Original Research Article

Effect of molybdenum and bio-fertilizers on growth and yield of cowpea (*Vigna unguiculata* L.)

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ABSTRACT

A field experiment was conducted during *Kharif,* 2021 at crop research farm, Department of Agronomy, SHUATS, Prayagraj (U.P) with the objective to evaluate the influence of molybdenum and biofertilizers on growth and yield of cowpea. The soil texture of the experimental plot was sandy loam, nearly neutral in soil reaction having pH 7.1. The experiment was laid out in Randomized block design with ten treatments and were replicated thrice. The treatments comprising of different levels of molybdenum and bio-fertilizers *i.e. Rhizobium* and Phosphate solubilizing bacteria whose effect was observed in Cowpea. The treatment 6 with application of molybdenum 4g/kg seed and *Rhizobium* + PSB recorded significantly higher in plant height (78.64cm), branches/plant (15.07), nodules/plant (37.87) and dry weight (45.11g/plant). Molybdenum 4g/kg seed and *Rhizobium* + PSB also recorded significantly higher in yield and yield attributes *viz.* pods/plant (16.20), seeds/pod (12.80), seed yield (1.50t/ha), stover yield (4.17t/ha). Therefore, treatment with application of Molybdenum 4g/kg seed along with *Rhizobium* and PSB was more productive and can be recommended to farmers after further trails.

Keywords: *Rhizobium, Phosphate solubilizing bacteria, yield attributes, randomized block design*

1. INTRODUCTION

Cowpea “an annual legume” native to central Africa. Globally, it is grown in both sub-tropical and tropical regions from 35^0 N to 30^0 S. It is a crop of prosperity and sustainability. It is a versatile crop used as pulse, vegetable, green manure and also fodder (Fery, 1985). It can also be grown as an intercrop and is tolerant to low rainfall and sandy soils. Cowpea can be cultivated as mixed crop, catch crop, inter crop, mulch crop and green crop. Nitrogen applied to the crop is less as the crop itself fixes atmospheric nitrogen and fulfill the nitrogen requirement of the crop. It is an affordable protein source consumed as vegetable. The protein content present in cowpea is about 25-30% in mature seeds, 4-5% in immature pods and 3-5% in green leaves. Cowpea is rich in amino acids like lysine, phenyl amine and leucine (Bressani and Elias, 1980). In India vegetable cowpea is cultivated having an area of 23,012 ha with 1,33,587 tons of green pod production and productivity of 5800 kg/ha. The leading states are Uttar Pradesh, Jharkhand, Odisha, West Bengal, etc.

Nitrogen fixing bacteria need Molybdenum for the function of the enzyme nitrogenase that helps in nitrogen fixation. In nitrogen assimilation the enzyme nitrate reductase is required. Molybdenum acts as a cofactor in this process. The application of molybdenum in the soil will encourage the formation of nodules by fixing atmospheric nitrogen. Molybdenum is a necessary element; it is a component of the nitrogenase enzyme, and every bacterium that fixes nitrogen requires it. (Hansch and Mendel, 2009). The role of molybdenum in legumes are nodulation, nitrate reduction, nitrogen fixation and general metabolism (Togay et al. 2008). In legume crops, molybdenum has a beneficial effect on production, quality, and the formation of nodules. Molybdenum will increase crop growth and yield characteristics by increasing the bioavailability of other key elements. *Rhizobium* is a diazotrophic and symbiotic bacteria that fix atmospheric nitrogen inside the root nodules of legumes and plants uptake nitrogen in available forms. This symbiosis results in the formation of root nodules, which contain bacteria that can convert air nitrogen to ammonia. Phosphate solubilizing bacteria aid in the conversion of insoluble phosphorus into usable forms ($H_2Po_4^-$, HPo_4^{2-}) that plants may absorb and use to improve growth and yield. Seed inoculation with bacterial fertilizers such as Rhizobium and PSB

boosted plant height, nodule count, and pod number, resulting in a higher crop yield (Kumar et al. 2016). The purpose of the study is to observe the effect of molybdenum and bio fertilizers on growth parameters and yield attributes of cowpea. This can increase the production and productivity of the crop.

