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Effect of Fertility levels and Biofertilizers on Growth and Yield of Cowpea

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Abstract

Cowpea (*Vigna unguiculata* L.), commonly known as Chawla, Lobia, black-eyed pea or southern pea etc. is a popular short season drought hardy nature and short duration pulse crop farmed throughout India. Its wide and droopy leaves keep soils and soil moisture conserved due to shading effect. Being a legume crop, cowpea fits well in inter-cropping system and an integral part of sustainable agriculture. A field experiment was conducted during kharif season of 2022 to study the effect of fertility levels and biofertilizers on growth and yield of cowpea at the Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner. The experiment was laid out in split plot design with 24 treatment combination replicated thrice. The results revealed that growth and yield of cowpea were significantly influenced by different fertility levels. Results showed that application of 20 kg/ha N + 40 kg/ha P_2O_5 gave significantly higher plant height, number of branches/plant, number of root nodules/plant, dry weight of root nodules, dry matter accumulation, crop growth rate, relative growth rate, number of pods/plant, number of seeds/pod, test weight, seed, straw and biological yield and harvest index as compared to control and application of 10 kg/ha N + 20 kg/ha P_2O_5, but it was at par with application of 30 kg/ha N + 60 kg/ha P_2O_5. Among biofertilizer treatments seed inoculation with *Rhizobium + PSB + VAM* recorded highest plant height, number of branches/plant, number of root nodules/plant, dry weight of root nodules, dry matter accumulation, crop growth rate, relative growth rate, number of pods/plant, number of seeds/pod, test weight, seed, straw and biological yield, harvest index as compared to control, *Rhizobium,* PSB, Rhizobium + PSB and VAM.

***Key words*:** Cowpea, Biofertilizers, Fertilizers, Growth, Yield

Pulses play an important role in Indian Agriculture as they restore soil fertility by fixing atmospheric nitrogen through their nodules. These are drought resistant and prevent soil erosion due to their deep root system and good ground coverage. Cowpea (*Vigna unguiculata* L.) belongs to the family Fabaceae is known as drought hardy nature, its wide and droopy leaves keep soils and soil moisture conserved due to shading effect. It is locally known as 'Chawla', and commonly known in India a Lobia is one of the important *kharif* pulse crops. It is also known as black-eyed pea or southern pea etc. It is a warm season crop, well adapted to many areas of the humid tropics and subtropical zones. It is grown throughout India for its long, green vegetable pods, seeds and foliage for fodder. Tender pods used as vegetable and dry beans as pulse. Due to its nutritive value and soil improving properties, it is also used as fodder, green manure and cover crop. It contains 22-24% protein, 55-66% carbohydrates, 5.42% fat, 1.62 g calcium, 1.66 g magnesium and 0.56 g phosphorus. Though it has high nutritive values and has the potential to cultivate as an intercrop and main crop, the area under cultivation is very low. In India, cowpea occupies 654 lakh hectares area and production of 599 lakh tonnes along with productivity of 916 kg/ha [1]. In Rajasthan, the area under cowpea was 76.31 thousand hectares with the annual production of 42.02 thousand tonnes and productivity of 551 kg/ha [2]. Low yield of cowpea in arid western Rajasthan associated with cultivation of cowpea on light soils with low in organic matter, low in available nutrient status, low water holding capacity and high evaporation. Under such conditions, proper management of fertility through inorganic fertilizers along with biofertilizers can be an effective intervention in enhancing cowpea production and productivity.

The efficient use of nutrients is one of the most important factors in any program designed to achieve an economic increase in agricultural production. Continuous and unbalanced use of nutrients is an important area of concern. Soil degradation and depletion of fertility due to the unbalanced and inadequate use of nutrients is largely responsible for the reduction of crop productivity. Nitrogen is the chief promoter of growth, as it is constituent of proteins, enzymes, vitamins and plant hormones. Nitrogen plays an important role in various processes of the plant and it is a constituent of chloroplast. It imparts the chlorophyll content of the leaves and stems and

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enables efficient photosynthesis. Among the nutrients, phosphorus also has an adverse impact on legume production as it is one of the vital nutrients required for optimum growth, development, productivity of plants [3], as well as for nodulation and enhanced N-fixation [4].

Maintaining soil health through balanced nutrition is essential to maintain crop productivity [5]. Soil fertility can also be regulated by soil microbial enzymatic activities which are responsible for the soil properties and cultivation factors [6]. The depletion of the soil organic matter can be prevented by the biofertilizer particularly rhizobia, which is an alternative source of N fertilizer [7]. The intimate symbiotic relationship between rhizobia and legumes results in nodule formation by lipochitooligosaccharide (LCO) signals and enhance yield [8-9]. In order to raise the soil fertility and crop production, bio-fertilizers have been recognized as a substitute to chemical fertilizers in sustainable farming [10]. Rhizosphere harbors diverse and rich regime of beneficial microorganisms which directly affect plant health and soil fertility in which a significant number of bacterial and fungal species have a mutual association with plants.

