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/m²/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...
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., T1 - control (farmer’s practice RDF i.e. NPK 25:50:20 kg/ha), T2 - PSB+35 kg P/ha, T3 - PSB+45 
kg P/ha, T4 - PSB+55 kg P/ha, T5 - VAM+35 kg 
P/ha, T6 - VAM+45 kg P/ha, T7 - VAM+55 kg 
P/ha, T8 - PSB+VAM+35 kg P/ha, T9 - PSB+VAM+45 kg P/ha, T10 - 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 Sammuvria 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 T10 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
Effect of biofertilizers and phosphorus on growth parameters

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/m²/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/m²/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 T10 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 T10. 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); Venkat Rao 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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