MINERAL COMPOSITION OF LEAVES OF SOME FOREST TREES GROWN ON ALKALI SOILS*

By

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Introduction

Forest trees differ markedly in their ability to tolerate soil salinity and alkalinity. The differences amongst various species are reflected in differential absorption and accumulation of cations principally Na in their roots and shoots. Thus *Cassia acutifolia* is reported to accumulate large amounts of Ca and Na in its leaves when growing on a saline soil (Ayoub, 1975). Some crassulacean acid metabolism plants have been shown to absorb considerable amounts of sodium and translocate most of it to the top when grown in sand culture containing different concentrations of Na (Rouhani & Bassiri, 1976). Subtropical fruit species have also been found to accumulate fairly large amounts of Na in their leaves when growing on alkali soils (Garg & Khanduja, 1976). Little information published or otherwise, is available on the cation composition of forest trees growing on alkali soils in Northern India. Such information could be useful in determining the adaptation potential of these species to alkali soil which cover large areas in the plains of Northern India.

Materials and methods

Leaf samples of the forest trees, *Acacia nilotica* (var. *cupressiformis*), *Bauhinia diphylla*, *Cassia siamea*, *Callistemon phoenicecus*, *Pongamia glabra* and *Terminalia arjuna* were collected from Banthra Research Station (24°52') of the institute in Lucknow district. The trees were about 10 years old growing without the use of fertilizer or soil amendments since their plantation. The sample area is in the arid zone of North India with an annual precipitation of 75 to 100 cm. Sampling was carried out in October, 1975. Each sample consisted of 100 leaves collected at third and fourth position from the growing point of the shoot. The leaves were air dried after washing them in distilled water, dried in an oven at 70°C for 24 hours, ground in a mill and stored in air tight bottles. Nitrogen was determined by macro Kjeldahl method, phosphorus by vanadomolybdate method, calcium, sodium, potassium by flame emission technique and magnesium by Eriochrome black dye method (Jackson, 1967).

The soil of the sample area is silty clay loam, and is alkaline in reaction. Immediately before the study, soil samples at 0–15 cm and 15–45 cm depths in the root zone of the trees were analysed for pH, E.C. and exchangeable Na^+ K^+ and Ca^{2+} in neutral normal ammonium, acetate extract by flame photometer (Jackson, 1967).

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Results

The results of the soil and plant analyses of the sample area are given in the Table 1 and 2. The soil pH in the 0–15 cm depth varied widely with the plant species being highest in the root zone of *Bauhinia*. The pH increased in the 15–45 cm depth in all the species, the increase being more marked in *Pongamia* and *Terminalia* species which had the lowest pH value in the 0-15 cm depth. Whereas, electrical conductivity showed a similar trend it increased in the 15–45 cm depth of the root zone of all the species, except under *Acacia nilotica*. Highest conductivity was recorded under *Cassia siamea*.

Exchangeable Na^+ showed a sharp increase in the 15–45 cm depth In contrast, exchangeable Ca^{2+} decreased while exchangeable K^+ showed erratic variation in that it decreased in the 15–45 cm depth of root zone of *Acacia* and *Terminalia*, increased in *Bauhinia*, *Cassia* and *Pongamia*, and showed no change in *Callistemon*.

The sum of cations was highest in the leaves of *Terminalia* and did not differ significantly from that of *Cassia* leaves. Highest concentration of Ca and Mg was observed in *Terminalia*; K in *Bauhinia*; Na in *Cassia* leaves. Differences in leaf-Na amongst the species excepting *Cassia* were not well marked. In contrast, leaf-Ca.-Mg varied widely with the species, *Callistemon* showing the least concentrations of these cations.

Differences in the concentration of nitrogen were more pronounced than those of P due to plant species. Lowest nitrogen (0.96 per cent) was recorded in *Callistemon* in contrast to 3.89 per cent in *Pongamia* and 3.45 per cent in *Acacia*. Leaf-P was highest in *Bauhinia* and *Terminalia* and varied little with other species excepting *Callistemon* which showed the least phosphorous. Thus, the macro-nutrient element composition of *Callistemon* is lowest amongst the species studied.

The ratio of leaf-Na to total sum of cations was found to be 1 : 3 in *Callistemon*, 1 : 5 in *Cassia* and *Pongamia*, 1 : 8 in *Acacia* and *Terminalia* and 1 : 9 in *Bauhinia*.

Discussion

The plant species included in the study seem to be very variable in the concentration of various macro-nutrients in their leaves. It is interesting to note that concentration of leaf-Na varied widely amongst *Pongamia*, *Terminalia* and *Callistemon* despite the fact that, differences in soil exchangeable Na^+ in the root zones of these species were small. Similarly, exchangeable sodium in the root zone of *Cassia* was slightly, higher than that of *Bauhinia*, Na concentration in name its leaves was nearly two fold that of *Bauhinia* leaves. On the other hand, differences in soil Na in case of *Acacia* and *Bauhinia* are not reflected in their leaves.

It has been shown by Yadav & Singh (1970) that *Pongamia* and *Terminalia* can grow successfully on soil with pH 8.3 in top 60 cm depth. Our studies indicate that these species can grow in soils with pH as high as 9.7. They have also shown that *Acacia nilotica* is able to grow on moderately calcareous saline-alkali soil with pH 9.0. In our studies *Acacia nilotica* (var. *Cupressiformis*) was found to grow well in soil with pH 9.4 to 9.6. In general, all the species studied were found to grow at soil pH ranging from 9.6 to 9.8.