Introduction of efficient strain of *Rhizobium* in soil which are poor in nitrogen may be helpful in boosting up production and consequently more nitrogen fixation. Inoculation of seeds with *Rhizobium* culture is a very low-cost method of nitrogen fertilization in legume and has been found beneficial [11]. Phosphate Solubilizing Bacteria (PSB) plays an important role in solubilizing of soil P through secretion of various organic acids and makes it available to plant. It dissolves inter-locked phosphates appear to have an important implication in agriculture. Inoculation of seed with PSB culture may increase the production and productivity of cowpea crops as reported by Kumar *et al.* [12]. VAM plays an important role in enhancing phosphorus availability to plant in P deficient soils. VAM fungi can save P fertilizer by 25-30%. It is well known that VAM fungi improve plant growth through increased uptake of relatively immobile nutrients such as P, Zn, Cu etc. [13]. Keeping in view aforesaid points a study was planned to evaluate the effect of biofertilizers and fertility levels on growth attributes and yield of cowpea.

MATERIALS AND METHODS

The experiment was conducted at the Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *Kharif* 2022. College of Agriculture, Bikaner (Rajasthan, India) is situated at 28.10°N latitude and 73.35°E longitude at an altitude of 235 m above mean sea level. The soil of experimental field was loamy-sand, alkaline in reaction (pH 8.5) having 104.2 kg/ha available N (Alkaline permanganate method, [14], low level of available phosphorus of 15.2 kg/ha (Olsen's method, [15] and medium in available potassium of 173.3 kg/ha (Flame photometric method, [16] in 0-15 cm soil depth. The experiment was laid out in split plot design with two factors replicated thrice. Twenty-four treatment combinations comprising of four fertility levels with N: P_2O_5 kg ha^{-1} (Control, 10:20, 20:40 and 30:60) were taken as main plot treatments and six biofertilizer levels (control, *Rhizobium*, PSB, *Rhizobium* + PSB, VAM and *Rhizobium* + PSB + VAM) as sub plot treatments. Cowpea variety RC-19 was sown on 15.07.2022 using 25 kg seed ha^{-1} at the spacing of 30 × 10 cm. All the recommended agronomical practices were followed during growing period as per package of practices of IC Zone. Thinning was done at 20 DAS to maintain proper plant to plant distance. Post sowing irrigations of 50 mm depth were given on 21.08.2022 and 15.09.2022. Rainfall received during the crop growth period was 240.3 mm. Experimental data recorded in various observations were statistically analyzed with the help of Fisher's analysis of variance technique [17]. The analysis of data for the various treatments was compared together using CD at 5% significant levels.

RESULTS AND DISCUSSION

Effect of fertility levels

Higher plant height, number of branches / plant, number of nodules / plant, dry weight of nodules, dry matter accumulation, crop growth rate and relative growth rate observed with the application of 20 kg/ha N + 40 kg/ha P_2O_5 as compared to control and 10 kg/ha N + 20 kg/ha P_2O_5, but it was remained at par with 30 kg/ha N + 60 kg/ha P_2O_5 (Table 1). Different fertility levels effects on plant growth, including plant height can be explained by their direct and indirect contributions to the nutrients available to crop plants [18]. It is a well-known fact that providing appropriate fertilization to crops, like N and P enhances a number of physiological and metabolic processes in the plant system. The synthesis of proteins, chlorophyll and other organic compounds in the plant system depends heavily on nitrogen, making it the most significant mineral nutrient. For the growth and development of the crop canopy, plant height is a key factor. Due to the indeterminate tendency of cowpea plant, the mean plant height gradually increased as the advancement of age of the plant. Thus, plants uptake much nutrients from soil which reflected in increased in cell enlargement and cell elongation. The decrease in plant height under control and 10 kg/ha N + 20 kg/ha P_2O_5 fertility levels was due to the nutrient shortage in soil resulting in decline of growth of crop. The results are in conformity with the findings of Singh *et al.* [19] in cowpea and Luikham *et al.* [20] in green gram. Increase in number of root nodules/plant and dry weight of root nodules of cowpea might be due to the fact that nitrogen and phosphorus encourage the growth of roots and plants, initiates the formation of nodules and affect the general effectiveness of the *rhizobium*-legume symbiosis [21], which in turn improves the biological nitrogen fixation (BNF) system of legumes [22].

