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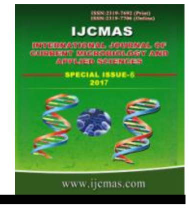

Original Research Article

Growth and Yield of Pigeonpea (*Cajanus cajan* L. Millsp) as Influenced by Phosphorus and Biofertilizer

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A B S T R A C T

The field investigation entitled "Effect of phosphorus and biofertilizers on growth, yield and economics of pigeon pea (*Cajanus cajan* L. Millsp.) under rainfed condition" was conducted at Experimental Farm, Agronomy Section, College of Agriculture, and Latur. The experimental field was leveled and well drained.). The soil was medium and black in colour with good drainage. The soil was clayey in nature and slightly alkaline (7.8) in reaction, low in nitrogen, medium in available phosphorus and rich in available potassium. The environmental conditions were favorably congenial for normal growth and maturity of pigeonpea crop. The experiment was laid out in Factorial Randomized Block Design with two factors and replicated thrice. Whereas first factor comprises levels of phosphorus *viz.* 0 (control), 40, 50 and 60 kg P ha^{-1}, second factor comprises seed inoculations with biofertilizer *viz.* alone inoculation of *Rhizobium* @ 6 ml kg^{-1} seeds, alone inoculation PSB @ 6 ml kg^{-1} seeds and dual inoculation *Rhizobium* + PSB each of @ 6 ml kg^{-1} seeds. The experimental site having gross and net plot size was 5.4 x 4.5 m^2 and 4.2 x 3.9 m^2 respectively. The application of phosphorus @ 60 kg ha^{-1} given significantly higher growth and yield attributes, gross monetary return, net monetary return and B: C ratio over the rest of the levels of phosphorus. Whereas NMR was remained at par with 50 kg P ha^{-1}. Among three biofertilizer treatments, dual seed inoculation with *Rhizobium* + PSB was recorded higher growth and yield attributes, gross monetary return, net monetary return and B: C ratio than the individual seed inoculation of *Rhizobium* or PSB.

Keywords

Pigeonpea, Phosphorus, Biofertilizer

Introduction

Pigeonpea (*Cajanus cajan* L. Millsp.) is one of the major grain legume (pulse) crop of the tropics and subtropics, endowed with several unique characteristics. It finds an important place in the farming system adopted by small holder farmer in a large number of developing countries. Although, globally pigeon pea ranks sixth in area and production in comparison to other grain legumes such as beans, peas and chickpeas, it is used in more diversified ways than other. Phosphorus is a key element involved in various function in growth and metabolism of pulses. It is frequently a major limiting nutrient for plant growth in most Indian soils. Only a part of the phosphorus supplemented through fertilizers is utilized by the plants and a large portion of it is converted into insoluble fixed forms, the recovery efficiency of phosphorus in crops of is generally 10-30% (Swarup, 2002). Phosphorus solubilising bacteria

(PSB) can play an important role in increasing phosphorus availability by solubilising the P and supplying it to plants in a more available form (Khan *et al.,* 2007).

Phosphorus deficiency in soils is usually the key factor for poor yield of pulses. Yield of pulses can significantly be increased by applying phosphorus on the basis of soil test information. Phosphorus applied to pulse crops may yield residual effect up to a limit of 20-35 kg P_2O_5 ha^{-1}. Inoculation of seeds with phosphorus solubilising organisms like PSB (phosphate solubilising bacteria) and PSF (phosphate solubilising fungi) results in increase of phosphorus use efficiency. The degree of response to applied phosphorus can further be improved management practices.

Phosphorus is an important mineral element for grain legumes as it helps in root development, participates in synthesis of phosphates and phosphoprotiens and takes part in energy fixing and releasing process in plants. Significant response of pigeon pea to phosphate nutrition has been reported by several workers (Singh and Yadav, 2008). Biofertilizers enhance soil fertility and crop yield by solubilizing unavailable sources of elemental nitrogen and bound phosphate into available forms in order to facilitate the plant to absorb them. *Rhizobium* fixes nitrogen up to 4-200 kg ha^{-1} in pigeon pea. *Rhizobium* inoculation improved nodulation, nitrogen fixation, crop growth and yield. Efficiency of bacteria is more than fungal strains. PSB substitutes 15-20 percent dose of phosphorus and this mechanism governed by phosphates production.

