A QUALITATIVE STUDY OF THE NODULATING ABILITY OF LEGUMES OF PAKISTAN. LIST 5.

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ABSTRACT

Legume-*Rhizobium* symbiosis accumulates substantial amounts of mineralizable nitrogen which help in ecological rehabilitation of degraded soils and increase the soil fertility in agricultural ecosystem. Nodulation was studied in 72 legume species from various parts of Pakistan. All the species of Papilionoideae and Mimosoideae were nodulated whereas all the species examined in Caesalpinioideae were non-nodulated. Attempts to elicit nodulation in Caesalpinioideae species by rhizobial inoculation were not successful and they were accepted as lacking nodulating ability. Nodulation is reported for the first time in 6 species within 3 genera of Mimosoideae and 9 species within 5 genera of Papilionoideae. Majority of the species were abundantly nodulated under natural soil conditions or when grown in uninoculated garden soil indicating distribution of wide range of naturalized rhizobia. The study shows that the wild legumes hold great promise for inclusion in revegetation of denuded and derelict ecosystems.

KEY WORDS: Nodulation, Leguminosae, taxonomy, Pakistan.

INTRODUCTION

Legumes are the most suited candidates for the improvement of agro-forestry soils and revegetation of derelict ecosystems (Babu et al. 1993). They fix atmospheric nitrogen, survive in poor nutrient soils and colonize open habitats (Allen and Allen 1981; Babu et al. 1993; Sprent 1994). Some legumes increase phosphorus availability to associated plants and thus improve their growth by providing nitrogen and phosphorus to these plants (O'Dell and Trappe 1992).

Legumes are well distributed in Pakistan and Leguminosae ranks as the third largest family in order of abundance (Ali and Qaiser 1986). Some legumes are indigenous while other are introduced and have become widely naturalized (Kirkbride 1986). Ali and Qaiser (1986) reported 107 legume genera from Pakistan, of which 68 genera have one or more native species. A total of 539 legume species are reported to occur in Pakistan, of which 426 are native (Kirkbride 1986). With the introduction of a large number of exotic plants in agriculture and forestry, the total number of legumes has changed during the last decade.

There is an increasing interest in exploring nodulated legumes because of their great potential in agrosystems and eco-

logical rehabilitation of degraded soils (Jha et al. 1987; Brockwell et al. 1995). Nodulation has been studied in some legumes of Pakistan in their natural habitat (Athar and Mahmood 1980, 1985, 1990; Athar 1993; Mahmood and Iqbal 1994). However, majority of the legumes found in Pakistan still await inspection for their nodulating ability. The present study was conducted to examine the nodulating ability of certain legume species cultivated or naturally occurring in Pakistan. Legumes surveyed included small weeds, large woody shrubs and indigenous and introduced ornamental trees.

MATERIALS AND METHODS

Legume species growing under natural growth conditions were surveyed for their nodulating ability from various parts of Pakistan. Wild legumes were examined under natural growth conditions while legumes of agricultural importance were observed from the cultivated fields. Legumes of horticultural significance were studied from the gardens or roadside plantations. In case of shrub or woody legumes, root system was traced from the stem bases of identified mature plants. Caesalpinioideae species which repeatedly lacked nodules under natural habitat were grown in the greenhouse in pots filled with garden soil and inoculated with a mixture of broad host range *Rhizobium*/*Bradyrhizobium* strains including *Rhizobium* sp. NGR 234 (Somasegaran and Hoben 1994). Temperature in the greenhouse was maintained at 26°C/ 20°C day and night, respectively. These legumes were grown for two years and periodically observed for nodulation.

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TABLE 1. List of legume species examined for nodulation.

Species ¹	Nodulation	
	Present study ²	Previous record ³
CAESALPINIOIDEAE		
Caesalpinieae		
<i>Caesalpinia gilliesii</i> (Hook.) Dietr.	-C	N
<i>Delonix elata</i> (L.) Garmlb	-C	N
Cassieae		
<i>Cassia corymbosa</i> Lamk.	-W	N
<i>C. sophera</i> L.	-W	N
Cercideae		
<i>Bauhinia corymbosa</i> Roxb. ex DC.	-C	N
<i>B. tomentosa</i> L.	-C	N
MIMOSOIDEAE		
Acacieae		
<i>Acacia adsurgens</i> Maiden & Blakely	+I	B
<i>A. ampliceps</i> Maslin	+I	B
<i>A. aneura</i> F. Muell.	+I	A
<i>A. cochliacantha</i> Humb. & Bonpl. ex Willd.	+I	B
<i>A. cyclops</i> A. Cunn.	+I	A
<i>A. deanei</i> (R.T. Bak.) W.C. McG.	+I	A
<i>A. macracantha</i> Humb. & Bonpl. ex Willd.	+I	A
<i>A. pennatula</i> (Schldl. & Chem.) Benth.	+I	A
<i>A. saligna</i> (Labill.) H. L. Wendel	+I	A
<i>A. sclerosperma</i> F. Muell.	+I	B
<i>A. stenophylla</i> A. Cunn. ex Benth.	+I	A
<i>A. victoriae</i> Benth.	+I	A
<i>Faidherbia albida</i> Del.	+C	A
Ingeae		
<i>Enterolobium contortisiliquum</i> (Vell.) Morong	+I	B
Mimoseae		
<i>Leucaena diversifolia</i> Benth.	+I	A
<i>L. pulverulenta</i> (Schltdl.) Benth.	+I	B
<i>Mimosa tenuiflora</i> Benth.	+I	A
<i>M. pudica</i> L.	+W	A
PAPILIONOIDEAE		
Desmodieae		
<i>Desmodium canadense</i> (L.) DC.	+W	A
Galegeae		
<i>Astragalus glycyphyllos</i> L.	+W	B
<i>Colutea nepalensis</i> Sim.	+W	B
<i>Caragana arborescens</i> Lam.	+I	A
<i>Galega officinalis</i> L.	+W	A
Genisteae		
<i>Lupinus polyphyllus</i> Lindl.	+C	A
Loteae		
<i>Lotus ornithopodioides</i> L.	+I	A