2. MATERIALS AND METHODS

A field experiment was carried out during *Kharif,* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj to evaluate the effect of molybdenum and bio - fertilizers on growth parameters of cowpea. The soil of experimental site was sandy loam in texture with low available nitrogen, low available phosphorus, 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.,* Mo 2g/kg seed + *Rhizobium*, Mo 2g/kg seed + PSB, Mo 2g/kg seed + *Rhizobium* + PSB, Mo 4g/kg seed + *Rhizobium*, Mo 4g/kg seed + PSB, Mo 4g/kg seed + *Rhizobium* + PSB, *Rhizobium*, PSB, *Rhizobium* + PSB and Control (20: 60: 40 kg/ha NPK) which were replicated thrice. Cowpea variety Gomati was sown at 25 kg/ha by maintaining the spacing of 30cm × 10 cm in net plot area of 3m × 3m on 17 June 2021. Seeds are treated a day prior with Molybdenum 2 and 4g/kg seeds as taken in the treatment combination. These seeds are dried in shade and again treated with bio - fertilizers *i.e. Rhizobium* (20g/kg seed), PSB (20g/kg seed) and *Rhizobium* + PSB (10g/kg seed each) as described in treatment combination. Treated seeds are dried in a shady area and sown in the field immediately. Along with this Recommended dosage of fertilizer is also applied during sowing. The observations on growth parameters *i.e.* plant height (cm), Number of Branches/plant, number of nodules/plant, plant dry weight (g), Crop growth rate (g/m^2/day) and relative growth rate (g/g/day) were recorded from five randomly tagged plants from each plot at various growth stages whereas yield attributing parameters *i.e.* Number of seeds/pod, number of pods/plant, seed index (g), seed yield (t/ha), stover yield (t/ha) and harvest index (%) were recorded at harvesting stage from net plot. The seed and stover yield was taken for the net plot of 1m^2 and further calculated to 1 hactare. Harvest index is calculated using the formula (economic yield / biological yield) ×100. The recorded data were analyzed statistically by ANOVA technique. Significant difference among the treatment mean was verified against the critical difference at 5% level of significance.

Table 1. Physical properties of soil of the experimental area

Mineral fraction	Values (%)	Methods (references)
Sand (%)	60 (%)	**International Pipette Method (Piper, 1966)**
Silt (%)	20 (%)	
Clay (%)	20 (%)	
Textural class	Sandy loam	**USDA Triangle(Williams, 1975)**

3. RESULT AND DISCUSSION

Growth Parameters

Crop growth parameters in cowpea were measured in terms of plant height (cm), number of branches/plant, plant dry weight at harvesting stage and number of nodules/plant at 45DAS are shown in Table 2. During research trail, significantly higher plant height (78.64cm) at harvest was recorded with the application of molybdenum 4g/kg seed along with *Rhizobium* and PSB as compared to other treatments and Molybdenum 2g/kg seed + *Rhizobium* + PSB (77.59cm) was statistically at par. Increase in plant height might be due to increased availability of nitrogen due to Molybdenum which helps in the process of nitrogen assimilation and *Rhizobium* used for nitrogen fixation. Through this nitrogen availability increases which further increases plant height. (Chatterjee *et al.* 2017).

At harvest significantly higher number of branches (15.07) were recorded in seed treatment with Mo 4g/kg seed along with *Rhizobium* and PSB. Treatment with application of Molybdenum 2g/kg seed along with *Rhizobium* and PSB (14.40) was statistically at par. The reason might be due to seed