Yield and yield attributing characters viz. number of pods / plant, number of seeds/pod and test weight, seed, straw and biological yield and harvest index increased with increasing levels of fertility (Table 2). Application of 20 kg/ha N + 40 kg/ha P_2O_5 recorded higher number of pods/plant (22.77), number of seeds/pod (9.59), test weight (60.89 g), seed (1013 kg/ha), straw (2611 kg/ha) and biological (3624 kg/ha) yield and harvest index (27.93%) which were at par with 30 kg/ha N + 60 kg/ha P_2O_5. At fertility levels of 10 kg/ha N + 20 kg/ha P_2O_5 and control, nutrient availability was comparatively meager which caused poor growth and development of crop. Higher fertility levels of 20 kg/ha N + 40 kg/ha P_2O_5 and 30 kg/ha N + 60 kg/ha P_2O_5 helped in maintaining the better nutrient availability for optimum growth and development of plants throughout the crop growing period. The increase in yield attributes with increase in fertility levels due to cumulative effect on growth and vigour of plants. The continuous availability of N and P in plant at all stage, might have resulted in higher photosynthesis, better root development which increased the supply of photosynthates from source to sink. The seed and straw yield significantly influenced with application of different fertility levels might be due to improvement in yield attributes and cumulative interaction between vegetative and reproductive growth of the crop [23].

Effect of biofertilizers

The results revealed that seed inoculation with *Rhizobium*+ PSB+ VAM recorded significantly higher growth parameters viz., plant height, number of branches/plant, and number of nodules/plant, dry weight of nodules, dry matter accumulation, crop growth rate and relative growth rate as compared to the control, seed inoculation with *Rhizobium*, PSB, *Rhizobium* + PSB and VAM (Table 1). In the mobilization of P and the uptake of phosphorus by plants, VAM inoculation also performs an important and distinctive role. The major cause of the significant increase in plant height, dry matter accumulation, number of nodules/plant and number of branches plant with VAM was linked to the mobilization of phosphorus to the plant, which may have aided in simple uptake. *Rhizobium* activity may have been aided by the considerably larger availability of phosphorus in the rhizosphere, which increased the number of nodules/plant. *Rhizobium + PSB + VAM* might have improved nitrogen, phosphorus and potassium in rhizophere as they are symbiotic nitrogen fixers, phosphorus solubilizers and mobilizing. Thus, the increased availability of nitrogen due to Rhizobium coupled with phosphorus due to PSB and VAM might open the door for increased utilization of others nutrient also and have resulted in more increase in growth in comparison to Rhizobium, PSB and VAM inoculations [24-25].

Table 1 Effect of fertility levels and biofertilizers on growth parameters of cowpea

Treatments	Plant height (cm)		No. of branches / plant	No. of nodules / plant	Dry weight of nodules (mg/plant)	Dry matter accumulation (g/plant)			Crop growth rate ($g/m^2/day$)			Relative growth rate (mg/g/day)	
	At 30 DAS	At harvest				30 DAS	45 DAS	At harvest	0-30 DAS	30-45 DAS	45 DAS harvest	30-45 DAS	45 DAS harvest
Fertility levels ($N:P_2O_5$ kg/ha)													
Control	21.03	55.11	6.10	19.78	208.9	4.06	14.04	22.66	4.52	22.18	8.45	82.42	37.48
10:20	23.63	61.54	6.98	23.65	245.1	4.39	15.80	25.66	4.88	25.36	9.67	84.96	38.06
20:40	25.17	66.33	7.62	26.01	263.7	4.69	17.20	28.71	5.21	27.82	11.28	86.45	38.57
30:60	25.49	67.93	7.82	27.37	276.0	4.75	18.45	30.04	5.27	30.45	11.37	90.53	39.09
S.Em. ±	0.41	1.26	0.13	0.43	4.1	0.09	0.36	0.49	0.10	0.90	0.14	2.49	0.04
CD at 5%	1.43	4.35	0.45	1.48	14.1	0.31	1.26	1.69	0.35	3.10	0.48	8.60	0.13
Biofertilizers													
Control	21.92	58.34	6.35	20.91	219.9	4.22	14.93	24.05	4.69	23.79	8.94	83.76	38.14
Rhizobium	23.72	62.34	7.15	24.66	254.4	4.53	16.13	26.65	5.04	25.78	10.31	84.28	38.21
PSB	23.43	62.03	7.00	23.44	243.6	4.42	15.90	26.02	4.91	25.50	9.92	84.87	38.24
Rhizobium + PSB	24.69	65.15	7.56	25.82	260.7	4.61	17.31	28.33	5.12	28.24	10.80	88.04	38.55
VAM	23.18	59.97	6.89	23.40	238.0	4.38	15.52	25.61	4.87	24.75	9.89	84.06	38.06
Rhizobium + PSB + VAM	26.03	68.53	7.81	26.97	273.9	4.67	18.46	29.95	5.19	30.64	11.27	91.52	38.62
S.Em. ±	0.44	1.16	0.14	0.39	4.5	0.08	0.38	0.56	0.09	0.83	0.21	1.86	0.05
CD at 5%	1.26	3.31	0.40	1.12	12.8	0.23	1.08	1.60	0.25	2.36	0.59	5.32	0.14

