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SHORT COMMUNICATION

Effects of sheared-root inoculum of *Glomus fasciculatum* on tobacco grown at different phosphorus levels in alfisols

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Southern light soils (SLS) of Andhra Pradesh are known for low fertility and poor phosphorus status. Tobacco is the main commercial crop grown in this area. Lack of phosphate in these soils is the most important constraint in tobacco plant growth. Nearly 80-85% of P applied to these soils is unavailable to plants because of their inaccessibility, fixation and immobilization (4). Research in the past years has proved that vesicular-arbuscular mycorrhiza (VAM) can improve plant growth through increased uptake of phosphorus and other mineral nutrients, especially in low fertile soils (2). In general, AM fungi improve the P uptake of their host plant especially under P limited conditions. VAM fungi explore the soil more thoroughly and hence are able to locate and use the point source of P (8). The use of AMF may contribute to reducing chemical fertilizer inputs and sustaining plant productivity in agriculture (6), yet according to Medina *et al.* (5) introduced isolates differed in their ability to stimulate plant growth in natural soils in the presence of indigenous fungi. The present study was conducted under field conditions for three years (2005-07) to assess the effectiveness of the introduced AMF *Glomus fasciculatum* on tobacco growth at different P-levels in alfisols.

Sheared-root inoculum of *G. fasciculatum* VAM isolate was obtained from Tata Energy Research Institute, New Delhi. The inoculum (3.0×10^5 AMF propagules g^{-1}) consisted of root fragments, vesicles, mycelia, and spores passed through a 450 µm sieve and air dried at room temperature for 72 h. The inoculum was mixed with sand at the rate of 500 g dry weight per 1000 seedlings and placed simultaneously during transplanting. The field experiment was conducted at Central Tobacco Research Institute, Regional Station, Kandukur. The soil was sandy loam, slightly alkaline (pH 7.4), EC – 0.20 mmhos/ cm^2, organic carbon 0.30, available phosphorus 4.5 kg/ha with a small indigenous spore population (0.2 spores g^{-1} dry soil) of *Glomus* sp.

The experimental area was divided into 2.6 m x 5.85 m plots with 65 cm x 65 cm spacing. The recommended doses of N and K (40 and 60 kg/ha respectively) were applied to all the plots in the form of ammonium sulphate and sulphate of potash respectively. The recommended dose of P (60 kg/ha) for tobacco grown in SLS, or graded levels of P, was applied as basal in the form of super phosphate. Usual agronomic practices like watering, weeding etc., were carried out. The experiment was arranged in a randomized block design with four replications for each of ten treatments, i.e. five P-application rates (P_0, P_{20}, P_{40}, P_{60} and P_{80}) and two fungal treatments, i.e. introduced or indigenous AMF. Growth of tobacco plants was measured at 120 days after transplantation. After 75 days of transplantation, 10 plants were sampled at random from each plot and pooled for assessing root infection. The procedure adopted by Phillips and Hayman (7) for root clearing, staining and assessment of mycorrhizal colonization was employed. Total nitrogen by microjeldhal method, phosphorus by vanado molybdo phosphoric yellow color method, Potassium by flame photometry and quality parameters such as nicotine, reducing sugars and chlorides were determined in cured leaf.

The indigenous AMF population consisted primarily of *Glomus sp.*, and decreased gradually with P-levels (Table-1). Among the 10 treatments, the highest VAM colonization was recorded in P_0 + VAM, followed by P_{20} + VAM. VAM in combination with higher doses of P showed moderate infection. As is apparent from the data, the soil inoculation with *Glomus fasciculatum* significantly increased the percentage of VAM root colonization at all the five levels of P_2O_5 application. Root colonization was significantly higher due to lower levels of P, *i.e.* at P_0 and P_{20} kg P_2O_5 /ha. Application of 60 and 80 kg P_2O_5 had no adverse effects on the VAM root colonization (1). Plant height, number of leaves (total and curable), leaf size, yield of green leaf, cured leaf, bright leaf and grade index of inoculated plants was higher than in the controls at all P levels but the difference was not always significant (Table 1 & 2). P contents of the leaves increased significantly ($P<0.05$) with increasing P-levels in both inoculated plants and controls. Inoculated plants produced significantly higher cured leaf yield than control plants at all P levels studied. Cured leaf contained significantly more nicotine and reducing sugars compared to control plants. Inoculated tobacco plants showed highest nicotine and sugars. No significant difference in chlorides was found in the treatments. Inoculation with *G. fasciculatum* stimulated tobacco growth beyond indigenous AMF as already reported in different crops (6). The study site not only had very low indigenous AMF but also very low P-status which allowed the effectiveness of the introduced AMF to be adequately tested. Percent VAM colonization decreased significantly with increasing P-application in both inoculated and control plots as reported by Entry *et al.* (3). The nitrogen content of leaf in

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Table 1. Effect of mycorhizal inoculation of soil on growth and yield of tobacco in alfisols

