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Effect of biofertilizers and phosphorus on growth parameters and yield of Cowpea (*Vigna unguiculata* (L.) Walp.) in sandy loam soil of Prayagraj

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Abstract

A field experiment was carried out during *Kharif,* 2020 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) on sandy loam soil to assess the effect of biofertilizers and phosphorus on growth parameters and yield of Cowpea. The design of field experiment was Randomized block design consisting of ten treatments each replicated thrice. Experimental results showed significant increase in growth parameter *viz*., Plant height (81.09 cm), number of branches (4.87), number of nodules (53.27), plant dry weight (30.43 g/plant), crop growth rate (12.59 g/m^2/plant) and yield attributing parameters *viz.,* pods/plant (14.73), seeds/ pod (8.85), 100-seed weight (8.02 g), seed yield (2.62 t/ha) and biological yield (9.07 t/ha) were recorded with dual inoculation of Phosphate Solubilizing Bacteria and Vesicular Arbuscular Mycorrhiza along with 55 kg phosphorus per hectare.

Key words: ***Biofertilizer, Biological yield, Cowpea, Growth, Phosphorus, Phosphate Solubilizing Bacteria, Seed yield, Vesicular Arbuscular Mycorrhiza***

Introduction

Cowpea is an important kharif legume crop commonly known as lobia, southern pea, black eyed pea farmed throughout India for green pods, pulses, green manuring and livestock fodder. Cowpea is commonly grown in sub- tropical regions that are moderately humid and warm. It is more drought resilient however it is not tolerant to frost and waterlogging. Seeds of cowpea are nutritious and cheap source of quality protein, vitamins, iron, phosphorus as well as an excellent substitute for eggs, meat and other protein rich foods thus they are significant part of human diet. Cowpea grows predominantly in peninsular and central India. In northern India, it is grown in, Punjab, Rajasthan Haryana, Madhya Pradesh and Uttar Pradesh. During 2017 – 2018 the total coverage under cowpea in Uttar Pradesh is 23.61 lakh hectare with a production around 22.34 lakh tones (Anonymous, 2018). Phosphorus availability in Indian soils is poor to medium, however application of adequate amount of phosphorus has been recorded for higher formation of good quality nodules led to enhances growth and yield in legumes (Sammuria *et al*., 2009). Biofertilizers are used with an objective to increase the microbial population in the rhizosphere which in turn enhances the availability of nutrients for easy assimilation by plants (Sudhakar and Ranganathan, 2020). Inoculation of seed with Phosphate Solubilizing Bacteria in the rhizosphere of crop solubilize unavailable soil phosphorus and make available to plants. Vesicular arbuscular mycorrhiza (VAM) fungi improve plant growth through phosphorus nutrition. VAM is different from phosphate solubilizer as it does not solubilize the unavailable or insoluble phosphorus but assimilate phosphorus, zinc and other nutrient and translocate them into the host root along with their own need (Pandey *et al*., 2014). Since a large portion of the phosphorus in soil is insoluble, it is not directly available to the plants. PSB converts insoluble phosphate into soluble forms through production of organic acids, acidification, chelating and exchange reactions. Likewise, VAM develop hyphae that extend into phosphorus-available zone which is located distant from the roots, increasing the absorption surface. Hence, keeping in view all above mentioned aspects, present study was formulated to access the most suitable combination

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of biofertilizers and phosphorus for enhancing the growth parameters and yield of cowpea.

Materials and Methods

A field experiment was carried out during *Kharif,* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj to assess the effect of biofertilizers and phosphorus on growth parameters and yield of Cowpea. The soil of experimental site was sandy loam in texture with low available nitrogen, low available phosphorus and medium available potassium (190.8 kg/ha, 18.25 kg/ha and 236.20 kg/ha, respectively). The experiment was laid out in Randomized Block Design consisting of ten treatment combinations *viz.,* T_1 - control (farmer's practice RDF *i.e.* NPK 25:50:20 kg/ha), T_2 - PSB+35 kg P/ha, T_3 - PSB+45 kg P/ha, T_4 - PSB+55 kg P/ha, T_5 - VAM+35 kg P/ha, T_6 - VAM+45 kg P/ha, T_7 - VAM+55 kg P/ha, T_8 - PSB+VAM+35 kg P/ha, T_9 - PSB+VAM+45 kg P/ha, T_{10} - PSB+VAM+55 kg P/ha which were replicated thrice. Cowpea variety Pusa Dofasli was sown @ 25 kg/ha by maintaining spacing of 30 cm x10 cm in net plot area of 3m x 3m on 24 June 2020. Full dose of phosphorus was applied through SSP and cowpea seeds were treated with 10 ml/ kg seed with PSB culture and 10 g/kg seed with VAM culture and shade dried before sowing.According to the treatment blanket application of nitrogen and potassium @ 25 kg/ha and 20 kg/ha through urea and MOP, respectively. The observations on growth parameters *i.e.* plant height (cm), number of nodules/plant, number of branches/plant, plant dry weight (g), crop growth rate and relative growth rate were recorded from five randomly tagged plants from each plot at various growth stages whereas yield attributing parameters were recorded at harvesting stage from net plot. The recorded data were analysed statistically by ANOVA technique (Gomez and Gomez, 1984). Significant difference among the treatment mean was verified against the critical difference at five per cent level of significance.

