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A COMPARISON OF NITROGEN CONCENTRATION BETWEEN WILD AND CULTIVATED LEGUMES OF SINDH

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Abstract

Estimates of nitrogen concentration in cultivated and wild species of 115 leguminous plants of Sindh are reported. The main aim of this investigation was to find relationship between nitrogen contents of nodulated versus non-nodulated legumes, between wild and cultivated legumes and between herbs, shrubs and tree legumes. Nitrogen concentrations of nodulated plants were found significantly higher ($p<0.05$) than non-nodulated plants. Nitrogen concentrations of cultivated plants were marginally better ($p<0.1$) when compared with wild plants. Nitrogen contents of herbs and shrubs showed a significant correlation ($p<0.05$). This relationship was non-significant between herbs and trees and between shrubs and trees. Nitrogen concentrations of the leguminous plants were also correlated with soil texture, soil pH and nodulation frequency. Nodulation frequency did not bear significant correlation with soil textural type but showed a significant correlation with soil pH ($p<0.01$). Nitrogen concentration showed a significant relationship with soil pH ($p<0.01$) and with nodulation frequency ($p<0.01$). The significance of wild legumes growing in natural ecosystems of Sindh is discussed.

Introduction

Tropical soils are often deficient in nitrogen (Elkan *et al.*, 1981; Giller & Wilson, 1991). One of the approaches for restoring soil nitrogen is the exploitation of legume Rhizobium symbiosis. The role of nodulated legumes in improving and maintaining soil fertility is well documented (Allen & Allen, 1981; Subramanium & Babu, 1994; Thomas, 1995). The global records of nodulation show that at species level only 15% of legume species have been examined (Allen & Allen, 1981), which has now increased to 20% (Faria *et al.*, 1989).

Legumes form a prominent and widespread flora of Pakistan where 107 genera and 530 species have been reported (Ali, 1973a, b; 1977). Leguminosae ranks as the third largest family in Pakistan in order of abundance (Ali & Qaiser, 1986). Reports compiled on nodulation status of Pakistani legumes by Athar & Mahmood (1978, 1980, 1985, 1990), Mahmood & Athar (1985); Mahmood & Iqbal (1994) and Athar (1996) indicated that nodule formation was more commonly present in Mimosaceae and Papilionaceae than in Caesalpiniaceae.

Nodulation studies on legumes of Sindh have been carried out (Mahmood & Iqbal, 1994) where 115 species including herbs, shrubs and trees were examined for root nodules in natural ecosystems. The plants examined included both wild and cultivated legumes. where 'wild' is a legume of no agriculture significance or one now being considered as growing in a natural community (MAC connel & Bond, 1957).

Literature shows that quantitative studies with nitrogen have concentrated on legumes of agricultural importance in the past and only a few quantitative data are available on wild legumes (MacConnell & Bond, 1957; Vlassak & Shivshankar, 1973; Lawrie, 1981). In the present investigation, data on quantitative estimation of nitrogen in wild and cultivated legumes of Sindh is presented. Correlation between percent nitrogen estimated for herbs, shrubs and trees and between percent nitrogen estimated for nodulated and non-nodulated legumes have been derived. Correlations between nodulation frequency of the plant species with soil textural type, soil pH and percent nitrogen have also been worked out.

Materials and Methods

Periodic field trips were made to various parts of Sindh over a period of three years and leguminous plants including herbs, shrubs and trees were examined for nodulation in natural ecosystems. Altogether 115 species comprising 79 of Papilionaceae, 16 of Mimosaceae and 20 of Caesalpiniaceae were surveyed. The methods used in the collection and preservation of nodules have been described earlier (Mahmood & Iqbal, 1994). During the nodulation survey of the plants a portion of shoot was also collected from each plant. The shoot was pressed in a plant press and brought to the laboratory. The shoots were oven dried at 80°C for 48 hrs and milled in an electric grinder and total nitrogen estimated with Microkjeldahl apparatus following Bergersen (1980). Texture of soil samples collected from the rhizosphere of the leguminous plants was determined following Russell (1961). pH of the soil was recorded on a pye-79 pH meter. Statistical analysis of the data was performed following Zar (1974).

Results and Discussion

(a) Relationship between nodulation frequency and soil texture. Soil samples collected from the rhizosphere of leguminous plants varied between loam, clay loam, loam-clay loam, sandy loam, loam-sandy loam, sand to sandy loam and clay-clay loam (Table 1). Members of the families Mimosaceae and Papilionaceae were nodulating moderately to abundantly in loam, clay loam, sandy loam and loam (Table 1). Loam alone or mixed with clay or sand favoured moderate to abundant nodulation. Nodulation frequency did not bear significant relationship with soil textural type.

