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Influence of phosphorus and bio-fertilizers on growth and yield of cowpea [*Vigna unguiculata (*L.*)* Walp.] in acidic soil of NEH region of India

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ABSTRACT

A field experiment was carried out on cowpea (*Vigna unguiculata* (L.) variety Kashi Kanchan during summer season at the experimental farm, department of Vegetable Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. The experiment was laid out in factorial complete randomized block design with 12 treatments i.e. three levels of phosphorus [control 0 kg(P_0), 20 kg (P_1) and 40 kg (P_2) /ha] and four levels of bio-fertilizer [control (B_0), *Rhizobium*10 ml/kg seed (B_1), PSB 10 ml/kg seed (B_2) and *Rhizobium* + PSB both 10 ml/kg seed (B_3)] with three replications. The uniform dose of nitrogen (N) and potassium (K) @ 20 kg/ha along with 10 t/ha FYM (Farm Yard Manure) were applied to all the treatments. Result indicated that the application of P_2 (40 kg P/ha) significantly increased the plant height, leaf area index, stem girth, number of nodules per plant, number of branches per plant , total dry matter, pod yield, available soil nutrient status *viz.*, pH, N, P, K, organic carbon and NPK content in plant after harvesting. Similarly, seed inoculation with B_3 (*Rhizobium* + PSB) significantly enhanced the growth, yield, soil nutrient status and nutrient content in plant over single inoculation of *Rhizobium* and PSB. Combined inoculation of seed with *Rhizobium* + PSB (B_3) along with 40 kg P/ha (P_2) significantly increased the stem girth (1.84 cm), total dry matter (13.91g/plant), green pod yield (196.37g/ plant and 120.90q/ha), soil nutrient status *viz.*, pH(6.20), available N (370.89 kg/ha), available P (38.57 kg/ha), available K (168.77 kg/ha), organic carbon (2.80%) and N, P and K (0.17%, 0.16% and 0.39%) content over rest of treatment combination.

Key words: Acidic soil, Bio-fertilizer, Cowpea, Phosphorus, PSB, *Rhizobium.*

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.)Walp] is an important legume vegetable crop grown commercially in summer season and rainy season. Cowpea pods are containing quality protein and minerals. Few species are grown for grain, fodder and green manuring purposes. The cowpea cultivation is gaining popularity among vegetable growers due to short duration, quick growing nature, soil enriching habit, higher yield and higher profitability per unit area that gradually replacing the other traditional summer vegetable crops. However, productivity of cowpea is lowest in NEH region due to inadequate use of fertilizers and lack of improved package of practices. This crop is highly responsive to nitrogen, which promotes the leaf, stem and other vegetative growth while phosphorus enhances the activity of *Rhizobium* and increases the root nodulation thus, helping to fix more of atmospheric nitrogen in root nodules (Khandelwal *et al*., 2012). Most of the soil of North eastern region of India is characterized by acidic in nature and low in available nitrogen and phosphorus. A large proportion of soluble inorganic phosphate added to soil is rapidly fixed as insoluble forms soon after application and becomes unavailable to the plants. In acid soils, free oxides and hydroxides of Al and Fe fix P (Vassileva *et al.,* 2001and Khiari and Parent, 2005). Hence, utilization of available P in the soil by crops is very low. Therefore, use of bio-fertilizers has a greater importance in increasing fertilizer use efficiency. Several reviews suggested that seed inoculation with nitrogen and phosphate solubilizing bio-fertilizers (PSB) significantly enhanced the plant growth, root proliferation, nodulation and subsequently pod yield of cowpea (Bohra *et al.*, 1990 and Stamford *et al.*, 2013).There is a tremendous scope to increase current yield potential of cowpea in NEH region by enhancing the nutrient availability and better plant growth through incorporation of bio-fertilizers in the present production system. The selection of effective combination of fertilizer and *Rhizobium* and PSB containing bio-fertilizers is a critical step. Keeping these objective in mind, the present study was formulated to access the most suitable combination of phosphorus and bio-fertilizers for maximization of cowpea productivity in acid soil of NEH region of India.