Results and Discussion

Growth parameters

Crop growth parameters in cowpea were measured in terms of plant height (cm), plant dry weight (g), number of branches per plant at harvesting stage and number of nodules per plant at 45 DAS are shown in Table 1. During research trial, significantly higher plant height (81.09 cm) at harvest was recorded by dual seed inoculation of Phosphate Solubilizing bacteria and Vesicular Arbuscular Mycorrhiza along with 55 kg phosphorus per hectare as compared to other treatments. Increase in plant height due to seed inoculation with PSB and VAM which were uniformly coated resulting in better uptake and translocation of plant nutrients to growing plants. Another reason might be due to phosphate solubilizing action of PSB and phosphorus mobilizing effect of VAM fungi which boosted accessible phosphorus to the plant roots by converting insoluble phosphorus into usable form. Due to the cumulative action of two biofertilizers this attributed to better availability and uptake of phosphorus for augmenting the growth in terms of plant height, plant dry weight and number of branches (Yadav *et al*., 2017). Similar findings were also supported by Sammauria *et al*. (2009); Pramanik and Bera (2012) and Nadeem *et al*. (2017).With the progression of crop stage, number of branches gradually increased and significantly influenced by various treatments (Table 1). At harvest, significant and higher number of branches/plant (4.87) was recorded with dual inoculation PSB and VAM along with 55 kg phosphorus per hectare than other treatment combination. The probable reason might be to render insoluble and unavailable phosphorus into available form by the synergistic action of these two biofertilizer *i.e.* PSB+VAM. These results are in consonance with those reported by Singh *et al*. (2006); Dongare *et al*. (2016) and Prajapati *et al*. (2017). With the advancement of crop age, it was noticed that number of nodules was decreased at successive observations. At 45 DAS, dual seed inoculation of PSB and VAM plus 55 kg phosphorus per hectare has significantly increased the number of nodules/ plant (53.27) over control (Table 1). At this stage, number of nodules/plant was increased by 56.67 per cent in T_{10} over control. Better nodulation and dry matter production could be attributed to beneficial effect biofertilizer and phosphorus application on root proliferation and upsurge the phosphorus availability hence providing more root surface for bacterial infection and enhanced biological nitrogen fixation (Nadeem

Table 1: Effect of biofertilizers and phosphorus on growth parameters of Cowpea

Treatments	At Harvest			At 45 DAS	During 60 – 75 DAS	
	Plant height (cm)	Branches/ plant (No.)	Dry weight (g)	Nodules/ Plant (No.)	CGR ($g/m^2/day$)	RGR (g/g/day)
Control (Farmer's practice)	68.01	3.67	21.87	34.00	9.32	0.0142
PSB + 35 kg P/ha	65.79	3.53	20.94	36.80	9.21	0.0148
PSB + 45 kg P/ha	75.93	4.40	26.17	45.67	11.94	0.0153
PSB + 55 kg P/ha	74.20	4.13	25.35	43.67	11.51	0.0153
VAM + 35 kg P/ha	61.84	3.40	19.82	33.67	7.46	0.0124
VAM + 45 kg P/ha	70.57	3.93	24.31	39.33	11.40	0.0158
VAM+ 55 kg P/ha	71.06	4.07	24.96	41.53	11.55	0.0156
PSB + VAM + 35 kg P/ha	69.58	3.87	23.74	40.60	10.66	0.0151
PSB + VAM + 45 kg P/ha	77.55	4.60	28.49	49.00	12.19	0.0140
PSB + VAM + 55 kg P/ha	81.09	4.87	30.43	53.27	12.59	0.0137
SE(m)±	2.40	0.15	1.66	2.44	0.73	0.001
CD (P=0.05)	7.15	0.46	4.95	7.26	2.17	NS

Table 2: Effect of biofertilizers and phosphorus on yield attributes and yield of Cowpea