(b) Relationship between nodulation frequency and soil pH. Most of the plants belonging to the families Mimosaceae and Papilionaceae showed abundant nodulation between the pH range 8.3-8.6 . However *Sesbania sesban, Sesbania concolor, Indigofera linifolia, Alhagi maurorum* and *Melilotus alba* showed abundant nodulation in the pH range 8.0-8.3 (Table 1). Nodulation frequency showed a significant relationship with the soil pH ($p < 0.01$). Sheikh & Tokur (1978) observed optimum nodulation in chickpea plants at pH 7.65. The development of root nodules was markedly reduced at pH 8.75. Sundram (1979) recorded optimum pH of 4.2 for nodulation of *Arachis hypogea* plants grown in pots.

Table 1. Nodulation Frequency and Nitrogen Concentration in wild and cultivated Legumes of Sindh.

S. No.	Species	Habit	Nature	Nodulation/ frequency	Soil pH	Soil type	% Nitrogen
	Caesalpiniaceae						
1.	*Bauhinia purpurea* L.	Tree	C	-	8.1	Clay loam	2.0
2.	*B. variegata* L.	Tree	C	-	8.4	Loam	1.1
3.	*Caesalpinia gilliesii* (Hook.) Dietr	Shrub	C	-	8.1	Sandy loam	1.7
4.	*C. bonduc* (L.) Roxb.	Shrub	W	-	8.5	Sand	1.8
5.	*Cassia pulcherrima* (L.) Swartz.	Shrub	C	-	8.1	Sandy loam	1.0
6.	*C. alata* L.	Shrub	C	-	8.0	Loam	1.5
7.	*C. auriculata* L.	Shrub	C	-	8.6	Sandy loam	2.6
8.	*C. fistula* L.	Tree	W	-	8.6	Loam	1.6
9.	*C. holosericea* Fresen	Herb	W	-	8.0	Loam-Sandy loam	1.9
10.	*C. italia* ssp. *micrantha* Brenan	Herb	W	-	8.2	Sand	1.9
11.	*C. italica* (Mill) P.W.Andr.ssp. *italica*	Herb	W	-	8.1	Sandy loam	1.2
12.	*C. occidentalis* L.	Shrub	C	-	8.6	Sandy loam	1.8
13.	*C. roxburghii* DC.	Tree	C	-	8.2	Clay loam	2.1
14.	*C. senna* L.	Herb	W	-	8.0	Sand	1.4
15.	*C. siamea* Lamk.	Tree	C	-	8.4	Clay loam	1.2
16.	*C. surattensis* Burm.f.	Shrub	W	-	8.0	Clay loam	2.3
17.	*Delonix regia* (Bojer) Rafin.	Tree	W	-	8.1	Sandy loam	2.2
18.	*Parkinsonia aculeata* L.	Small Tree	C	-	8.6	Clay loam	1.9
19.	*Peltophorum Pterocarpum* (DC.) Backer ex. K. Heyne	Tree	W	-	8.2	Sand-Sandy Loam	2.3
20.	*Tamarindus indica* L.	Tree	W	-	8.5	Sandy loam	3.1
	Mimosaceae						
1.	*Acacia farnesiana* (L.) Willd.	Tree	W	+++	8.3	Loam	3.5
2.	*A. nilotica* (L.) Del.	Tree	W	++	8.0	Clay Loam	1.7
3.	*A. nilotica* ssp. *hemispherica* Ali & Faruqi	Tree	W	+	8.2	Sand	1.7

Table 1 (Cont'd.)