inoculation with *Rhizobium* and PSB which increased the availability of phosphorus in root zone and nitrogen uptake by plants. These resulted in higher number of branches (Chauhan *et al.* 2017). Due to cumulative action of two bio - fertilizers this attributed to better availability and uptake of phosphorus for augmenting the growth in terms of plant height, number of branches and plant dry weight (Nadeem *et al.* 2017). These findings were in line with those reported by Dhakal *et al.* (2019). With the advancement in crop age, it was observed that number of nodules were decreased at successive observations. Significantly higher number of nodules (37.87) were observed at 45DAS in treatment Mo 4g/kg seed along with *Rhizobium* and PSB. Treatment with application of Molybdenum 2g/kg seed along with *Rhizobium* and PSB (35.33) was statistically at par as compared to other treatments. This might be due to the synergetic effect of *Rhizobium* and PSB for biological nitrogen fixation as against their individual application (Heisnam *et al.* 2017). Significantly higher dry weight (45.11 g/plant) was recorded in treatment Mo 4g/kg seed along with *Rhizobium* and PSB Treatment with application of Molybdenum 2g/kg seed along with *Rhizobium* and PSB (42.77 g/plant) was statistically at par as compared to other treatments. This might be due to higher availability of nutrients, synthesis of more carbohydrates and their translocation to different plant parts resulted in increased vegetative growth including the reproductive structures which in turn increase dry weight of the plant. Similar results were obtained by Hariredy *et al.* (2021). During 30-45 DAS, significantly higher crop growth rate (40.59 g/m^2/day) and relative growth rate (0.054 g/g/day) were recorded in seed treatment with Mo 2g/kg seed along with *Rhizobium* and PSB over other treatments. This might be due to better accumulation of dry matter throughout the plants vegetative and reproductive phase, which enhances the physiological and metabolic activity and growth by assimilating the available nutrients at higher rate, facilitating more photosynthesis, resulting in higher crop growth rate (Gad *et al.* 2013).

Table 2. Effect of molybdenum and bio- fertilizers on growth of cowpea

Treatments	At harvest			At 45 DAS	30-45 DAS	
	Plant height (cm)	Number of branches/plant	Dry weight (g)	Number of nodules/plant	CGR (g/m^2/day)	RGR (g/g/day)
1	73.59±SE	13.73±SE	40.41±SE	31.93±SE	34.85±SE	0.051±SE*
2	73.46±SE	13.80±SE	41.08±SE	33.60±SE	33.07±SE	0.046±SE
3	77.59±SE*	14.40±SE*	42.77±SE*	35.33±SE*	40.59±SE**	0.054±SE**
4	73.75±SE	13.87±SE	41.89±SE*	34.27±SE	39.09±SE*	0.053±SE*
5	75.21±SE*	14.07±SE*	41.56±SE	34.60±SE	37.33±SE	0.050±SE
6	78.64±SE**	15.07±SE**	45.11±SE**	37.87±SE**	39.93±SE*	0.050±SE
7	73.87±SE	13.70±SE	38.49±SE	34.53±SE	30.36±SE	0.044±SE
8	74.71±SE	13.67±SE	38.74±SE	33.93±SE	30.10±SE	0.046±SE
9	74.65±SE	13.73±SE	39.34±SE	35.93±SE	32.29±SE	0.048±SE
10	71.76±SE	13.00±SE	36.46±SE	30.53±SE	31.18±SE	0.049±SE
F test	5.34	3.90	25.84	9.31	6.64	2.77
SEm±	0.88	0.27	0.49	0.66	1.57	0.002
CD (P=0.05)	2.64	0.81	1.48	1.97	4.68	0.006

1- Mo 2g/kg seed + Rhizobium 2- Mo 2g/kg seed + PSB 3- Mo 2g/kg seed + Rhizobium + PSB 4- Mo 4g/kg seed + Rhizobium 5- Mo 4g/kg seed + PSB 6- Mo 4g/kg seed + Rhizobium + PSB 7- Rhizobium 8- PSB 9- Rhizobium + PSB 10- Control (20 : 60 : 40 kg/ha NPK)

** = Highly Significant * = Significant

In each column, mean followed with the same letter(s) are not significantly different (*P*=0.05)

Yield parameters

The observation regarding yield and yield attributes *viz.,* number of pods/plant, seeds/pod, seed index, seed yield, stover yield and harvest index were shown in Table 3. Significantly higher number of pods/plant (16.20) was recorded in treatment Mo 4 g/kg seed along with *Rhizobium* and PSB. Treatment with application of Molybdenum 2g/kg seed along with *Rhizobium* and PSB (15.40) was found statistically at par compared to other treatments. Significantly higher number of seeds/pod