Table 1

Soil analysis of the root zone under various forest tree species

Tree species	Depth 0–15 cm					Depth 15–45 cm				
	pH	EC mmhos cm^{-1} at 25°C)	Exchangeable cation mEq/100g Na^+	K^+	Ca^{2+}	pH	EC mmhos cm^{-1} at 25°C)	Exchangeable cations mEq/100g Na^+	K^+	Ca^{2+}
Acacia arabica var. *cupressiformis*	9 4	0.22	8.69	2 23	15.00	9 6	0. 4	12 05	0 95	10.00
Bauhinia diphylla	9 6	0.30	11.41	0.63	13.50	9.8	0.52	20.20	1.11	9 25
Callistemon phoeniceus	9.2	0.17	6.52	0.63	17.25	9 6	0 42	16.40	0.63	10 00
Cassia siamea	9.2	0.27	9 23	1 43	14 50	9 8	0.60	20.74	1.51	7.75
Pongamia glabra	9.1	0.24	6 52	0.95	16.75	9 7	0.43	16.94	1 11	7 50
Terminalia arjuna	9.1	0.27	8.15	1.11	18 25	9.7	0.47	16 40	0.71	7 00

Table 2

Mineral Composition of leaves of forest trees grown on alkali soil

Tree species	N (% dry weight)*	P	K (mEq per 100g dry weight)*	Ca	Mg	Na	mEq sum of cations	Leaf–Na Total cations
Acacia arabica var. *cupressiformis*	3.45	0.27	79.48	47.90	31 57	21 73	180.68	1 : 8
Bauhinia diphylla	2.08	0.36	102.56	59.88	47.36	26.00	235 80	1 : 9
Callistemon phoeniceus	0.96	0.16	33.33	15.96	21.70	29.55	100.54	1 : 3
Cassia siamea	3 09	0.27	87.17	67.88	53 28	52.16	260.49	1 : 5
Pongamia glabra	3 89	0 27	97.47	31.93	37.49	39.12	206.01	1 : 5
Terminalia arjuna	1.94	0.32	89.22	97.80	86.34	34.77	288.13	1 : 8

*The values represent means of 5 samples.

It is interesting to note that higher sum of cations in *Terminalia* was due to comparatively greater concentration of *Bivalent* cations; in *Bauhinia* and *Acacia* K concentration equalled that of Ca and Mg. *Callistemon* showed least concentration of all the cations in its leaves.

The ratio of leaf-Na to total sum of cations show preferential accumulation of Na by *Callistemon* in relation to other species.

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SUMMARY

Mineral composition of leaves of six forest tree species growing on an alkali soil showed highest concentration of cations in *Terminalia* and lowest in *Callistemon*. Sodium concentration was highest in *Cassia* leaves. The ratio of leaf-Na to total sum of cations showed preferential accumulation of Na by *Callistemon* in relation to other species. All the species were found to grow well with pH 9.6 to 9.8 in their root zone.

समाक्षारीय मृदाओं में उगे हुए कतिपय वन वृक्षों की पत्तियों की खनिजीय रचना

लेखक वी० के० गर्ग व एस० डी० खण्डूजा

सारांश

समाक्षार मृदा में उगी हुई छह वन वृक्ष जातियों की पत्तियों की खनिजीय रचना में घनायनों का सबसे अधिक संकेन्द्रण *टर्मिनेलिया* में तथा सबसे कम संकेन्द्रण *कैलिस्टेमन* में पाया गया। सोडियम संकेन्द्रण सबसे अधिक *कैसिया* की पत्तियों में मिला। कुल घनायनों से सोडियम (Na) के अनुपात में अन्य वृक्ष जातियों की तुलना में सोडियम का अधिमान्य जमाव होता पाया गया। जड़ प्रदेश में पीएच मान 9.6 से 9.8 रहने पर सभी वृक्ष जातियां भली भांति बढ़ती पाई गईं।

Minerale Abfassung der Blätter einiger Forstbäumen, an alkalischen Boden gewachsen

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ZUSAMMENFASSUNG

Minerale Abfassung der Blätter der sechs forstbäumen Arten, an alkalischen Boden gewachsen, zeigte die hochsten Konzentration der Cationen in *Terminalia* und niedrigsten Konzentration in *Callistemon*. Die Natriumkonzentration war in *Cassia* Blättern hochsten. Das Verhältnis des Blattnatriums zur ganz Summe der Cationen zeigte Vorzugsanhäufung des Na bei *Callistemon* als die anderen Arten. Alle Arten waren auf ph 9,6 bis 9,8 in Wurzelzone, gut zu wachsen, gefunden.

La constitution minérale des feuilles de quelques arbres forestiers cultivés sur les sols basique

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Résumé

Une étude de la composition minérale des feuilles de six espèce d'arbres forestiers, cultivés sur les sols basiques, a révé é l'accumulation la plus élevée et la plus basse des cations dans le cas de *Terminalia* et *Callistemon* respectivement. L'accumulation de sodium a été la plus élevée dans les feuilles de *Cassia*. Le rapport entre la teneur en Na des feuilles et l'accumulation globale des cations montré, par rapport à d'autres espèces, l'accumulation préférentielle de Na dans les feuilles de *Callistemon*. On a éprouvé que toutes les espèces ont été bienvenantes entre les valeurs de pH variant de 9.6 à 9.8, dans le voisinage des racines.

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