S. No.	Species	Habit	Nature	Nodulation/ frequency	Soil pH	Soil type	% Nitrogen
4.	*A. nilotica* ssp. *indica* (Benth.)	Tree	W	+	8.2	Sand	1.9
5.	*A. nilotica* ssp. *subalata* (Vatke) Brenan	Tree	W	++	8.5	Sandy loam	1.8
6.	*A. senegal* (L.) willd.	Tree	W	+	8.2	Sandy loam	2.0
7.	*Adenanthera pavonina* L.	Tree	W	-	8.2	Loam	1.9
8.	*Albizia lebbeck* (L.) Benth	Tree	C	+	8.2	Loam - Sandy Loam	1.7
9.	*Leucaena leucocephala* (Lam.) de wit.	Tree	W	+++	8.4	Loam	2.1
10.	*Mimosa hamata* willd.	Shrub	W	+	8.3	Loam	1.7
11.	*M. pudica* L.	Shrub	W	++	8.0	Clay loam	2.0
12.	*Pithicellobium dulce* (Roxb) Benth.	Tree	C	+++	8.6	loam	2.1
13.	*Prosopis cineraria* (L.) Druce	Shrub	W	+	8.5	Sandy loam	1.2
14.	*P. glandulosa* Torr.	Tree	W	+++	8.6	Loam	1.9
15.	*P. juliflora* (Swartz) DC.	Shrub	W	+++	8.6	Loam	1.6
16.	*Samania saman* (Jacq.) Merr.	Tree	C	++	8.7	Sandy loam	2.0
Papilionaceae							
1.	*Alhagi maurorum* Medic	Shrub	W	++	8.2	Loam - Clay loam	2.1
2.	*Alysicarpus bupleurifolius* (L.) DC.	Herb	W	++	8.1	Loam	2.0
3.	*A. heterophyllus* (Baker) Jafri & Ali	Herb	W	++	8.0	Loam - Clay	1.7
4.	*A. longifolius* (Rottl. ex Spreng.) Wight & Arn.	Herb	W	+	8.3	Clay loam	2.5
5.	*A. monilifer* (L.) DC.	Herb	W	++	8.2	Sandy loam	1.1
6.	*A. ovalifolius* (Sch.) J. Leonard	Herb	W	++	8.5	Sand	2.1
7.	*A. rugosus* (willd) DC.	Herb	W	++	8.4	Clay loam	2.2
8.	*A. tetragonolobus* Edgeworth	Herb	W	++	8.1	Sandy loam	1.9
9.	*Arachis hypogaea* L.	Herb	C	+++	8.6	Loam	2.0

Table 1 (Cont'd.)

S. No.	Species	Habit	Nature	Nodulation/ frequency	Soil pH	Soil type	% Nitrogen
10.	*Atylosia platycarpa* Benth	Herb	W	+++	8.6	Sand	2.5
11.	*Cajanus cajan* (L.) Mill sp.	Herb	W	++	8.0	Sandy loam	2.7
12.	*Cicer arietinum* L.	Herb	C	+++	8.4	Clay loam	2.1
13.	*Clitoria ternatea* L.	Woody Tree	W	+	8.5	Clay loam	1.7
14.	*C. juncea* L.	Herb	W	++	8.2	Clay loam	2.1
15.	*Crotalaria medicaginea* Lamk.	Herb	W	+++	8.3	Loam	3.8
16.	*C. medicaginea* Lank var. *medicaginea*	Herb	W	+	8.1	Sandy loam	2.5
17.	*Cyamopsis titragonoloba* (L.) Taubert	Herb	C	++	8.1	Clay loam	2.1
18.	*Dalbergia latifolia* Roxb.	Tree	W	+++	8.6	Loam	2.5
19.	*D. sissoo* Roxb.	Tree	C	+++	8.6	Sandy loam	2.2
20.	*Erythrina* sp. L.	Shrub	W	++	8.2	Clay loam	1.0
21.	*Glycine max* (L.) Merrill	Herb	C	+++	8.3	Loam	3.5
22.	*Indigofera argentea* Burm. f.	Herb	W	+	8.5	Clay loam	1.1
23.	*I. cordifolia* Heyne ex. Roth	Herb	W	+	8.3	Sand	1.4
24.	*I. hochstetteri* Baker	Herb	W	+	8.2	Sandy loam	1.6
25.	*I. linifolia* (L.f.) Retz.	Herb	W	+++	8.1	Loam	1.8
26.	*I. oblongifolia* Forsk.	Shrub	W	+	8.3	Loam	1.9
27.	*I. sessiliflora* DC.	Herb	W	+++	8.4	Clay loam	3.3
28.	*Lablab purpureus* (L.) Sweet.	Herb	C	+++	8.6	Loam	3.3
29.	*Lathyrus aphaca* L.	Trailing	W	++	8.5	Loam	1.5
30.	*L. odoratus* L.	Herb	W	++	8.2	Loam	2.9
31.	*L. sativus* L.	Herb	W	++	8.0	Clay loam	1.0
32.	*L. sphaericus* Retz.	Herb	W	++	8.5	Sandy loam	1.8
33.	*Lens culinaris* Medic	Herb	C	+++	8.3	Clay loam	1.5
34.	*Macroptilium lathyroides* (L.) Urb.	Herb	W	++	8.2	Loam	1.6
35.	*Medicago lupulina* L.	Herb	W	+	8.4	Clay loam	2.8
36.	*M. polymorpha* L.	Herb	W	+++	8.6	Loam	1.0
37.	*M. sativa* L.	Herb	C	+++	8.4	Clay loam	2.1

Table 1 (Cont'd.)

