__Original Research Article__

Growth analysis and Response studies in cowpea [*Vigna unguiculata* (l.) Walp] under the influence of PROM and Phosphatic Inoculants

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_2O_5/ha) and four phosphatic inoculants (control, PSB, VAM and PSB + VAM). The total 16 treatment combinations were tested in factorial randomized block design with three replications. Results revealed that application of PROM equivalent to 40 kg P_2O_5/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_2O_5/ha proved significantly better over lower levels. Based on response studies, application of PROM equivalent to 56.15 kg P_2O_5/ha corresponding with seed yield of 1084.6 kg/ha was worked out to be the optimum dose of PROM for cowpea.

Keywords: LAI, CGR, PROM, PSB, VAM, Cowpea

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 (Mann, 1975). 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 (Swarup, 2002). Phosphorus is accounted to stimulate growth, initiate nodule formation and also have an impact on the efficiency of the *Rhizobium*-legume symbiosis (Haruna and Aliyu, 2011). It additionally helps in flower initiation, seed and fruit development (Ndakidemi and Dakora, 2007).

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. 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_2-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.

Material and Method

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_2O_5) applied as basal equivalent to 20 kg, 40 kg or 60 kg P_2O_5/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 sporacarp 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.

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 = leaf area / 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, 1950). 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. 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 (1968). 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:

$$Xopt = \frac{Q/P - b_1}{\quad}$$

$$2b_2$$

Where, Xopt = 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

Result and Discussion

1. Growth attributes

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.* (2004) and Vikram and Hamzehzarghani (2008) in greengram and Meena (2005) in soybean.

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*. (2013), Singh *et al*. (2018) and Bhabai *et al.* (2019) in mungbean who recorded improvement in growth attributes parameters and nodulation due to application of microbial inoculants.

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 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 (2006) in soybean and Singh *et al*. (2015) in mungbean.

3. Response studies

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.* (1973). 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^2 (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.

Conclusion

Based on the results of one year experimentation, it may be inferred that application of PROM equivalent to 40 kg P_2O_5/ha combined with dual phosphatic inoculation of PSB + VAM ($P_{40}I_{PV}$) 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_2O_5/ha corresponding with seed yield of 1084.6 kg/ha was worked out to be the optimum dose of PROM for cowpea.

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^2/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
Levels of PROM										
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_2O_5/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_2O_5/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_2O_5/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
Phosphatic inoculation										

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**	$Y = -547.123 + 13.059X_1$
	Total nodules per plant	0.957**	$Y = -1526.098 + 128.596X_2$
	Effective nodules per plant	0.931**	$Y = -875.266 + 127.773X_3$
	Fresh weight (mg)	0.976**	$Y = -963.436 + 4.550X_4$
	Dry weight (g)	0.964**	$Y = -1126.372 + 25.869X_5$
	Number of pods per plant	0.961**	$Y = -772.313 + 119.786X_6$
	Number of seeds per pod	0.918**	$Y = -1016.372 + 216.457X_7$
	Test weight (g)	0.969**	$Y = -1306.425 + 27.713X_8$
	Protein content	0.947**	$Y = -1269.542 + 128.014X_9$
	Total N uptake	0.998**	$Y = 211.104 + 12.593X_{10}$
	Total P uptake	0.998**	$Y = 239.099 + 72.822X_{11}$

Total K uptake	0.995**	$Y = 194.561 + 10.449X_{12}$

** Significant at 1 per cent level of significance

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_0	668.25
	b_1	10.1875
	b_2	-0.04938
2. Coefficient of		
(i) Determination	(R^2)	0.998**
(ii) Multiple correlation	(R)	0.999**
3. Optimum levels of PROM PROM opt.		56.15
4. Yield at optimumlevel of PROMY 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 interceptor (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

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