



# Growth Analysis and Response Studies in Cowpea [*Vigna unguiculata* (L.) Walp] under the Influence of PROM and Phosphatic Inoculants

Bhavna Singh Rathore <sup>a++\*</sup>, S. S. Yadav <sup>b#</sup>, Disha Joshi <sup>c++</sup>,  
Biram Singh Gurjar <sup>d†</sup> and Ram Singh Verma <sup>e†</sup>

<sup>a</sup> Department of Agronomy, SKRAU, Bikaner, Rajasthan, India.

<sup>b</sup> College of Agriculture, SKNAU, Jobner, Rajasthan, India.

<sup>c</sup> Department of Agronomy, MPUAT, Udaipur, Rajasthan, India.

<sup>d</sup> Department of Agronomy, KVK, Keshwana, Jalore-1, Rajasthan, India.

<sup>e</sup> Department of Agriculture, J.S.S Belsar, Gonda, U.P., India.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/IJPSS/2023/v35i224173

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/108215>

Original Research Article

Received: 12/09/2023

Accepted: 16/11/2023

Published: 05/12/2023

## ABSTRACT

A field experiment was carried out at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif*, 2020 on loamy sand soil which consisted four levels of PROM (control, PROM equivalent to 20 kg, 40 kg and 60 kg P<sub>2</sub>O<sub>5</sub>/ha) and four phosphatic inoculants (control, PSB, VAM and PSB + VAM). The total 16 treatment combinations were tested in factorial randomized

++ Ph.D. Scholar;

# Professor;

† Subject Matter Specialist;

† Assistant Professor;

\*Corresponding author: E-mail: bhavnasingh0409@gmail.com;

block design with three replications. Results revealed that application of PROM equivalent to 40 kg P<sub>2</sub>O<sub>5</sub>/ha significantly enhanced the dry matter accumulation at 25 DAS, CGR during 0 - 25 DAS and leaf area index over preceding levels. However, in terms of dry matter accumulation at 50 DAS and at harvest, CGR during 25 - 50 DAS and 50 DAS – at harvest, PROM equivalent to 60 kg P<sub>2</sub>O<sub>5</sub>/ha proved significantly better over lower levels. Based on response studies, application of PROM equivalent to 56.15 kg P<sub>2</sub>O<sub>5</sub>/ha corresponding with seed yield of 1084.6 kg/ha was worked out to be the optimum dose of PROM for cowpea.

**Keywords:** Cowpea, leaf area index; *Vigna unguiculata*; factorial randomized block design.

## 1. INTRODUCTION

“Cowpea [*Vigna unguiculata* (L.) Walp] is one of the important *kharif* pulse crops in India referred as *lobia* and developed for vegetable, grain, forage and green manuring. This crop has great significance due to its short duration, high yielding and rapid growing variety. Green tender pods of cowpea are utilized as vegetable. Cowpea is rich in protein, minerals and vitamins, generally preferred for its tender pods and fresh seeds but in some parts of the country, dry seeds are also consumed. Being rich in protein and containing numerous other nutrients, it is sometimes also called as ‘vegetable meat’. Cowpea seeds contain about 21.2% to 30.6% protein, 60.3% carbohydrate, 1.85 fat and is also good source of calcium, phosphorus and iron” [1]. “Being a legume, phosphorus fertilization assumes a significant part in deciding the yield of cowpea. Phosphorus is imperative constituent of nucleic acid, phosphoric acid and several enzymes. Phosphorus is the second most important nutrient next to nitrogen. Only 15-30% of applied fertilizer P is taken up by crops in the year of its application and the unutilized part is converted into insoluble phosphorus” [2]. “Phosphorus is accounted to stimulate growth, initiate nodule formation and also have an impact on the efficiency of the *Rhizobium*-legume symbiosis” [3]. “It additionally helps in flower initiation, seed and fruit development” [4].