S. No.	Species	Habit	Nature	Nodulation/ frequency	Soil pH	Soil type	% Nitrogen
38.	*Melilotus alba* Dear.	Herb	W	+++	8.2	Loam	2.0
39.	*M. indica* (L.) All.	Herb	W	+++	8.5	Loam	1.9
40.	*Phaseolus lunatus* L.	Herb	W	+++	8.4	Loam	2.6
41.	*Pisum sativum* L.	Climber	C	+++	8.4	Clay Loam	1.1
42.	*Psophocarpus tetragonolobus* (L.) DC.	Herb	C	+++	8.3	Loam	1.0
43.	*Rhynchosia minima* (L.) DC.	Herb	W	+	8.0	Loam	2.2
44.	*R. pulverulenta* Stocks	Herb	W	++	8.2	Sandy loam	2.6
45.	*Sesbania bispinosa* (Jacq.) W.F. Wight	Tree	W	++	8.0	Clay loam	2.6
46.	*S. concolor* Gillett	Tree	W	+++	8.1	Sandy loam	2.3
47.	*S. grandiflora*	Unarmed, Shrub	W	+	8.5	Loam	2.6
48.	*S. sesban* (L.) Merrill	Tree	C	+++	8.0	Sandy loam	2.2
49.	*S. sesban* (L.) Merrill var. *muricata* Baquar	Tree	W	+++	8.5	Sandy loam	2.5
50.	*S. sesban* (L.) Merrill var. *sesban*	Tree	C	+++	8.1	Sandy loam	2.6
51.	*Taverniera lappacea* (Forssk.) DC.	Shrub	W	++	8.0	Sand	1.9
52.	*Tephrosia strigosa* (Dalz.) Sant. & Mahes	Herb	W	++	8.3	Clay loam	1.9
53.	*T. subtriflora* Baker	Herb	W	++	8.5	Clay loam	2.2
54.	*T. uniflora* Pers. ssp. *uniflora*	Herb	W	++	8.0	Sandy loam	2.0
55.	*Trifolium alexandrianum* L.	Herb	C	+++	8.5	Clay loam	1.9
56.	*T. pratense* L.	Herb	W	+++	8.3	Sandy loam	4.0
57.	*Trifolium* repens L.	Herb	W	++	8.2	Clay loam	3.3
58.	*T. resupinatum* L.	Herb	W	++	8.2	Sandy loam	3.1
59.	*Trigonella corniculata* L.	Herb	W	+	8.0	Clay loam	2.2
60.	*T. foenum-graecum* L.	Herb	C	+++	8.5	Clay loam	3.0
61.	*T. gracilis* Benth.	Herb	W	++	8.0	Clay loam	2.6
62.	*T. monantha* C.A. Meyer	Herb	W	++	8.1	Sandy loam	3.1
63.	*Vicia monantha* Retz.	Herb	W	++	8.6	Loam	2.3
64.	*V. sativa* L.	Herb	W	++	8.7	Clay loam	1.0

Table 1 (Cont'd.)

S. No.	Species	Habit	Nature	Nodulation/ frequency	Soil pH	Soil type	% Nitrogen
65.	*Vigna aconitifolia* (Jacq.) Marechal	Herb	W	++	8.2	Clay loam	2.1
66.	*V. dalzelliana* (O. Kuntze) Verdc.	Herb	W	+++	8.3	Clay loam	1.2
67.	*V. mungo* (L.) Hepper	Herb	C	++	8.4	Loam	3.0
68.	*V. mungo* (L.) Hepper var. 48	Herb	C	+++	8.5	Clay loam	3.2
69.	*V. mungo* (L.) Hepper var. Sialkot	Herb	C	+++	8.6	Sandy loam	3.5
70.	*V.radiata* (L.) Wilezek	Herb	C	+++	8.5	Clay loam	2.1
71.	*V.radiata* (L.) Wilczek var. Pak.17	Erect herb	C	+++	8.7	Clay loam	2.9
72.	*V.radiata* (L.) Wilcsek var.71-17	Erect herb	C	+++	8.5	Clay loam	3.3
73.	*V.radiata* (L.) Wilczek var. 3854	Erect herb	C	+++	8.6	Clay loam	3.2
74.	*V.radiata* (L.) Wilczek var.6601	Erect herb	C	+++	8.6	Clay loam	3.5
75.	*V.trilobata* (L.) Verdc.	Herb	C	+++	8.2	Loam	2.0
76.	*V. unguiculata* (L.) Walp.	Herb	C	++	8.5	Sandy loam	2.6
77.	*V. unguiculata* (L.) Walp.Tvx-02F-3871	Herb	C	+++	8.6	Clay loam	3.5
78.	*V. unguiculata* (L.) Walp.118E-13	Herb	C	+++	8.6	Sandy loam	3.8
79.	*V. vexillata* (L.) A.Rich	Herb	W	+	8.0	Loam	2.9