Table 2 Effect of fertility levels and biofertilizers on yield attributes and yields of cowpea

Treatments	Number of pods/plant	Number of seeds/pods	Test weight (g)	Yields (kg/ha)			Harvest index (%)
				Seed	Straw	Biological	
Fertility levels ($N:P_2O_5$ kg/ha)							
Control	15.59	8.77	57.08	684	2075	2759	24.73
10:20	19.84	9.24	59.15	877	2359	3236	27.12
20:40	22.77	9.59	60.89	1013	2611	3624	27.93
30:60	23.85	9.88	61.79	1077	2766	3843	28.03
S.Em. ±	0.38	0.10	0.38	22	64	82	0.29
CD at 5%	1.32	0.35	1.32	75	220	285	0.99
Biofertilizers							
Control	17.65	8.82	58.40	788	2196	2985	26.19
Rhizobium	20.28	9.41	59.38	906	2451	3357	26.88
PSB	19.78	9.28	59.15	883	2411	3294	26.69
Rhizobium +PSB	21.75	9.67	60.82	965	2566	3531	27.23
VAM	19.66	9.17	58.86	878	2369	3247	26.89
Rhizobium + PSB + VAM	23.94	9.87	61.76	1057	2722	3780	27.83
S.Em. ±	0.35	0.12	0.49	18	52	66	0.28
CD at 5%	1.01	0.35	1.39	50	147	188	0.79

Biofertilizer treatments showed significant influence on yield and yield attributing characters viz. number of pods/plant, number of seeds/pod and test weight, seed, straw and biological yield and harvest index (Table 2). Significantly higher number of pods/plant (23.94) was obtained under seed treatment with *Rhizobium* + PSB + VAM and proved superior over rest of treatments. Seed treatment with *Rhizobium* + PSB + VAM remained statistically at par with *Rhizobium* + PSB and recorded significantly higher values of number of seeds/pods (9.87) and test weight (61.76 g) as compared to control, *Rhizobium*, PSB and VAM. A greater number of pods/plant might result from better assimilate distribution from the source to the reproductive portions under biofertilizers. Greater partitioning of assimilates towards productive structure may have resulted from improved root development and photosynthetic assimilation in seed treated with biofertilizers, as evidenced by the increased number of branches. *Rhizobium* + PSB + VAM increased the number of pods/plant produced because the plant grew more quickly and had more branches as a result of better soil microbial activity [26-28].

Seed treatment with the *Rhizobium* + PSB + VAM obtained significantly higher seed (1057 kg/ha), straw (2722 kg/ha) and biological (3780 kg/ha) yield as compared to control, *Rhizobium*, PSB, *Rhizobium* + PSB and VAM. Phosphorus plays an important role in the plant's root development, facilitating the earlier formation of nodules, enhancing the activity of Rhizobia, increasing their numbers and enhancing the nitrogen fixation [29]. It also affects plant growth and metabolism through energy storage and transfer in the nodules and shortage of phosphorus hamper biological nitrogen fixation [30]. Combined seed treatment with Rhizobium + PSB + VAM containing biofertilizers might have improved the available nitrogen, phosphorus and potassium status of the soil by means of biological nitrogen fixation and phosphorus solubilization. Seed inoculation with biofertilizers supplied the bioactive compounds such as vitamins, hormones, and enzymes which influenced the plant metabolism [31]. The availability and optimum supply of essential nutrients such as nitrogen, phosphorus and potassium favorably influenced the plant vigor, morphology and metabolic processes, which ultimately enhanced the pods per plant and total yield of cowpea. The beneficial effects of *Rhizobium* as explained earlier thus might have increased the availability of nitrogen and phosphorus along with other nutrients which in term resulted in to higher production of assimilates and their partitioning to different reproductive structures such as yield attributes and ultimately, seed yield. The beneficial effect of phosphate solubilizing bacteria increased the availability of phosphorus and nitrogen along with other nutrients enhanced photosynthesis and production of photosynthates and their partitioning different reproductive structure which helped in improving the yield attributes (number of pods/plant, number of seeds/pod and test weight) and finally the seed yield [32-34].

CONCLUSION

On the basis of one year experimentation, it may be concluded that growth and yield of cowpea can be maximized by combined application of 20 kg/ha N + 40 kg/ha P_2O_5 along with seed inoculum with *Rhizobium* + PSB + VAM.

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