“Phosphate Rich Organic Manure (PROM) also referred as “green chemistry phosphatic fertilizer” is an effective source of P to replace the costly chemical phosphatic fertilizers. Inoculation of legume seeds with phosphate solubilizing bacteria (PSB) enhances nodulation, available phosphorus content of the soil and root and shoot biomass. Mycorrhiza association is a symbiotic non-pathogenic association between plant roots and fungal hyphae with a fungal relation between soil and the root. Vesicular Arbuscular Mycorrhizas (VAMs) can supply

Phosphorus and Nitrogen needed by its symbiotic partner” [5]. Furthermore, under low nitrogen fertilizer inputs, availability of phosphorus is a main consideration confining the rate of N-fixation in legumes. The joint inoculation of N<sub>2</sub>-fixers, PSB and mycorrhizal fungi could be more powerful than single organism for supplying a more balanced nutrition for legume plants under conditions of decreased nutrient inputs.

## 2. MATERIALS AND METHODS

This experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif*, 2020. The Jobner is situated 45 km west of Jaipur at 26°05' N-latitude and 75°28' E-longitude and at an altitude of 427 metres above mean sea level. The region falls under Agro climatic zone III a (Semi-Arid Eastern Plains Zone) of Rajasthan. The field experiment comprised of four levels of PROM (Control, PROM equivalent to 20kg/ha, PROM equivalent to 40kg/ha and PROM equivalent to 60kg/ha) control and four phosphatic inoculants (Control, PSB, VAM and PSB + VAM) there by making 16 treatment combinations. The experiment was laid out in Factorial Randomized Block Design with three replications. In treatments PROM (10.4% P<sub>2</sub>O<sub>5</sub>) applied as basal equivalent to 20 kg, 40 kg or 60 kg P<sub>2</sub>O<sub>5</sub>/ha was applied to the soil at the time of sowing as per treatments and incorporated well in soil of the plots before sowing. “Cowpea seed was inoculated with liquid PSB culture *i.e.*, *Bacillus megatherium* @3 ml/kg seed as per routine procedure, 2-3 hours before sowing as per treatments. After seed treatment it was dried in shade. The soil based VAM (*Trichoderma viride*) containing hyphae, spores and sporocarp was incorporated into soil in crop rows at the time of sowing @5 kg/ha VAM was mixed with 8-10 kg vermi-compost as per treatment and thoroughly mixed manually in the treated plots in the furrows. Seeds of cowpea variety, RC-19 were sown on 7th July, 2020 in rows spaced at 30 cm apart at the depth of 4-5

cm with the help of 'kera' method using a seed rate of 20 kg/ha". [16]

"CGR is calculated on the basis of following formula  $CGR = (1/P) \times (W_2 - W_1) / (t_2 - t_1)$  LAI is calculated on the basis of following formula  $LAI = \text{leaf area} / \text{ground area}$ . RGR is calculated on the basis of following formula  $RGR = (1/W) (dW/dt)$ . The experimental data recorded for CGR, RGR and LAI were subjected to statistical analysis in accordance with the "Analysis of Variance" technique suggested by Fisher [6]. Appropriate standard error for each of the factor was worked out. Significance of differences among treatment effects was tested by "F" test. Critical difference (CD) was worked out, wherever the difference was found significant at 5.0 or 1.0 per cent level of significance". [5] To assess the relationship, correlation and regression coefficients between seed yield of cowpea (Y) and the independent variables (X) such as crop dry matter accumulation, yield attributes and nutrient uptake by crop were computed using the method given by Snedecor and Cochran [7]. The regression equations were also fitted and tested for significance. To describe the relationship of cowpea equivalent yield (Y) as a function of simple effect of optimum dose of PROM (X), correlation and regression studies were undertaken. Response equations were fitted to the yield to describe them mathematically. The following equation proved to be the best fit:  $Y = b_0 + b_1 X + b_2 X^2$ , Where, Y = Expected yield (kg/ha), X = Unit of PROM level (%),  $b_0$  = Constant,  $b_1$  and  $b_2$  = Regression coefficients. After fitting response curve, optimum doses of PROM was worked out using the following formula:

$$X_{opt} = \frac{Q/P - b_1}{2b_2}$$

Where,  $X_{opt}$  = Optimum level of PROM (%), P= Price of per kg seed (₹), C= cost of per unit of PROM (₹),  $b_1$  and  $b_2$  = Coefficients of response equation

