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Growth and nodulation of cowpea [*Vigna unguiculata* (L.) Walp] as influenced by phosphorus levels and bio-inoculants

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Cowpea has unique place in Indian agriculture particularly from the nutritional and soil fertility point of view. Cowpea is well adapted to stress condition and possesses excellent nutritional quality. Its 100 g edible green pods contain 84.6 g moisture, 4.3 g protein, 0.2 g fat, 0.9 g minerals, 2.0 g fiber, 8.0 g carbohydrates etc. It plays an important role by serving as pulse (dry seeds) as well as vegetable (green pod) in subtropical regions. It is extensively grown in the eastern part of the country particularly in U. P. and Bihar. It improves the soil fertility by increasing the amount of nitrogen in the soil through symbiotic nitrogen fixation. It is one of the best components of crop diversification in traditional rice-wheat cropping system (Mortimore *et al*., 1997). Vegetable cowpea variety Kashi Kanchan is a short duration crop having bush and erect type of plants. Pods are thick, dark green and slightly curved. Inoculation of leguminous seeds with *Rhizobium* is considered as the cheapest way of getting atmospheric nitrogen to the plants and soil. The continuous cultivation of non leguminous crops decreases the nitrogen status of the soil to a great extent. On the other hand, cropping with legumes results in no such depletion of soil nitrogen and also the nitrogen fixed by the legume crops is beneficial to the succeeding crops. Among various plant nutrients, phosphorus is regarded as the pioneer plant nutrient needed by the leguminous crops for rapid and healthy root development which later on becomes helpful in better nodulation, growth and yield (Prasad and Prasad, 1993). The use of PSB as inoculant increases the P uptake by plants. Simple inoculation of seeds with PSB gives crop yield response equivalent to 30 kg P_2O_5/ ha or 50 percent of the need for phosphatic fertilizers. Keeping this in view, the present investigation was conducted to study the effect of *Rhizobium*, PSB and phosphorus on growth and nodulation of cow pea cv. Kashi Kanchan.

A field experiment was conducted at the experimental farm of Indian Institute of Vegetable Research, Varanasi during summer season of 2011. The soil of the experimental site was silt loam in texture having pH 7.75, EC 0.574 dS/m, organic carbon 0.43 % with available nitrogen 215.0 kg/ha, available P 36.5 kg/ha and ammonium acetate extractable K 215 kg/ha. The experiment was laid out in Randomized Block Design (RBD) with three replications. There were nine treatment combination of *Rhizobium,* PSB and P_2O_5 designated as T1-control, T_2- P_2O_5 @40 kg/ha, T_3- P_2O_5 @80 kg/ha, T_4- *Rhizobium,* T_5- P_2O_5 @40 kg/ha + *Rhizobium,* T_6 - P_2O_5 @80 kg/ha + *Rhizobium,* T_7- PSB, T_8- P_2O_5 @40 kg/ha+ PSB, T_9- P_2O_5 @80 kg/ha+ PSB. The seeds were treated with captan @ 3 g/kg of seeds before sowing against wilt and with *Rhizobium* and PSB culture for nodulation and phosphate solubilisation respectively. The seeds were sown on the ridges on 26.3.11 at a distance of 60x30cm in 5m x 2.5m plots. The fertilizer was applied in each plot according to the treatment and the total amount of phosphorus was incorporated as per the treatment at the time of sowing. The crop received a basal application of 30 kg/ha of nitrogen as urea and 60kg K_2O/ha as muriate of potash. A sample of five plants was taken randomly from two central rows in each experimental plot at different intervals for recording growth parameters like plant height, number of leaves, primary branches, dry matter accumulation and nodulation. For estimating total dry matter accumulation, each sample was first air dried and later on oven dried at 60^0 C to constant weight. The sum of dry weight of all plant parts was taken as total dry matter accumulation per plant in gram. The data were statistically analysed as per the standard analytical methods.

Plant height increased significantly due to biofertilizers and phosphorus application at every successive stage

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of plant growth. The maximum plant height was recorded 64.53 and 58.80 cm due to *Rhizobium* and PSB, respectively after 45 days of sowing (Table-1). Similarly, the plant height also increased significantly by increasing levels of phosphorus at 15, 30 and 45 days of sowing. At all these stages of plant growth, maximum plant height i.e. 11.13, 32.01 and 75.87cm was recorded under the supply of 80 kg P_2O_5/ha. The increase in plant height as compared to control might be due to increased availability of nutrient especially N and P_2O_5 from the early stages of growth (Ramana *et al*., 2011). Increase in plant growth might also be due to hastened meristematic activities, better root growth and better absorption of nutrients by increased application of P (Singh *et al*., 1980). The translocation of photosynthates by the action of P also showed an improvement in various growth parameters (Verma and Saxena,1995).