MATERIALS AND METHODS

A field experiment was conducted at Vegetable Research Farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, East Siang, Arunachal

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Pradesh, India during summer season. The experimental site is situated between 28°04‘N latitude and 95°22‘E longitude at an elevation of 153 meters above the mean sea level. The soil of experimental field was sandy loam in texture with pH value of 5.25, organic carbon 2.16%, available nitrogen 312.47 kg/ha, available phosphorus 17.08 kg/ha and available potassium 125.76 kg/ha. The treatments comprised of recommended doses of N (20 kg/ha), K_2O (20 kg/ha) and FYM (10 t/ha) with three levels of P [control 0 kg (P_0), 20 kg (P_1) and 40 kg (P_2) /ha] and four levels of bio-fertilizer [control (B_0), *Rhizobium*10 ml/kg seed (B_1), PSB 10 ml/kg seed (B_2) and *Rhizobium* + PSB both 10 ml/kg seed (B_3)] in cowpea variety Kashi Kanchan, thereby making 12 treatments. The experiment was laid out in Factorial Complete Randomized Block Design with three replications. Farm yard manure (10 t/ha) was applied in the experimental field before 25 days of seed sowing. The recommended doses of N (20kg/ha) and K (20kg/ha) and required quantity of P as per the treatments were added as basal dose through urea, muriate of potash and single super phosphate, respectively. Seeds were treated with liquid bio-fertilizer @10 ml/kg as per the treatment, thereafter, the seeds were placed in shade for few hours for the completion of inoculation. After that, seeds were sown @ 20 kg/ha keeping row space 50 cm and plant to plant space 30 cm and seed were sown at average depth of 2.5 cm. The observations were recorded on ten randomly selected plants from each plot on different growth and yield characters *viz*., plant height (cm), leaf area index (LAI), stem girth (cm), number of nodules per plant, number of branches per plant, total dry matter (g/plant) and pod yield (g/plant and q/ha). The soil and plant samples were collected at the end of the experiment to estimate pH, organic carbon and available N P K in soil and N P K content in plants by adopting the standard analytical methods (Walkley and Black, 1934; Bray and Kurtz, 1945; Toth *et al.*, 1948; Stanford and English, 1949; Jackson, 1973 and Baker and Thompson, 1992).The data were statistically analyzed as per procedure given by Panse and Sukhatme, (1985) using Microsoft Excel version 2007. The treatment means were compared using least significant difference (LSD) test at 0.05 level of significance.

RESULTS AND DISCUSSION

Effect of phosphorus levels: Result indicated that application of phosphorus@ 40 kg/ha significantly increases the plant height (65.53 cm), leaf area index (7.62), stem girth (1.78 cm), number of nodules per plant (25.67), number of branches per plant (7.60), total dry matter (11.44 g/plant) and green pod yield per plant (174.87g) and per hectare (112.16 q (Table 1). Application of phosphorus might have

Table 1: Effect of phosphorus and bio-fertilizer on growth and yield parameters in cowpea.