### 3. RESULTS AND DISCUSSION

#### 3.1 Growth Attributes

##### 3.1.1 Effect of PROM

Application of different levels of PROM significantly improved the dry matter/plant at all the stages and growth attributes viz., CGR, RGR

and leaf area index of cowpea crop (Table 1). Application of PROM equivalent to 40 kg  $P_2O_5$ /ha attained significantly highest crop dry matter accumulation at 25 DAS (Table 1). However, it was found at par with PROM equivalent to 60 kg  $P_2O_5$ /ha. Being at par with each other, these two treatments also registered significant improvement in CGR during all the stages of crop (Table 1). On the other hand, RGR of cowpea during all the growth stages remained uninfluenced (Table 1). Significantly higher LAI was also recorded under treatment PROM equivalent to 40 kg  $P_2O_5$ /ha which was at par with PROM equivalent to 60 kg  $P_2O_5$ /ha (Table 1). Application of PROM have increased the P uptake by plants. Accelerated biological nitrogen fixation might have increased the availability of N to plants which in turn also improved the growth of cowpea in terms of biomass production. Similar findings were also reported by Shaktawat et al. [8] and Vikram and Hamzehzarghani [9] in greengram and Meena [10] in soybean.

##### 3.1.2 Effect of phosphatic inoculation

Growth parameters of cowpea like dry matter accumulation, CGR, RGR and LAI were significantly improved due to phosphatic inoculation with PSB+VAM over control. Phosphatic inoculation with PSB alone was found equally effective but significantly superior to VAM and uninoculated control (Table 1). The overall development of plant in terms of root and shoot might have resulted in more absorption of nutrients and enhanced photosynthesis and production of assimilates, which led to increased dry matter accumulation. The results obtained in present investigation are in line with the findings of Patel et al. [11], Singh et al. [12] and Bhabai et al. [13] in mungbean who recorded improvement in growth attributes parameters and nodulation due to application of microbial inoculants.

#### 3.2 Correlation and Regression

Correlation coefficients and regression equations were worked out between seed yield and various growth and yield attributes like dry matter accumulation, total nodules per plant, effective nodules per plant, fresh weight, dry weight, number of pods per plant, number of seeds per pod, test weight, protein content, total N, P and K uptake. The values calculated are presented in Table 2. The results of correlation coefficients revealed that highly significant and positive

**Table 1. Effect of varying levels of PROM and phosphatic inoculation on periodical dry matter accumulation and growth indices of cowpea**

Treatments	Dry matter/plant (g)			CGR (g/m <sup>2</sup> /day)			RGR (mg/g/day)		LAI	
	25 DAS	50 DAS	At harvest	0-25 DAS	25-50 DAS	50 DAS -At harvest	25-50 DAS	50 DAS-at harvest	25 DAS	50 DAS
<b>Levels of PROM</b>										
Control	13.52	77.03	92.45	0.54	2.54	0.62	43.51	4.55	2.35	5.21
PROM equivalent to 20 kg P <sub>2</sub> O <sub>5</sub> /ha	15.48	88.33	106.38	0.62	2.91	0.72	43.55	4.64	2.89	5.74
PROM equivalent to 40kg P <sub>2</sub> O <sub>5</sub> /ha	16.66	97.52	118.39	0.67	3.23	0.83	44.18	4.84	3.21	6.15
PROM equivalent to 60kg P <sub>2</sub> O <sub>5</sub> /ha	16.91	104.85	127.46	0.68	3.52	0.90	45.62	4.87	3.36	6.29
SEm±	0.39	2.53	2.68	0.02	0.09	0.02	1.04	0.12	0.07	0.13
CD (P=0.05)	1.13	7.30	7.73	0.05	0.25	0.05	NS	NS	0.20	0.37
<b>Phosphatic inoculation</b>										
Control	13.93	83.41	100.26	0.56	2.78	0.67	44.67	4.58	2.63	5.27
PSB	16.09	93.29	112.57	0.64	3.09	0.77	43.55	4.68	3.03	5.94
VAM	15.88	91.83	110.87	0.64	3.04	0.76	43.81	4.70	2.94	5.87
PSB + VAM	16.67	99.20	120.98	0.67	3.30	0.87	44.51	4.95	3.21	6.30
SEm±	0.39	2.53	2.68	0.02	0.09	0.02	1.04	0.12	0.07	0.13
CD (P=0.05)	1.13	7.30	7.73	0.05	0.25	0.05	NS	NS	0.20	0.37
CV (%)	8.66	9.52	8.34	9.94	9.75	8.40	8.16	8.44	8.01	7.69

