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EFFECT OF SOME MICROBIAL INOCULANTS ON GROWTH, BIOMASS AND NUTRIENT UPTAKE OF TAMARIND (*TAMARINDUS INDICA*) SEEDLINGS

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The major limiting factor in an afforestation programme is the poor establishment of seedlings which can be improved by developing suitable microbial inoculants for tree species. Such micro-organisms stimulate plant growth by providing necessary nutrients by their colonisation at the rhizosphere or through their symbiotic association (Varma & Schuepp 1995). Phosphobacteria by virtue of their capacity to elaborate certain growth promoting substances like gibberellic acid (GA_3) and indole-3-acetic acid (IAA) (Sekar *et al.* 1995) induce growth of other associative organisms like arbuscular mycorrhizae (AM) and *Rhizobium* and increase the availability of minerals and nutrients. AM inoculation increased the growth and vigour of roots in *Tamarindus indica* (Bagyaraj & Reena 1990). The role of microbial organisms has already been proved extensively in the field of agriculture and horticulture, but information regarding their applicability in forest species is scanty in India. Although, in forestry, some research reports are available to demonstrate that such organisms accelerate growth (Sudhir *et al.* 1994, Mukerji *et al.* 1996) and biomass production (Reddy *et al.* 1996), and enhance uptake of N (Mathur & Vyas 1996), P (Dela Cruz *et al.* 1988) and K (Merina Prem Kumari 1991), studies on elite tree seedlings are meagre. Thus, a study was carried out on *T. indica.*

Acid scarified seeds of tamarind were inoculated with *Rhizobium* (*Rhizobium* sp. ALM2, 10^8 cells/g) and phosphobacteria (*Pseudomonas striata* PB2, 10^9 cells/g). AM fungi (*Glomus fasciculatum*, 4 spores/g) were used in soil inoculation. The treatments were:

T_1 – 5 g *Rhizobium* / 100 seeds; T_2 – 5 g phosphobacteria / 100 seeds; T_3 – 2 g AM / bag; T_4 – 5 g *Rhizobium* + 5 g phosphobacteria / 100 seeds; T_5 – 5 g *Rhizobium* / 100 seeds + 2 g AM / bag; T_6 – 5 g phosphobacteria / 100 seeds + 2 g AM / bag; T_7 – 5 g *Rhizobium* / 100 seeds + 5 g phosphobacteria / 100 seeds + 2 g AM / bag

The seeds after *Rhizobium* and phosphobacteria inoculation were shade dried for half an hour and sown in 10 × 15 cm polybags containing nursery soil mixture (red soil:sand:farm yard manure @ 2:1:1 ratio).

The experiment was set up in a completely randomised design replicated 4 times, each with 25 polybags. The recommended nursery after-care practices were followed to raise good and healthy seedlings. At 30, 60 and 90 days after sowing (DAS), 5 seedlings in each replication were selected at random and determinations were made on shoot and root lengths, total dry weight, total leaf area (LICOR model LI 3000 leaf area meter), total chlorophyll content (Yoshida *et al.* 1971), soluble protein (Lowry *et al.* 1951), and total nitrogen, phosphorus and potassium (Jackson 1973). The data were subjected to an analysis of variance after Panse and Sukhatme (1967). Discussion is confined to results relating to 90 DAS.

The combined inoculation of *Rhizobium* + phosphobacteria + AM (T_7) improved the shoot and root lengths and total leaf area (Table 1) compared to the uninoculated control and other

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Table 1. Effect of bioinoculants on growth parameters of tamarind seedlings at 90 days after sowing