TABLE 1. Cont.

Species ¹	Nodulation	
	Present study ²	Previous record ³
Millettieae		
<i>Wisteria chinensis</i> DC.	+I	A
<i>W. sinensis</i> (Sim.) Sweet	+C	A
Phaseoleae		
<i>Glycine max</i> (L.) Merr.	+C	A
<i>G. soja</i> Sieb. & Zucc.	+C	A
<i>G. wiaghtii</i> (R. Grah. ex W. & A.) Verdc.	+C	A
<i>Mucuna nigricans</i> (Lour.) Steud.	+W	B
<i>M. pruriens</i> (L.) DC.	+W	A
<i>Vigna dalzelliana</i> (O. Kuntze) Verdc.	+W	A
Robinieae		
<i>Robinia pseudoacacia</i> L.	+C	A
<i>Sesbania punicea</i> Benth.	+I	A
Thermopsidaeae		
<i>Thermopsis inflata</i> Camb.	+W	A
Trifolieae		
<i>Medicago aculeata</i> Willd.	+I	A
<i>M. arabica</i> (L.) Huds.	+I	A
<i>M. blanchiana</i> Boiss.	+I	A
<i>M. disciformis</i> DC.	+I	A
<i>M. globosa</i> Presl.	+I	B
<i>M. intertexa</i> Mill.	+I	A
<i>M. littoralis</i> Lois.	+I	A
<i>M. murex</i> Willd.	+I	A
<i>M. orbicularis</i> (L.) Bartal.	+W	A
<i>M. polymorpha</i> L.	+W	A
<i>M. reticulata</i> Benth.	+I	B
<i>M. rigidula</i> (L.) All.	+I	A
<i>M. rotata</i> Bois.	+I	B
<i>M. rugosa</i> Desr.	+I	A
<i>M. scutellata</i> (L.) Mill.	+I	A
<i>M. tornata</i> (L.) Mill.	+I	A
<i>M. truncatula</i> Gaert.	+I	A
<i>M. tribuloides</i> Desr.	+I	B
<i>M. turbinata</i> (L.) All.	+I	A
<i>Trifolium alpestre</i> L.	+I	A
<i>T. fragiferum</i> L.	+C	A
<i>T. incarnatum</i> L.	+I	A
Vicieae		
<i>Lathyrus latifolius</i> L.	+I	A
<i>L. odoratus</i> L.	+C	A
<i>L. tingitanus</i> L.	+I	A
<i>Lens ervoides</i> (Brign.) Grande	+I	B
<i>L. nigricans</i> (Bieb.) Godr.	+I	A
<i>L. orientalis</i> (Boiss.) Popov.	+I	B
<i>Vicia cracca</i> L.	+I	A
<i>V. sepium</i> L.	+W	A

¹Species are arranged alphabetically within genera. The nomenclature and tribal classification are as described by Polhill and Raven (1981). Authors citations are quoted following instructions of Brummit and Powell (1992).

²Plant type:
C = Cultivated; W = Wild; I = Introduced in Pakistan.

³Nodulating status:
A = Nodulation previously observed; B = Nodulation reported for the first time; N = Nodulation never observed.

Special care was taken to discriminate root nodules from other kinds of root malformation such as caused by nematodes, insects or other root-inhabiting parasitic microorganisms (Truchet et al. 1989). Occasionally nodule smears and nodule slices were prepared to exclude many stubby root outgrowths (including ectomycorrhizae) which are very similar to root nodules and very easily misidentified. Nodulation data were recorded and herbarium specimens were prepared for the identification of the plants.