**Table 2. Correlation coefficients and linear regression equation showing relationship between independent variables (X) and dependent variable (Y) in cowpea**

Dependent variable (Y)	Independent variable (x)	Correlation coefficient (r)	Regression equation (Y= a + bx)
Seed yield (kg/ha)	Dry matter at harvest	0.975**	Y = -547.123 + 13.059X <sub>1</sub>
	Total nodules per plant	0.957**	Y = -1526.098 + 128.596X <sub>2</sub>
	Effective nodules per plant	0.931**	Y = -875.266 + 127.773X <sub>3</sub>
	Fresh weight (mg)	0.976**	Y = -963.436 + 4.550X <sub>4</sub>
	Dry weight (g)	0.964**	Y = -1126.372 + 25.869X <sub>5</sub>
	Number of pods per plant	0.961**	Y = -772.313 + 119.786X <sub>6</sub>
	Number of seeds per pod	0.918**	Y = -1016.372 + 216.457X <sub>7</sub>
	Test weight (g)	0.969**	Y = -1306.425 + 27.713X <sub>8</sub>
	Protein content	0.947**	Y = -1269.542 + 128.014X <sub>9</sub>
	Total N uptake	0.998**	Y = 211.104 + 12.593X <sub>10</sub>
	Total P uptake	0.998**	Y = 239.099 + 72.822X <sub>11</sub>
	Total K uptake	0.995**	Y = 194.561 + 10.449X <sub>12</sub>

\*\* Significant at 1 per cent level of significance

correlation is existing between seed yield and yield attributes and nutrient uptake such as number of pods/plant (0.961), number of seeds/pod (0.918), dry matter accumulation ( $r = 0.975$ ), total nodules per plant ( $r = 0.957$ ), effective nodules per plant ( $r = 0.931$ ), fresh weight ( $r = 0.976$ ), dry weight ( $r = 0.964$ ), test weight (0.969), N uptake (0.998), P uptake (0.998) and K uptake (0.995) also provided an additional support for increased seed yield due to application of phosphorus (Table 2). This might

be the fact that higher seed yield was the result of excess storage of assimilates in leaves and later translocation into seeds at the time of senescence. From regression studies (Table 2), it was noted that a unit increase in number of pods/plant, number of seeds/pod, test weight and total N, P and K uptake increased the seed yield of cowpea. Similar results were also reported by Babu [14] in soybean and Singh et al. [15] in mungbean.

**Table 3. Seed yield (Y) of cowpea as a function of PROM fertilization ( $Y = b_0 + b_1X + b_2X^2$ )**

Study parameters	Values PROM
1. Partial regression coefficients	
b <sub>0</sub>	668.25
b <sub>1</sub>	10.1875
b <sub>2</sub>	-0.04938
2. Coefficient of	
(i) Determination (R <sup>2</sup> )	0.998**
(ii) Multiple correlation (R)	0.999**
3. Optimum levels of PROM PROM opt.	56.15
4. Yield at optimum level of PROM Y opt.	1084.63
5. Maximum yield at PROM Y max	1193.74
6. Response at optimum level of PROM	416.38
7. Response per unit of PROM at optimum level	7.42

Note (1) Response, yield levels of PROM intercept ( $b_0$ ) are presented in kg/ha  
(ii) Total partial regression coefficient ( $b_1$  and  $b_2$ ) are based on X units of 10 kg  
(iii) \*\* Significant at 1% level of significance

### 3.3 Response Studies

#### 3.3.1 Description of seed yield (Y) as a function of PROM levels

To describe the relationship between yield of cowpea (Y) and applied PROM levels, regression studies were undertaken. Since the main effect of PROM on yield of cowpea was found significant (Table 3), it was considered appropriate to establish a relationship describing the yield of cowpea as a function of main effect of PROM levels. Second degree polynomials describing the relationship was established by the least square as described by Croxton et al. [16]. The relationship of the type  $Y = b_0 + b_1X + b_2X^2$  describing yield as a function of PROM level derived from the observed data was curvilinear and presented in Table 3.

The yield of cowpea showed very high closeness to the observed yields as evidenced by very high coefficients of determination R<sup>2</sup> (0.999). The estimated optimum level of PROM recording the predicted yield of 1084.63 kg/ha have been worked out to be 56.15% PROM. The predicted optimum levels of PROM were worked out at prevailing market price of PROM and cowpea seed @ ₹ 58/kg. The response per unit at optimum level of PROM was 56.15 kg.