Treatment	Plant height (cm)	Leaf area index	Stem girth (cm)	Number of nodules/ plant	Number branches/ plant	Total dry matter (g/plant)	Yield (g/plant)	Yield (q/ha)
Phosphorus								
P_0	57.66	6.29	1.56	18.41	6.56	7.38	128.59	86.54
P_1	62.35	7.14	1.68	21.70	7.08	10.37	147.67	96.57
P_2	65.43	7.62	1.78	25.67	7.60	11.44	174.87	112.16
CD at 5%	**5.63**	**0.28**	**0.06**	**2.34**	**0.52**	**0.74**	**13.82**	**6.11**
SEd±	2.71	0.14	0.03	1.13	0.25	0.36	6.67	2.94
Bio-fertilizer								
B_0	58.22	6.79	1.62	19.89	6.53	8.67	134.11	92.48
B_1	59.42	6.95	1.63	22.06	6.76	9.23	146.65	95.69
B_2	61.06	7.03	1.71	19.56	7.28	9.31	144.26	95.44
B_3	68.56	7.29	1.76	26.19	7.75	11.72	176.47	110.09
CD at 5%	**6.50**	**0.32**	**0.07**	**2.71**	**0.60**	**0.85**	**15.95**	**7.05**
SEd±	3.13	0.16	0.03	1.30	0.29	0.41	7.69	3.40
Interaction								
$P_0 B_0$	55.41	6.13	1.52	16.55	6.03	6.40	114.19	79.83
$P_0 B_1$	57.20	6.18	1.56	17.52	6.20	7.62	124.45	85.73
$P_0 B_2$	58.47	6.37	1.57	18.33	6.80	6.44	135.56	89.17
$P_0 B_3$	59.57	6.46	1.61	21.22	7.20	9.07	140.15	91.43
$P_1 B_0$	59.13	6.78	1.58	18.33	6.43	10.29	122.96	88.04
$P_1 B_1$	57.93	7.06	1.55	22.78	6.67	9.05	131.85	87.53
$P_1 B_2$	61.13	7.08	1.78	19.33	7.53	9.98	142.96	92.77
$P_1 B_3$	71.20	7.64	1.82	26.33	7.67	12.17	192.89	117.93
$P_2 B_0$	60.13	7.47	1.76	24.78	7.13	9.33	165.18	109.56
$P_2 B_1$	63.13	7.61	1.77	25.89	7.40	11.01	183.66	113.80
$P_2 B_2$	63.57	7.63	1.77	21.00	7.50	11.50	154.27	104.38
$P_2 B_3$	74.90	7.78	1.84	31.00	8.38	13.91	196.37	120.90
CD at 5%	**NS**	**NS**	**0.12**	**NS**	**NS**	**1.48**	**27.63**	**12.21**
SEd±	5.43	0.28	0.06	2.26	0.50	0.71	13.53	5.89

resulted in increased carbohydrate accumulation and their remobilization to reproductive parts of the plants, being the closest sink and hence, resulted in increased plant growth, flowering and fruiting. Similar result was reported by Khandelwal *et al*. (2012).

A significant effect of increasing levels of phosphorus up to 40 kg/ha was observed over control on physio-chemical properties of soil *viz.;* pH (5.80), available nitrogen (358.30 kg/ha), available phosphorus (34.79 kg/ha), available potassium (151.65 kg/ha) and organic carbon (2.59%), and N (0.14%), P (0.14%) and K (0.34%) content in plant (Table 2). This might be attributed to the role of phosphorus in root development and proliferation, nodules formation and N_2fixation by supplying assimilates to the roots. These findings were in support with the earlier work of Sharma and Verma (2011) and Singh *et al*.(2013).

Effect of bio-fertilizer: Seed inoculation with *Rhizobium* + PSB significantly increased plant height (68.56 cm), leaf area index (7.29), stem girth (1.76 cm), number of nodules per plant (26.19), number of branches per plant (7.75), total dry matter (11.72 g/plant) at harvesting stage of crops and green pods yield (176.47 g/plant and 110.09 q/ha) over single inoculation of *Rhizobium* and PSB (Table 1). Overall improvement in the crop growth and yield parameters under the influence of microbial fertilization i.e.; *Rhizobium*, PSB and *Rhizobium* + PSB seems to be on account of their impact on nutritional environment and involvement in various physiological processes in the plant system which are considered to be pre-requisits for growth of the crop. Better nodulation in combined inoculation might be due to increased P availability through PSB and enhanced biological N_2 fixation. Synergism in *Rhizobium* and PSB might have also resulted in better nodulation with their dual inoculation as against single inoculation (Singh and Prasad, 2008).These findings corroborate the results of Ramana *et al*. (2010)and Khandelwal *et al*. (2012).

The inoculation of seeds with *Rhizobium* + PSB increased the soil nutrient status and N,P and K content in plant after harvesting over single inoculation of *Rhizobium* and PSB. This may be due to better nitrogen fixation by the

Table 2: Effect of phosphorus and bio-fertilizer on physico-chemical properties of soil and nutrient content in plant after harvesting of cowpea.

