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INFLUENCE OF MICROBIAL INOCULANTS AND PHOSPHORUS LEVELS ON ROOT CHARACTERS, GROWTH AND YIELD OF VEGETABLE COWPEA (*VIGNA UNGUICULATA* SUB SP. *SESQUIPEDALIS*[L.]VERDCOURT)

Laterite soils accounting for 58 per cent of the total geographical area of Kerala are noted for high P fixing capacity and lack of response to added phosphatic fertilizers. The commonly applied P fertilizer is Mussoorie rock phosphate (MRP), which is slowly available to crop as it contains insoluble tricalcium phosphates. Research results revealed that arbuscular mycorrhizal fungal (AMF) colonization significantly increased nutrient uptake, particularly immobile or sparingly soluble forms of P by the host plant (Manjunath *et al.* 1989). Phosphate solubilising microorganisms (PSM) also help in the solubilisation of fixed forms of P supplied through fertilizers thereby enhancing P availability. Vegetable cowpea, a widely cultivated leguminous vegetable in Kerala is rich in proteins, minerals, vitamins and dietary fibre. The present study was undertaken to find out the efficiency of these microbial inoculants individually as well as in combination with different levels of P on root characters and yield of vegetable cowpea.

Field experiment was conducted at the Instructional Farm, College of Agriculture, Trivandrum, Kerala, during summer season of 1998-1999. The soil of the experimental site comes under the order Oxisol, sandy loam in texture, acidic in reaction (pH 5.0), low in available N (78.4 kg ha^{-1}) and K_2O (29.1 kg ha^{-1}), medium in available P (24.0 kg ha^{-1}). The experiment was laid out in factorial randomized block design (RBD) with three replications. The treatments consisted of the factorial combinations of three microbial inoculants (M_1-AMF, M_2-PSM and M_3-AMF+PSM) and four levels of P (P_1-0 kg P_2O_5 ha^{-1}, P_2-15 kg P_2O_5 ha^{-1}, P_3-30 kg P_2O_5 ha^{-1} and P_4-45 kg P_2O_5 ha^{-1}) along with two control treatments (C_1-No bioinoculants + No NPK absolute control) and C_2-No bioinoculants + N and K fertilizers + No P_2O_5). The variety used was Sharika, a popular high yielding trailing type of vegetable cowpea with long green pods. FYM was applied @ 25 t ha^{-1}, uniformly to all plots and mixed with topsoil. A common dose of 30 kg N ha^{-1} and 10 kg K_2O ha^{-1} was given to all the plots except C_1. The crop was managed by adopting the scientific management practices as per package of practices of the Kerala Agricultural University. AMF cultures containing spores of *Glomus* sp. infected sorghum root pieces and infected medium (perlite vermiculite) were applied to soil @ 5 g $plant^{-1}$ in plots receiving AMF treatment at the time of sowing. Along with this, a mixture of bacteria (*Pseudomonas* and *Bacillus* sp.) and fungi (*Aspergillus* sp.) was used as PSM culture. It was applied *in situ* @ 1g $plant^{-1}$ after thoroughly mixing with well rotten FYM. Pods were harvested from 50 DAS onwards and subsequent harvesting was done in alternate days up to 100 DAS. Observations on root length, root weight, root volume and effective nodules were recorded at flowering stage whereas AMF colonization percent was recorded at flowering and harvest stages of the crop.

Results revealed the significant role of bioagents in improving root characters except root weight (Table 1). Application of AMF alone as well as in combination with PSM significantly improved root length over PSM alone whereas regarding root volume, dual inoculation as well as PSM alone was superior to AMF inoculation. Similar results regarding the improvement of root characters by bioagents were reported by Bagyaraj and Manjunath (1980). A significant improvement in all the root characters was obtained at 15 kg P_2O_5 ha^{-1}, 15, 30 & 40 kg P_2O_5 ha^{-1} being on par. The infection of AMF seems to be inhibited by higher levels of P and lower pH (Saif, 1986). Bioinoculants along with lower dose of P viz. 15 kg P_2O_5 ha^{-1} recorded the maximum root weight and root volume (Table 2). AMF alone and 0 kg P_2O_5 ha^{-1} recorded the maximum number of effective nodules (Tablel). Reduction in nodulation at higher P levels may be attributed to the imbalance of nutrients in soil with medium P status. From Table 2, it is evident that AMF colonization was higher with lower dose of P.