Treatments	Growth					Yield				
	Plant height (cm)	No. of leaves /plant		Leaf size (cm)		Green leaf	Cured leaf	Bright leaf	% Bright leaf	Grade Index
		Total	Curable	Length	Width					
P_0+VAM	107.0	21.1	19.1	44.2	23.1	9221	1454	696	47.9	1138
P_{20} + VAM	106.0	21.5	19.8	44.5	23.6	9695	1538	745	48.4	1212
P_{40} + VAM	109.4	21.9	20.4	45.1	23.7	10042	1593	795	49.9	1263
P_{60} + VAM	110.0	22.0	20.3	45.0	24.1	10042	1604	816	50.9	1286
P_{80} + VAM	110.9	22.1	20.4	25.8	24.2	10086	1610	820	50.9	1288
P_0	98.3	20.1	17.6	42.8	22.2	8581	1334	608	45.6	1039
P_{20}	106.8	20.7	18.9	44.0	22.9	9165	1437	700	48.7	1128
P_{40}	107.0	21.1	20.1	44.8	23.4	9645	1515	748	49.4	1183
P_{60}	109.5	21.7	20.6	45.5	23.9	9948	1567	796	50.8	1267
P_{80}	112.9	22.0	20.4	45.3	24.1	10014	1576	802	50.9	1265
Seasons										
2005	127.9	22.8	20.0	43.3	23.4	9006	1420	644	45.4	1095
2006	110.0	20.6	19.9	50.6	26.5	11190	1755	920	52.4	1425
2007	85.1	21.0	19.2	40.2	20.6	8735	1393	695	49.9	1097
General mean	107.7	21.5	19.7	44.7	23.5	9644	1523	753	49.4	1206
SEm ± seasons	1.35	0.43	0.48	0.59	0.22	238.4	27.6	12.4		17.1
Treatments	2.63	0.52	0.49	0.75	0.53	219.1	36.0	25.2		29.3
CD at 5% seasons	4.56	1.47	NS	1.99	0.73	762.5	88.2	39.5		54.7
Treatment s	7.30	NS	1.36	NS	NS	607.4	99.7	69.9		81.2
Interactions	NS	NS	NS	NS	NS	NS	NS	NS		NS
CV% seasons	7.91	12.77	15.42	8.32	5.81	15.63	11.45	10.40		8.90
Treatments	8.47	8.47	8 .65	5.84	7.88	7.87	8.18	11.60		8.42

Table 2. Chemical composition of cured leaf

Treatments	%VAM colonisation	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Nicotine (%)	Sugars (%)	Chlorides (%)
P_0+VAM	76	3.66	0.18	1.46	4.23	4.82	0.46
P_{20} + VAM	71	3.72	0.20	1.38	4.26	6.37	0.47
P_{40} + VAM	64	3.90	0.21	1.33	4.30	5.49	0.49
P_{60} + VAM	58	3.96	0.21	1.28	3.93	5.11	0.46
P_{80} + $_{VAM}$	57	3.98	0.21	1.15	4.12	6.70	0.36
P_0	61	3.48	0.17	1.17	3.70	3.23	0.40
P_{20}	59	3.47	0.17	1.14	4.32	3.45	0.48
P_{40}	54	3.49	0.19	1.19	4.01	4.16	0.56
P_{60}	52	3.54	0.19	1.22	4.35	2.90	0.41
P_{80}	48	3.91	0.20	1.33	4.10	3.40	0.44
SEm±	1.35	0.14	0.01	0.12	0.131	0.78	0.042
CD at 5%	4.02	0.39	0.02	NS	0.381	2.25	NS

inoculated plant increased with increasing P-level and was significantly higher than in the controls. Leaf N concentration was not directly related to the increase in plant dry matter. AMF became rapidly effective and allowed inoculated plants to yield significantly higher dry weight than in the control plants at all P-levels through 16 weeks (2). Potassium content of leaf in VAM treated plants decreased with increase in P level and significantly lower than in the controls. In case of non-mycorrhizal plants K content gradually increased with the increase in P levels. The present study indicates significant responses in inoculated plants despite low root infection rates and low soil fertility. Optimal P-level and other soil nutrients are needed to stimulate AMF and obtain maximum yields.

The average infection caused by the introduced strain was significantly higher. The study site had reasonable indigenous AMF but very low P-status and showed the effectiveness of the introduced AMF to be adequately tested. Percent VAM colonization decreased significantly with increasing P-application in both inoculated and control plots as reported by Mohammed *et al*. (6). The mycorrhizal growth effect was higher at P_0, P_{20} and P_{40} and decreased at P_{60} and P_{80} whereas, plants inoculated produced significantly more leaf yield than the controls at almost all P-levels. This can be attributed to early colonization of the roots by the inoculum and may improve efficiency of P absorption and hence crop productivity (1). Optimal P-level and other soil nutrients are needed to stimulate AMF and obtain maximum yields.

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