1)
Ahmedabad	0.16(3)	0.19(7)	0.012(16)	0.019(13)	0.124(6)	0.132(6)
Bhopal	0.12(7)	0.21(5)	0.017(12)	0.030(11)	0.116(10)	0.122(11)
Beharampur	0.14(5)	0.21(5)	0.071(2)	0.082(2)	0.122(7)	0.123(10)
Satna	0.11(8)	0.23(3)	0.012(16)	0.016(16)	0.126(5)	0.129(7)
Varanasi	0.13(6)	0.21(5)	0.011(17)	0.017(15)	0.100(16)	0.112(11)
Patna	0.012(7)	0.20(6)	0.071(2)	0.018(14)	0.103(15)	0.123(10)
Jodhpur	0.13(6)	0.20(6)	0.016(13)	0.019(13)	0.117(9)	0.122(11)
Jaipur	0.14(5)	0.24(2)	0.011(17)	0.018(14)	0.114(11)	0.120(12)
Gurgaon	0.16(3)	0.22(4)	0.042(6)	0.054(5)	0.109(12)	0.116(13)
Hisar	0.12(7)	0.25(1)	0.032(8)	0.045(6)	0.128(3)	0.132(6)
Roorkee	0.18(1)	0.21(5)	0.062(3)	0.066(3)	0.130(1)	0.134(4)
Chandigarh	0.17(2)	0.20(6)	0.031(9)	0.031(10)	0.129(2)	0.131(7)
Jalandhar	0.17(2)	0.21(5)	0.031(4)	0.040(8)	0.117(9)	0.126(8)
L. S. D. at 5% level	0.007	0.007	0.029	0.017	0.087	0.078
C.V. at 5% level	3.089	2.870	12.917	7.347	16.050	13.910

Ca and Mg concentrations varied significantly ($p < 0.05$) among provenances. Ca content was noticed greatest in Hisar at both 7- and 30-month ages, while it was minimum at 2.1% in Hyderabad, Aurangabad, Akola, Medinipur, Jaipur and Chandigarh at the 7-month and at 1.5% in Jalandhar and Patna at the 30-month ages. Similarly the Mg concentration was noticed greater (up to 2.3% in Behrampur) at the 7-month age than at the 30-month age provenances (Table 3).

For these elements the variations were random and no significant correlations were observed for elemental concentrations of different provenance with their latitude of the origin site.

Discussion

In *Acacia nilotica*, biochemicals of leaf varied significantly among provenances, both at seedling and tree stage. The carbohydrate was greater in those provenances which had intermediate level of K.

Table 3. Foliar nutrient concentrations (% dry weight) of 7-month (A) and 30-month (B) plants of *Acacia nilotica* ssp. *indica* provenances (figure in parenthesis denotes ranking)