Microbial inoculants did not impart any significant role in improving yield (Tablel). This might be attributed to the inadequate release of P from insoluble and fixed forms by the inoculants in a soil with medium P status (Dubey and Gupta, 1996). Green pod and haulm yield increased significantly with increase in P levels

Table 1. Effect of microbial inoculants and phosphorus levels on root characters, nodulation (at flowering stage) and yield

Treatments	Root length cm	Root weight, g	Root volume cm^3	Number of effective nodules/plant	Pod yield kg ha^{-1}	Haulm yield kg ha^{-1}
Bioinoculants						
AMF	29.18	8.28	20.87	26.88	3828	7683
PSM	27.36	7.77	24.12	17.89	4032	8066
AMF+PSM	30.21	8.21	22.46	24.80	4087	8178
CD (0.05)	1.80	NS	2.32	3.05	NS	NS
Phosphorus levels (kg ha^{-1})						
0	27.31	7..59	17.64	22.39	3645	7291
15	31.30	8.85	29.02	26.77	3992	7986
30	28.86	7.95	20.21	19.66	4340	8718
45	28.19	7.95	23.06	23.94	3953	7907
CD (0.05)	3.15	0.90	3..32	2.56	387	811

Table 2. Interaction effects of bioinoculants and phosphorus levels on root characters, number of effective nodules flowering stage) AMF colonization % (flowering &harvest stages) green pod yield, haulm yield, net returns and benefit : cost ratio

Treatments	Root wt. g	Root volume cm^3	No. of effective nodules/ plant	*AMF colonisation%		Pod yield, kg ha^{-1}	Haulm yield, kg ha^{-1}	*Net returns Rs ha^{1}	*B:C ratio
				Flowering stage	Harvest stage				
M1P1	8.26	18.33	32.11	85.33	66.66	3508	7018	12353	1.01
M1P2	9.21	23.37	18.11	75.00	62.50	3734	7469	14239	1.34
M1P3	7.23	14.40	17.65	66.66	50.00	7469	8783	12988	1.21
M1P4	7.81	27.40	39.66	45.83	33.33	3729	7461	11995	0.76
M2P1	6.84	16.10	16.20	37.50	41.66	3637	7276	12116	0.96
M2P2	8.61	33.44	13.67	58.33	45.83	4031	8065	14239	1.34
M2P3	9.03	27.92	21.78	58.33	37.50	4227	8454	12358	1.06
M2P4	6.61	19.00	19.89	41.66	54.16	4234	8469	12001	0.82
M3P1	7.06	18.49	32.00	91.66	66.66	3790	7580	12006	0.84
M3P2	8.75	30.23	35.39	95.83	70.83	4094	8188	15529	1.51
M3P3	7.61	18.33	19.55	79.16	54.16	4451	8915	15673	1.54
M3P4	9.44	22.78	12.28	66.66	50.00	4014	8028	11971	0.72
CD (0.05)	2.58	4.80	5.24	-	-	3.70	7.70	-	-
Treat. means	8.09	22.48	23.19	-	-	3919	7804	-	-
C1	7.23	8.74	6..99	33.33	29.16	4003	7063	11481	0.52
C2	8.37	9.58	9.20	50.00	25.00	4423	7968	11581	0.64

Price of tender pods Rs 9 kg^{-1}, Wage rate Rs 135 day, Cost of inputs viz. urea, MRP, MOP and FYM were 5.0, 3.0, 6.0 and 2.5 Rs 9 kg^{-1} respectively.

up to 30 kg and was on par with 15 kg P_2O_5 ha^{-1} (Table 1). The medium P status of the experimental field and its acidic reaction with low N status might have resulted in nutrient imbalance leading to lack of response at higher P doses. These are in conformity with the results of Sarkar *et al.* (1995) in chickpea. Dual inoculation of AMF + PSM at 30 kg P_2O_5 ha^{-1}

registered the highest green pod yield (4451 kg ha^{-1}) and haulm yield (8915 kg ha^{-1}) (Table 2). The highest green pod yield in M_3P_3 also resulted in increased net return and benefit-cost ratio (Table 2). The results of the study showed that microbial inoculants have a definite role in improving the root characters of the crop.

It can be concluded that dual inoculation of AMF and PSM with 30 kg P_2O_5 ha^{-1} is ideal to obtain increased pod yield and returns from vegetable cowpea.

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