Treatments	Pods per plant (No.)	Seeds per pod (No.)	100-seed weight (g)	Seed yield (t/ha)	Biological yield (t/ha)
Control (Farmer's practice)	11.00	7.71	7.80	1.34	6.38
PSB + 35 kg P/ha	10.73	6.35	7.79	1.10	5.63
PSB + 45 kg P/ha	13.20	8.26	7.89	2.06	7.83
PSB + 55 kg P/ha	12.67	8.05	7.86	1.84	7.52
VAM + 35 kg P/ha	10.27	6.29	7.77	1.03	5.33
VAM + 45 kg P/ha	11.80	7.84	7.81	1.61	6.98
VAM+ 55 kg P/ha	12.33	7.92	7.86	1.76	7.28
PSB + VAM + 35 kg P/ha	11.33	7.90	7.81	1.63	7.09
PSB + VAM + 45 kg P/ha	13.87	8.78	7.94	2.57	8.89
PSB + VAM + 55 kg P/ha	14.73	8.85	8.02	2.62	9.07
SE(m)±	0.44	0.27	0.03	0.11	0.35
CD (P=0.05)	1.34	0.81	0.12	0.34	1.07

et al., 2017). These findings are in line with those reported by Biswas and Patra (2007); Mir *et al*. (2013); Jaga and Sharma (2015); Kant *et al*. (2016); Venkatrao *et al*. (2017); Yadav *et al*. (2017) and Singh *et al*. (2018). Plant dry weight increased with increasing crop age and there was significant difference among all treatment combinations at various growth stages (Table 1). The maximum dry weight (30.43 g/plant) was recorded with seed treatment of PSB and VAM along with 55 kg phosphorus per hectare which showed superiority over other treatments. The probable reason might be because of increase in plant vigor as number of branches/plant and plant height with combined application of biofertilizer and phosphorus proven effective in harvesting solar energy and nutrient uptake from the soil directed to increasing photosynthetic efficiency and dry matter production per plant (Prajapati *et al*., 2017). These findings were also supported by Kumar and Chandra (2003); Pramanik and Singh (2003); Singh and Pareek (2003); Biswas and Patra (2007); Dongare *et al*. (2016) and Nadeem *et al*. (2017). During 60-75 DAS, significant difference among the treatments was observed and significantly higher crop growth rate (12.59 $g/m^2/day$) was recorded with seed treatment with Phosphate Solubilizing Bacteria and Vesicular Arbuscular Mycorrhiza along with 55 kg phosphorus per hectare over other treatments (Table 1). This might be due to better accumulation of dry matter throughout the plant's vegetative and reproductive phase, which enhances the physiological and metabolic activity and growth by assimilating the available nutrients at higher rate and facilitating more photosynthesis, resulting in higher crop growth rate (Gupta *et al*., 2006). Similar results are in line with those of Biswas and Patra (2007) and Yadav *et al*. (2017). Observation regarding relative growth rate (g/g/day) was found non-significant through all growth stages.

Yield parameters

The observation regarding yield and contributory attributes *viz.,* number of pods/plant, seeds/pod, 100 seed weight, seed yield and biological yield are shown in Table 2. Significantly higher number of pods/plant (14.73), number of seeds/pod (8.85) and 100 seed weight (8.02 g) were recorded in co-inoculation of PSB and VAM along with 55 kg phosphorus per hectare over other treatments. The combined inoculation recorded higher yield attributes which might be due to synergetic effect between PSB and VAM (Pramanik and Singh, 2003). The yield attributing character because of beneficial effect of PSB and VAM along with basal application of phosphorus helps in development of extensive root system to extract more water and nutrient from soil thus resulting in better plant growth and yield attributes (Pramanik and Singh, 2003). These results corroborate with those reported by of Sammauria *et al*. (2009); Pramanik and Bera (2012); Kumawat *et al*. (2013); Biswas *et al*. (2015); Jaga and Sharma (2017); Prajapati *et al*. (2017) and Yadav *et al*. (2017). Significantly superior seed yield (2.62 t/ha) was recorded in T_{10} *i.e.* PSB + VAM +55 kg P/ha whereas, co-inoculation of PSB+VAM along with 45 kg phosphorus per hectare, which was found statistically on par with $T_{10.}$ Similarly, application of PSB+VAM+55 kg/ha P gave highest biological yield (9.07 t/ha) (Table 2). Increase in seed yield under this treatment probably due to concomitant increase in number of pods/plant, seeds/pod and 100 seed weight eventually directed to higher seed yield. Inter-relationship between seed yield and growth as well as yield attributing characters, revealed a substantial dependency of crop production on vegetative and reproductive growth of crops, which could explain the rise in biological output (Kumawat *et al*., 2013). These findings are in corroboration with those reported by Kant *et al*. (2016); Prajapati *et al*. (2017); Venkatrao *et al*. (2017); and Zafar *et al*. (2020).

Conclusion

Continuous usage of biofertilizer will not only reduce the need of chemical fertilizer, but it will also enhance crop yield and profit of farmer in long term use. In view of the obtained results, it could be concluded that among the studied treatments, combined seed inoculation of biofertilizers (PSB+VAM) along with 55 kg phosphorus per hectare was found to be more desirable that give higher growth parameters, yield attributes, seed yield and biological yield in sandy loam soil of Prayagraj. Thus, cowpea variety Pusa Dofasli and inoculation of Phosphate Solubilizing Bacteria, Vesicular Arbuscular Mycorrhiza along with phosphatic fertilizer may be recommended to apprehend higher yield of crops in this region.

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