(12.80) was recorded in treatment Mo 4 g/kg seed along with *Rhizobium* and PSB. Treatment with application of Molybdenum 2g/kg seed along with *Rhizobium* and PSB (11.67) was found statistically at par compared to other treatments. This might be due to the availability of Molybdenum and bio - fertilizers *i.e., Rhizobium* and PSB could be attributed to the effect of growth hormone like IAA and cytokinins produced by *Rhizobium* which stimulated root morphology. This in turn would have improved assimilation of nutrients in the plant which results more number of pods/plant and seeds/pod (Chatterjee *et al.* 2017). Significantly higher seed yield (1.50 t/ha) was observed in seed treatment with Mo 4 g/kg seed + *Rhizobium* + PSB. Seed treatment with Molybdenum 2g/kg seed along with *Rhizobium* and PSB (1.37t/ha) was found statistically at par compared to other treatments. Significantly higher stover yield (4.17 t/ha) was observed in seed treatment with Mo 4 g/kg seed + *Rhizobium* + PSB. Seed treatment with Molybdenum 2g/kg seed along with *Rhizobium* and PSB (4.08 t/ha) was found statistically at par compared to other treatments. Increase in seed yield under this treatment might be due to concomitant increase in number of pods/plant, seeds/pod and seed index 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 stover yield (Singh and Singh, 2017). These findings are in collaboration with those reported by (Kumar *et al.* 2018) and (Pragi *et al.* 2018). However, seed index and harvest index remained non-significant.

Table 3 Effect of molybdenum and bio - fertilizers on yield of cowpea

Treatments	At Harvest					
	Number of pods/plant	Number of seeds/pod	Seed index (g)	Seed yield(t/ha)	Stover yield (t/ha)	Harvest index (%)
1	13.40±SE	10.53±SE	17.67±SE	1.15±SE	3.42±SE	33.73±SE
2	14.27±SE	10.53±SE	18.00±SE	1.30±SE	3.75±SE	34.63±SE
3	15.40±SE*	11.67±SE*	22.67±SE	1.37±SE*	4.08±SE*	33.54±SE
4	13.93±SE	11.13±SE	20.67±SE	1.30±SE	3.75±SE	34.80±SE
5	14.93±SE	11.53±SE*	20.33±SE	1.34±SE*	3.92±SE*	34.31±SE
6	16.20±SE**	12.80±SE**	22.83±SE	1.50±SE**	4.17±SE**	36.07±SE
7	14.53±SE	10.53±SE	21.50±SE	1.17±SE	3.50±SE	33.64±SE
8	14.93±SE	10.67±SE	20.83±SE	1.22±SE	3.42±SE	35.73±SE
9	14.87±SE	11.00±SE	21.17±SE	1.26±SE	3.58±SE	35.39±SE
10	12.80±SE	10.07±SE	16.57±SE	1.12±SE	3.42±SE	32.64±SE
F test	7.17	5.65	NS	8.17	2.89	NS
SEm±	0.36	0.33	1.38	0.04	0.16	1.41
CD (P=0.05)	1.08	0.98	-	0.11	0.49	-

1- Mo 2g/kg seed + Rhizobium 2- Mo 2g/kg seed + PSB 3- Mo 2g/kg seed + Rhizobium + PSB 4- Mo 4g/kg seed + Rhizobium 5- Mo 4g/kg seed + PSB 6- Mo 4g/kg seed + Rhizobium + PSB 7- Rhizobium 8- PSB 9- Rhizobium + PSB 10- Control (20 : 60 : 40 kg/ha NPK)

** = Highly Significant * = Significant NS = non-significant
In each column, mean followed with the same letter(s) are not significantly different (*P*=0.05)

Fig 1. Picture with my Advisor

Fig 2. Measuring plant height

Fig 3. Seed treatment with molybdenum and biofertilizers

Fig 4. Picking the pods

4. CONCLUSION

From the above results, the effect of molybdenum and bio fertilizers on cowpea was observed it was concluded that application of molybdenum 4 g/kg seed along with *Rhizobium* and PSB had performed better in growth and yield parameters. As it was more productive it can be recommended to farmers after further trails.

Ethical Approval:

As per international standard or university standard ethical approval has been collected and preserved by the authors.

FUTURE SCOPE

As there was less research happened in this field, futher research should be done to obtain proper results and help farmers obtaining better yield. Since the findings are based on one season further trails are needed to confirm the results of this experiment.

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COMPETING INTRESTS

Authors have declared that no competing interests exist.

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