It is apparent from the data presented in Table-1 that the *Rhizobium* and PSB inoculation significantly increased the number of leaves per plant after 30 days of sowing. Similarly, both the levels of phosphorus application were also effective in increasing the number of leaves after 30 days of sowing. The data depicted in Table 1 indicate that the maximum number of branches per plant was found to be 31.80 due to phosphorus and *Rhizobium* at 45 days of sowing. Increase in the number of leaves and branches per plant due to PSB inoculation may be attributed to the conversion of unavailable phosphorus to available forms particularly during the early crop growth phase which would have helped in the absorption of all major and minor nutrients required for the plant to put forth early vigour in vegetative phase (Dubey, 1999).

The data presented in Table 2 indicate that phosphorus along with *Rhizobium* proved to be beneficial in increasing the shoot and root biomass. The maximum values of fresh weight of shoot and root was 49.77 g and 3.52 g, respectively due to the application of 80 kg P_2O_5/ha along with *Rhizobium* inoculation. Similarly, the dry weight of shoot and root was also recorded maximum i.e. 6.44 g and 0.73 g, respectively under

Table 1: Effect of phosphorus and bio-inoculants on growth parameters of cowpea

Treatments	Plant height (cm)			Number of leaves			Number of branches	
	15DAS	30DAS	45DAS	15DAS	30DAS	45DAS	30DAS	45DAS*
Control	10.24	29.89	58.4	5.20	24.10	114.40	2.53	24.10
40kg P_2O_5/ha	11.61	30.77	71.00	6.40	27.73	123.67	3.00	27.73
80kg P_2O_5/ha	11.13	32.01	75.87	6.73	29.80	132.87	3.27	29.80
Rhizobium	10.93	30.03	64.53	5.53	24.60	118.27	2.60	24.60
Rhizobium+40kg P_2O_5/ha	12.79	31.15	86.33	6.07	29.60	127.20	3.00	29.60
Rhizobium+80kg P_2O_5/ha	14.34	32.49	87.40	7.13	31.80	136.73	3.60	31.80
PSB	11.09	29.59	58.80	5.93	24.87	114.53	2.87	24.87
PSB+40kg P_2O_5/ha	12.25	30.93	65.69	6.27	28.60	119.40	3.27	28.60
PSB+80kg P_2O_5/ha	14.01	31.62	79.40	6.67	29.73	129.73	3.93	29.73
CD (0.05%)	NS	1.89	14.99	NS	3.74	NS	0.56	3.74

*DAS: Days after sowing

Table 2: Effect of phosphorus and bio-inoculants on nodulation and root and shoot biomass

Treatments	Shoot biomass /plant(g)		Root biomass/plant(g)		No. of nodules/ plant
	Fresh weight	Dry weight	Fresh weight	Dry weight	
Control	31.67	4.48	2.03	0.44	9.00
40kg P_2O_5/ha	37.44	5.33	2.38	0.57	11.30
80kg P_2O_5/ha	45.95	6.50	2.79	0.70	12.10
Rhizobium	34.94	4.78	2.35	0.61	11.33
Rhizobium+40kg P_2O_5/ha	44.16	6.03	2.76	0.64	14.67
Rhizobium+80kg P_2O_5/ha	49.77	6.44	3.52	0.73	19.87
PSB	32.02	4.47	2.05	0.46	11.10
PSB+40kg P_2O_5/ha	38.87	5.35	2.60	0.53	12.13
PSB+80kg P_2O_5/ha	47.53	7.11	2.72	0.67	13.20
CD (0.05%)	8.46	1.24	0.64	NS	2.15

this treatment. Phosphorus fertilization has also been reported to improved the root system in French bean which in turn helped more assimilation of nutrients resulting in increased growth. This finding corroborates with the findings of Srivastava and Ahlawat (1995) in pea, Shailesh *et al.,* (1996) in cow pea.

It is evident from Table 2 that the number of nodules per plant was increased significantly due to biofertilizer as well as phosphorus application. The value obtained due to *Rhizobium* and PSB was 11.33 and 11.10, respectively. However, the maximum number of nodules per plant (19.87) was obtained with the application of 80 kg of phosphorus along with *Rhizobium* inoculation. The infection of *Rhizobium* bacteria depends on their interception with the root hair. Under adequate phosphate availability, nodulation increases due to high bacterial infection on account of properly developed rooting system and increased density of nodule bacteria (Srivastava and Verma,1985). Increased nodulation implies greater symbiotic fixation of atmospheric N which also helps in cell division and root extension which ultimately result into vigorous plant growth. Similar results have also been reported by Josef and Verma (1994) in chickpea.

Thus, it is concluded that to have optimum growth and nodulation of cowpea cv. Kashi Kanchan, application of *Rhizobium* and PSB along with phosphorus @ 80 kg/ha is very useful.

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