Inoculants	Shoot length (cm)	Root length (cm)	Total leaf area (cm^2)	Total dry weight (g $plant^{-1}$)	N (%)	P (%)	K (%)	Total chlorophyll (mg g^{-1})	Soluble protein (mg g^{-1})
Rhizobium (R) (T_1)	37.8	52.3	72.3	2.55	2.29	0.68	3.81	1.70	6.60
Phosphobacteria (P) (T_2)	39.2	55.9	73.7	2.55	1.90	0.77	3.53	2.16	6.52
AM (T_3)	40.7	62.7	109.8	2.43	3.46	0.64	3.94	1.61	5.08
R + P (T_4)	36.8	52.0	117.9	2.76	2.03	0.67	4.26	2.01	5.99
R + AM (T_5)	43.0	47.9	89.0	2.87	2.29	0.67	4.57	2.09	6.72
P + AM (T_6)	44.1	53.6	55.0	2.83	1.83	0.75	4.90	2.46	6.91
R + P + AM (T_7)	51.8	70.5	158.3	2.95	3.50	0.85	6.16	2.54	7.18
Control	34.2	40.9	82.9	2.38	1.90	0.61	2.83	1.69	4.35
SEd (Standard error deviation)	1.49	1.59	1.55	0.049	0.050	0.009	0.013	0.141	0.135
CD (critical difference) (p = 0.05)	2.96	3.17	3.09	0.980	0.101	0.019	0.147	0.281	0.270

treatments. The increase in plant growth attributes might be due to increased uptake of nutrients in mycorrhizal associated plants and their synergistic effect with other inoculants. A similar effect due to such inoculation has earlier been reported in tree legumes (Dela Cruz *et al.* 1988), in various shola species (Sekar *et al.* 1995), *Thea sinensis* (Merina Prem Kumari 1991) and *Acacia nilotica* (Suresh 1994). The rhizosphere effect through microbial activity modifies the plant itself by providing plant growth substances and increasing the availability of nutrients at the root zone (Jakobsen *et al.* 1994).

In T_7 the total dry weight was higher in the seedlings than in the uninoculated control. However, the increase in total dry weight was also significant in dual inoculation, i.e phosphobacteria + AM and *Rhizobium* + AM. A similar phenomenon was also observed due to AM + *Rhizobium* inoculation in various *Acacia* spp. (Dela Cruz *et al.* 1988, Suresh 1994, Verma *et al.* 1994, Mandal & Kaushik 1995); AM + phosphobacteria in *Acacia* spp. (Saravanan 1991); AM + *Frankia* in *Alnus incana* (Chatarapaul *et al.* 1989) and *Azospirillum* + phosphobacteria + AM inoculation in shola species (Sekar 1992) and tea (Merina Prem Kumari 1991). Such an increase in biomass was also evident in *Leucaena leucocephala* due to *Rhizobium* + phosphobacteria + AM inoculation (Kalavathi *et al.* 1997). This increase may be strongly correlated with accumulation of N due to *Rhizobium* (Dadwal & Chouhan 1995) and P due to AM and phosphobacteria (Durga & Gupta 1995, Reddy *et al.* 1996).

The total chlorophyll and soluble protein contents were also more in T_7 than in the uninoculated control. This increase is in agreement with other findings (Saravanan 1991, McArthur & Kowlis 1993) and was attributed by Singh *et al.* (1983) to the greater supply of nitrogen to growing tissues. In the present study the increased uptake of N due to microbial inoculation was evident. Increase in chlorophyll content and soluble protein was also recorded in teak (Balasubramanian & Srinivasan 1995) and *Ziziphus mauritiana* (Mathur & Vyas 1996) due to inoculation of AM and in shola species (Sekar *et al.* 1995) due to inoculation of *Azospirillum* + phosphobacteria + AM.

The highest contents of N, P and K in T_7 clearly imply that the treated soils improved the uptake of these nutrients. Similar increase in N content has also been reported in different tree species (Merina Prem Kumari 1991, Sekar 1992, Kalavathi *et al.* 1997). Enhanced P content due to the combined inoculation with AM + *Azospirillum* + phosphobacteria (Sekar 1992) and dual inoculation with *Rhizobium* + AM (Dixon *et al.* 1993) has been recorded. In the present

study, the increase in P content might be due to the symbiosis exhibited by the micro-organisms that ultimately helped increase its availability for uptake at the root zone (Varma & Schuepp 1995). The above reason may also be given for the higher K uptake by the microbial inoculated seedlings compared to the control. Increased potassium uptake was also reported in *Acacia nilotica* (Suresh 1994) following *Rhizobium* + AM inoculation.

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