Treatment	pH	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Organic carbon (%)	N content in plant (%)	P content in plant (%)	K content in plant (%)
Phosphorus								
P_0	5.39	329.94	26.86	136.71	2.27	0.09	0.12	0.23
P_1	5.69	345.17	31.19	146.47	2.45	0.14	0.13	0.31
P_2	5.80	358.30	34.79	151.65	2.59	0.14	0.14	0.34
CD at 5%	**0.11**	**4.38**	**1.27**	**5.79**	**0.09**	**0.004**	**0.004**	**0.01**
SEd±	0.05	2.11	0.61	2.79	0.04	0.002	0.002	0.006
Bio-fertilizer								
B_0	5.50	329.65	26.60	138.15	2.36	0.11	0.12	0.27
B_1	5.51	347.44	29.53	140.76	2.34	0.11	0.13	0.29
B_2	5.62	340.26	32.09	142.66	2.49	0.13	0.13	0.30
B_3	5.87	360.52	35.55	158.20	2.57	0.14	0.15	0.33
CD at 5%	**0.13**	**5.05**	**1.47**	**6.69**	**0.10**	**0.004**	**0.004**	**0.01**
SEd±	0.06	2.43	0.71	3.23	0.05	0.002	0.002	0.006
Interaction								
$P_0 B_0$	5.28	317.37	21.23	137.64	2.27	0.07	0.12	0.20
$P_0 B_1$	5.32	333.84	25.86	136.40	2.34	0.09	0.12	0.20
$P_0 B_2$	5.49	323.81	29.85	133.40	2.22	0.14	0.13	0.27
$P_0 B_3$	5.46	344.73	30.52	139.40	2.27	0.09	0.13	0.25
$P_1 B_0$	5.56	321.57	26.23	134.78	2.33	0.14	0.12	0.29
$P_1 B_1$	5.52	348.31	28.24	141.31	2.30	0.13	0.12	0.33
$P_1 B_2$	5.73	344.83	32.72	143.37	2.54	0.13	0.13	0.28
$P_1 B_3$	5.95	365.95	37.56	166.42	2.63	0.16	0.15	0.35
$P_2 B_0$	5.66	350.00	32.35	142.04	2.48	0.14	0.13	0.31
$P_2 B_1$	5.70	360.17	34.51	144.58	2.37	0.12	0.14	0.33
$P_2 B_2$	5.65	352.14	33.72	151.21	2.70	0.12	0.14	0.34
$P_2 B_3$	6.20	370.89	38.57	168.77	2.80	0.17	0.16	0.39
CD at 5%	**0.22**	**8.75**	**2.54**	**11.58**	**0.18**	**0.007**	**0.008**	**0.02**
SEd±	0.10	4.22	1.22	5.59	0.09	0.003	0.004	0.01

bacteria, which in turn helped in better absorption and utilization of all the plant nutrients, thus resulting in more availability of nutrient in soil and N,P,K content in plant. The inoculation helps in realizing P from native as well as protecting fixation of added phosphate and rendered more available P for the plants leading to increased nutrient content in the plant. These results were in close conformity with the findings of Dekhane *et al.* (2011), Das *et al.* (2013) and Singh *et al.* (2013).

Interaction effect: Interaction effect of phosphorous and bio-fertilizer were significantly increased growth parameters like stem girth (1.84 cm), total dry matter (13.91 g/plant) and green pod yield (196.37 g/plant and 120.90q/ha) as well as physico-chemical properties of soil *viz.;* pH (6.20), available N (370.89 kg/ha), available P (38.57 kg/ha), available K (168.77kg/ha), organic carbon (2.80%) and N(0.17%), P (0.16%)and K (0.39%) content in plant (Table 1 & 2).Increased availability of soil nutrient by the *Rhizobium* + PSB might be due to better nodulation and greater availability of nutrient in the soil under the influence of inoculation resulting in better growth and development (Menaria and Singh, 2004).

The present findings indicated that application of 40 kg/ha phosphorus in combination with seed treatment with *Rhizobium* and phosphorus solubilizing bacteria along with recommended doses of nitrogen (20 kg/ha), potassium (20 kg/ha) and FYM (10 t/ha) enhanced the productivity of cowpea var. Kashi Kanchan and improved the physico-chemical properties of soil. This practice would bring beneficial results for profitability in cowpea cultivation and encourage inclusion of cowpea in crop sequence under acidic soil of NEH region of India.

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