### 4. CONCLUSION

Based on the results of one year experimentation, it may be inferred that application of PROM equivalent to 40 kg P<sub>2</sub>O<sub>5</sub>/ha combined with dual phosphatic

inoculation of PSB + VAM (P<sub>40</sub>IPV) was found the most superior treatment combination for obtaining higher values of Dry matter accumulation, CGR, RGR, Leaf area index and seed yield (1230 kg/ha) in cowpea. On the basis of production function, application of PROM equivalent to 56.15 kg P<sub>2</sub>O<sub>5</sub>/ha corresponding with seed yield of 1084.6 kg/ha was worked out to be the optimum dose of PROM for cowpea.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

1. Mann HS. Pulse and our protein gap. *Annals of Arid Zone* 1975;14:1.
2. Swarup A. Lessons from long term fertilizer experiments in improving fertilizer use efficiency and crop yields. *Fertilizer News*. 2002;47(12):59-73.
3. Haruna. I.M. and Aliyu, L.. Yield and economic returns of sesame (*Sesamum indicum* L.) as influenced by poultry manure, nitrogen and phosphorus at Samaru, Nigeria. *Elixir Agriculture*. 2011;39:4884-4887.
4. Ndakidemi PA. Dakora FD. Yield Components of Nodulated Cowpea (*Vigna unguiculata* (L.) Walp) and maize (*Zea mays*) plants grown with exogenous phosphorus in different cropping systems. *Australian Journal of Experimental Agriculture*. 2007;47:587-590.

5. Rathore BS, Yadav SS, Gurjar BS, Bhawariya A, Joshi D, Yadav M, Dhayal S, Bhukhar OS. Growth and yield of cowpea influenced by PROM and phosphatic inoculants. The Pharma Innovation J. 2022;11(2):1306-9.
6. Fisher RA. Statistical Methods for Research Workers. Oliver and Boyd, Edinburg, London. 1950;57-63
7. Snedecor GW, Cochran WG. Statistical Methods. Oxford and IBH Pub. Co., New Delhi; 1968.
8. Shaktawat MS, Verma A, Mathur V. Response of greengram to PROM on farmers field. (In) Proc. of PROM Review 2004. Organized by Phosphate Research and Development Centre, Rajasthan State Mines and Mineral Limited, Udaipur. 2004; 41-46.
9. Vikram A, Hamzehzarghani H. Effect of phosphate solubilizing bacteria on nodulation and growth parameters of greengram (*Vigna radiata* L.) Wilczek. Research Journal of Microbiology. 2008; 3(2):62-72.
10. Meena H. Response of soybean to PR (34/74) incubated with non-edible oil cakes, PSB and FYM. M.Sc. (Ag.) Thesis, MPUAT, Udaipur; 2005.
11. Patel HR, Patel HF, Maheriya VD, Dodia IN. Response of *khari* greengram to sulphur and phosphorus fertilization with and without biofertilizer application. The Bioscan. 2013;8(1):149-152.
12. Singh R, Singh V, Singh P, Yadav RA. Effect of phosphorus and PSB on yield attributes, quality and economics of summer greengram (*Vigna radiata* L.). Journal of Pharmacognosy and Phytochemistry. 2018;7(2):404-408.
13. Bhabai B, Mukhopadhyay D, Mitra B. Effect of biofertilizer and phosphorus on green gram (*Vigna radiata*). Journal of Pharmacognosy and Phytochemistry. 2019;8(4):505-509
14. Babu PVR. Agronomic efficiency of phosphate rock enriched with FYM in soybean. M.Sc. (Ag.) Thesis, ANGRAU, Hyderabad (AP); 2006.
15. Singh K, Manohar RS, Choudhary R, Yadav AK, Sangwan A. Response of different sources and levels of phosphorus on yield, nutrient uptake and net returns on mungbean under rainfed condition. Indian Journal of Agricultural Research. 2015; 35(4):263-268.
16. Croxton FC, Cowden DJ, Klein S. Applied general statistics 3rd Edn. Prentice Hall of India Pvt. Ltd. New Delhi; 1973.

© 2023 Rathore et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

The peer review history for this paper can be accessed here:  
<https://www.sdiarticle5.com/review-history/108215>