RESULTS AND DISCUSSION

The nodulation status of some of the legume species is presented in Table 1. These results were compared with the available reports on nodulation (Allen and Allen 1981; Athar and Mahmood 1980, 1985, 1990; Grobbelaar et al. 1983; Corby 1988; Faria et al. 1989, 1994; Wester and Hogberg 1989; Moreira et al. 1992; Aguilar et al. 1994; Mahmood and Iqbal 1994; Subramaniam and Babu 1994; Athar 1996). According to these reports, nodulation is reported for the first time in 6 species within 3 genera of Mimosoideae and 9 species within 5 genera of Papilionoideae (Table 1). The nodules observed in other species confirmed earlier reports (Allen and Allen 1981; Dreyfus and Dommergues 1981; Corby 1988; Aguilar et al. 1994; Mahmood and Iqbal 1994; Subramaniam and Babu 1994).

Among the leguminous plants growing in Pakistan, Papilionoideae constitutes the largest group. Legume representation in Pakistan reflects climate, and resulting vegetation types coincide with rainfall and temperature. This has resulted in greater development of Papilionoideae and poor distribution of Caesalpinioideae (Kirkbride 1986). Of the species examined 48 belonged to Papilionoideae, 18 to Mimosoideae and 6 to Caesalpinioideae. All members of Papilionoideae and Mimosoideae were found nodulated whereas all the species examined in Caesalpinioideae were non nodulated. Repeated attempts to elicit nodulation in Caesalpinioideae species by inoculation with broad host range rhizobial strains were not successful and they were accepted as lacking nodulating ability. These findings corroborate with Allen and Allen (1981), Athar and Mahmood (1980, 1985, 1990), Faria et al. (1989), Mahmood and Iqbal (1994), Sutherland and Sprent (1993), Sprent (1994) that species belonging to Caesalpinioideae are generally non-nodulated.

Nodules were mainly distributed on lateral roots and were generally found within immediate 5 to 10 cm layer of soil. Nodules in a few legumes, like *Sesbania punicea* and *Trifolium* spp. sometimes grew on the surface of soil and were covered with a layer of damp litter. Similar observations were made by Athar (1996) for nodules of *Lupinus* spp. from California. Majority of the species whether indigenous or introduced were abundantly nodulated under natural soil conditions or when grown in uninoculated garden soil indicating distribution of wide range of naturalized rhizobia in Pakistani soil. The shape and size of nodules varied greatly at different stages of development, growth and maturity. Nodules in Papilionoideae were generally semi-globose to globose with streaked or smoothed surface. They occurred singly or as lobed structures. Nodules in Mimosoideae were elongated and branched projecting into finger-like, fan-shaped or coralloid forms. Nodule morphology in Papilionoideae and Mimosoideae coincided very much with the description of Corby (1988), Mahmood and Iqbal (1994) and Somasegaran and Hoben (1994). The color of nodules varied for various species as well as with age of the plant. Nodules were mostly pink or brown with reddish

interior indicating their effectiveness in nitrogen fixation (Somasegaran and Hoben 1994).

The role of legumes in reclamation of degraded soils and in the improvement and revegetation of denuded and derelict ecosystems has been well documented (Babu et al. 1993; Sprent 1994; Brockwell et al. 1995). However, most studies include legumes of agricultural importance whereas the use of wild legumes has been mainly restricted to the improvement of productivity in marginal lands (Babu et al. 1993). Studies indicate that the wild legumes and their naturalized rhizobia hold great promise for inclusion in revegetation of denuded and derelict ecosystems (Jha et al. 1987; Babu et al. 1993). With a better understanding of wild rhizobia, it may be possible to exploit their potential to their maximum. Such a breakthrough would greatly reduced the need for fertilizer applications in natural ecosystems. This technology would also be useful in providing a wide array of high quality browse for wildlife enhancement.

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JAKOŚCIOWE BADANIA ZDOLNOŚCI TWORZENIA BRODAWEK U PAKISTAŃSKICH MOTYLKOWATYCH. LISTA 5

STRESZCZENIE

Symbioza Motylkowate – *Rhizobium* gromadzi znaczne ilości mineralnego azotu, który ułatwia ekologiczną odnowę zdegenerowanej gleby i zwiększa żyzność gleby w ekosystemach rolniczych. Tworzenie się brodawek badano u 72 gatunków motylkowatych z różnych obszarów Pakistanu. Wszystkie gatunki Papilionoideae i Mimosoideae miały brodawki, nie miał ich natomiast żaden z badanych gatunków Caesalpinioideae. Próby wywołania nodulacji u gatunków Caesalpinioideae przy pomocy indukcji *Rhizobium* nie dały wyników, co przyjęto jako brak zdolności do brodawkowania. Nodulację stwierdzono po raz pierwszy u sześciu gatunków należących do trzech rodzajów Mimosoideae i dziewięciu gatunków należących do pięciu rodzajów Papilionoideae. Większość gatunków była bogato brodawkowana w naturalnych warunkach glebowych lub rosnących w sterylnej glebie ogrodniczej. Wskazuje to na szerokie rozmieszczenie zdomowionych Rhizobiów. Badanie wykazało, że dziko rosnące motylkowate stanowią nadzieję na ich włączenie do odnowy zdegradowanych ekosystemów.

SŁOWA KLUCZOWE: nodulacja, motylkowate, taksonomia, Pakistan.