Provenance	N		P		K		Ca		Mg	
	A	B	A	B	A	B	A	B	A	B
Coimbatore	4.1(4)	3.7(3)	0.33(6)	0.23(4)	0.30(15)	0.29(10)	2.3(4)	1.6(6)	2.1(3)	1.2(4)
Anantpur	3.6(8)	3.0(10)	0.28(11)	0.18(9)	0.43(7)	0.29(10)	2.3(4)	1.6(6)	1.6(7)	1.4(2)
Dharwad	4.0(5)	3.3(7)	0.34(5)	0.26(2)	0.42(8)	0.31(8)	2.4(3)	1.9(3)	2.2(2)	1.3(3)
Hyderabad	4.1(4)	3.9(1)	0.33(6)	0.27(1)	0.40(9)	0.3(4)	2.1(6)	1.7(5)	1.9(5)	1.3(3)
Aurangabad	3.8(7)	3.1(9)	0.28(11)	0.19(8)	0.39(10)	0.32(7)	2.1(6)	1.7(5)	2.1(3)	1.3(3)
Akola	4.1(4)	3.4(6)	0.32(7)	0.26(2)	0.42(8)	0.30(9)	2.1(6)	1.8(4)	2.1(3)	1.2(4)
Banaskantha	4.0(5)	3.4(6)	0.30(9)	0.20(7)	0.35(13)	0.33(6)	2.3(4)	1.9(3)	1.8(6)	1.1(5)
Medinipur	3.8(7)	3.1(9)	0.30(9)	0.26(2)	0.47(4)	0.36(3)	2.1(6)	1.6(6)	1.8(6)	1.5(1)
Ahmedabad	4.3(2)	3.2(8)	0.29(10)	0.23(4)	0.36(12)	0.37(2)	2.3(4)	1.8(4)	2.1(3)	1.1(5)
Bhopal	3.8(7)	2.9(11)	0.27(12)	0.21(6)	0.50(2)	0.37(2)	2.5(2)	1.7(5)	2.3(1)	1.1(5)
Beharampur	3.8(7)	3.2(8)	0.48(1)	0.22(5)	0.48(3)	0.39(1)	2.2(5)	1.8(4)	2.3(1)	1.3(3)
Satna	4.0(5)	3.9(1)	0.30(9)	0.23(4)	0.33(14)	0.31(8)	2.4(3)	1.6(6)	1.8(6)	1.1(5)
Varanasi	4.1(4)	3.8(2)	0.28(11)	0.22(5)	0.40(9)	0.32(7)	2.3(4)	2.0(2)	2.2(2)	1.0(6)
Patna	4.4(1)	3.3(7)	0.33(6)	0.23(4)	0.44(6)	0.31(8)	2.4(3)	1.5(7)	2.2(2)	1.0(6)
Jodhpur	4.1(4)	2.8(12)	0.26(13)	0.19(8)	0.45(5)	0.3(9)	2.4(3)	1.9(3)	2.0(4)	1.2(4)
Jaipur	4.0(5)	3.5(5)	0.27(12)	0.17(10)	0.42(8)	0.30(9)	2.1(6)	1.8(4)	2.0(4)	1.4(2)
Gurgaon	4.2(3)	3.6(4)	0.36(4)	0.18(9)	0.43(7)	0.32(7)	2.2(5)	2.1(1)	1.9(5)	1.1(5)
Hisar	4.0(5)	3.5(5)	0.39(2)	0.20(7)	0.52(1)	0.34(5)	2.8(1)	.1(1)	2.1(3)	1.1(5)
Roorkee	3.9(6)	3.2(8)	0.38(3)	0.22(5)	0.38(11)	0.29(10)	2.3(4)	1.9(3)	1.9(5)	1.2(4)
Chandigarh	3.9(6)	3.6(4)	0.34(5)	0.19(8)	0.44(6)	0.35(4)	2.1(6)	1.9(3)	1.9(5)	1.1(5)
Jalandhar	4.0(5)	3.5(5)	0.31(8)	0.25(3)	0.47(4)	0.36(3)	2.2(5)	1.5(7)	2.0(4)	1.1(5)
L.S.D.at 5% level	1.561	1.148	0.533	0.452	0.287	0.281	0.481	0.578	0.837	0.750
C.V.at 5% level	22.102	22.692	17.135	22.422	16.197	12.777	15.351	16.927	26.363	24.212

Provenances having highest carbohydrate also showed maximum assimilation of chlorophyll. It may be due to the fact that carbohydrate protects chloroplast membrane during water and temperature stresses (Santarius 1973). Similar significant variations in chlorophyll content were also observed in six provenances of *Abies alba* in Czechoslovakia (Paule 1977), and of *Pinus caribaea* in central America (Gerhold 1959, Venator *et al.*1977). N and Mg are greatly concerned with chlorophyll biosynthesis, and a deficiency of these elements is responsible for significant decrease in chlorophyll content as reported in pine and spruce seedlings (Cizkova 1981). The synthesis of protein in leaves can be regarded as an index of photosynthetic productivity, and hence of adaptation to new conditions as observed in *Populus bolleana* and *Populus alba* (Kazaryan 1985). The variations in protein content owing to both genotype and environmental effects were also earlier reported in *Picea abies* (Lunderstadt 1980) and in *Leucaena leucocephala* cultivars (Arora *et al.* 1986). Starch content among the different provenances was less. K and certain isoenzymes are important factors in starch synthesis (Gerbrandy & Verleur 1971, Hawker *et al.* 1974). Sugar supply may also play a role in the balance between starch degradation and synthesis in leaf (Heldt *et al.* 1977) besides the genotype and environmental effects.

Mineral analysis facilitates the early selection of best adapted provenances, and provides one possible avenue for the detection of genetically superior trees from young selections (Steinbeck 1966). The differences in nutrient contents within a given species may be associated with plant growth (Bevege & Simpson 1973). Lukyanetes (1980) has also reported greater concentration of N in optimal growth provenances of *Quercus roubur* in the USSR.

Such studies have been done on many temperate trees but little on tropical trees particularly those of arid zones. For example, in *Pinus sylvestris* (Gerhold 1959, Bopp 1971), *Pinus radiata* (Forest & Ovington 1971), *Pseudotsuga menziesii* (Driessche 1973) and *Taiwania cryptomeriodes* (Wang 1976), large variations in foliage nutrient concentrations among provenances have been reported. The studies were useful for these species in the early selection of best adapted provenances.

In the present study, local provenances of Hisar and Gurgaon had higher concentrations of nutrients. In another paper (Toky & Krishan 1993), it was reported that these provenances were much faster in growth as compared to others. Hence, they may be adapted to the drier conditions that prevail at Hisar.

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