Total nitrogen content (column 8) is the mean of three replicates.

= absence of nodulation,

\+ = sparse nodulation (1 to 5 nodules) per plant,

++ = moderate nodulation (6-15 nodules) per plant,

+++ = abundant nodulation (more than 15 nodules) per plant.

(c) Relationship between nitrogen concentration (%) of leguminous plants and soil pH: The nitrogen concentration for different species varied between 1 and 4% (Table 1). Amongst wild herbs *Trifolium pratense* showed 4% nitrogen at pH 8.3 and amongst wild trees *Acacia farnesiana* showed 3.5% nitrogen at pH 8.3. Amongst cultivated legumes *Vigna unguiculata* var. 1182-E showed 3.5% nitrogen at pH 8.6, *V. mungo*

var. Sialkot, *V. radiata var.6601* and *V. unguiculata var.* TVX-0.2 F fixed 3.5% nitrogen at pH 6. Nitrogen concentration of leguminous plants showed a significant relationship ($p<0.01$) with soil pH. Sundram (1979) found an increase in the nitrogen contents of *Arachis hypogea* plants grown in pots in a pH regime of 3.3-7.0 where optimum pH for fixation of nitrogen varied between 5.9 and 6.2. Yost *et al.*, (1985) also reported an increase in the nitrogen contents of six legume species with increasing pH.

(d) **Relationship between nodulation frequency and nitrogen concentration of nodulated plants:** Nodulation frequency showed significant correlation ($p<0.01$) with nitrogen concentration of nodulated plants. Strong correlation between nodule frequency and nitrogen fixation was observed in *Dalbergia sissoo* and *Leucaena leucocephala* (Javid & Fisher, 1989).

(e) **Rrelationship between average nitrogen concentration(%) of non-nodulated legumes (Caesalpiniaceae) and nodulated legumes (Mimosaceae + Papilionaceae):** The average nitrogen concentration of 20 species of Caesalpiniaceae (all non-nodulated) was 1.83 mg whereas in 94 species of nodulated legumes (16 species of Mimosaceae + 79 species of Papilionaceae) it was 2.23 mg. The mean nitrogen concentration of (Mimosaceae + Papilionaceae) were significantly higher ($p<0.05$) than that of Caesalpiniaceae.

(f) **Comparison between nitrogen concentration(%) of cultivated and wild legumes:** Nitrogen concentration of cultivated and wild legumes were marginally significant ($P<0.1$). Nitrogen concentration of cultivated (2.338 ± 0.136) and wild legumes (2.094 ± 0.072) did not show much variation.

(g) **Comparison of nitrogen concentration of herbs, shrubs and tree legumes:** A significant relationship was found in the percent of nitrogen in herbs and shrubs (Table 1). This relationship was non-significant between herbs and trees and between shrubs and trees.

Estimates of nitrogen concentration (%) obtained for wild legumes growing in natural ecosystems of Sindh reaffirm the valuable role played by them as pioneering plants in establishing plant life in virgin soils (MacConnell & Bond, 1957; Vlassak & Shirshankar, 1973; Lawrie, 1981). It is encouraging to note that wild legume-Rhizobium symbiosis has been successfully employed in India for the improvement in productivity in marginal lands (Babu *et al.*, 1993; Subramanium & Babu, 1994) and for providing vegetational cover in denuded and derilict lands (Jha *et al.*, 1995). Wild species of herb, shrub and tree legumes showing higher nitrogen concentrations marked in the present study may be similarly employed for the improvement of disturbed lands of Sindh.

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