The term biofertilizer, represent everything from manures to plant extracts. Biofertilizers are those substances that contain living microorganisms and they colonize the rhizosphere of the plant increase the supply or availability of primary nutrient and or growth stimulus to target crop. There are numerous species of soil bacteria that colonize mainly in the rhizosphere of plants. Rhizobium belongs to family *Rhizobiaceae*, it is the symbiotic in nature, it fixes 50-100 kg ha^{-1} nitrogen with legumes only. It includes following genera*: Rhizobium, Bradyrhizobium, Sinorhizobium, Azorhizobium, Mesorhizobium and Allorhizobium*. Rhizobium is the most studied and important genera of nitrogen fixing bacteria (Odame, 1997). Phosphate solubilising microorganisms releases metabolite such as organic acid latter being converted into the soluble form (Nahas, 1996). Phosphate solubilising microorganisms dissolve soil through production of low molecular weight organic compound mainly gluconic and ketogluconic acid (Khan *et al.,* 2009)

Inoculants of efficient nitrogen fixing *Rhizobium* and phosphate solubilizing bacteria (PSB) which have established their capability in augmenting the productivity of pulses may fulfill the nitrogen and phosphorus needs considerably. The prices of inorganic fertilizers are beyond the reach of marginal farmers. Under these circumstances the present investigation is proposed to undertake entitled as "Effect of phosphorus and biofertilizers on growth, yield and economics of pigeonpea (*Cajanus cajan* L. Millsp.) under rainfed condition"

Materials and Methods

The field investigation entitled "Effect of phosphorus and biofertilizers on growth, yield and economics of pigeon pea (*Cajanus cajan* L. Millsp.) under rainfed condition" was conducted during kharif season 2016-2017 at Experimental Farm, Agronomy Section, College of Agriculture, Latur. The experimental field was leveled and well drained.). The soil was medium and black in colour with good drainage. The soil was clayey in nature and slightly alkaline (7.8) in reaction, low in nitrogen, medium in available phosphorus and rich in available potassium. The environmental conditions were favorably congenial for normal growth and maturity of pigeonpea crop.

The experiment was laid out in Factorial Randomized Block Design with two factors and replicated thrice. Whereas first factor comprises levels of phosphorus *viz*. 0 (control), 40, 50 and 60 kg P ha^{-1}, second factor comprises seed inoculations with biofertilizer *viz*. alone inoculation of *Rhizobium* @ 6 ml kg^{-1} seeds, alone inoculation PSB @ 6 ml kg^{-1} seeds and dual inoculation *Rhizobium* + PSB each of @ 6 ml kg^{-1} seeds.

The experimental site having gross and net plot size was 5.4 x 4.5 m^2 and 4.2 x 3.9 m^2 respectively. The recommended dose of fertilizer was applied at time sowing (25:50:00 NPK kg ha^{-1} where P applied as per treatments). The sowing was done on 22nd June 2016 by dibbling and harvested on 3rd January 2017. All the cultural practices were followed by as per package of practices. The yield data for seed and straw yield for all plots were collected at the end of experimentation. Processed seed sample were digested and N was determined by micro kjeldahal method as advocated by Piper (1966). Protein content was calculated by multiplying N content by the factor 6.25.

Results and Discussion

Growth parameters

The effect of different treatments was noticed on important growth parameters viz., plant height, leaf area, number of braches $plant^{-1}$, total dry matter $plant^{-1,}$ number of functional leaves, was influenced significantly due to the application of phosphorus and biofertilizer.

The application of 60 kg P ha^{-1} produced more vegetative growth in early period of crop growth. The effect of different levels of phosphorus on plant height was found to be significant and higher plant height was observed by the application of 60 kg P ha^{-1} at all the growth stages. It was remained at par with 50 and 40 kg P ha^{-1} and significantly superior over control (0 kg P ha^{-1}). The increase in plant height due to higher levels of phosphorus might be resulted towards beneficial effect of phosphorus on root proliferation, nodulation and accelerating effect of P on the synthesis of protoplasm there by plants grew taller. Similar results were reported by Kumar and Kushwaha (2006), singh and Ahlawat (2007), Singh and Yadav (2008), Kumar *et al.*, (2012), Singh and Singh (2012), Malik *et al.*, (2013) and Singh *et al.*, (2014).

The inoculation of *Rhizobium* + PSB recorded significantly the highest mean plant height (175.6 cm) followed by the individual seed inoculation of *Rhizobium* (165.8 cm) and PSB (162.6 cm). Seed inoculation of PSB found to be at par with *Rhizobium* inoculation at all growth stages. Combined seed inoculation with *Rhizobium* + PSB improved N and P status of soil and ultimately increased N and P uptake which enhance the plant growth attaining higher plant height. Similar findings reported by Singh and Yadav (2008), Singh and Singh (2012), Malik *et al.*, (2013).

Data on mean number of trifoliate functional leaves $plant^{-1}$ and leaf area $palnt^{-1}$ was revealed that these increased rapidly up to 120 DAS and decreased there after toward maturity due to leaf senescence of leaves. The application of 60 kg P ha^{-1} produced higher number of functional leaves (268.6) and leaf area plant^{-1} (4.56 dm^2) was remained at par with 50 and 40 kg P ha^{-1} and significantly superior over control. It may happen due to the major role of phosphorus in early formation of roots and shoots resulted in increase in number of leaves. The similar findings were given by Singh and Ahlawat (2007), Singh and Singh (2012) and Malik *et al.,* (2013).

The application of 60 kg P ha^{-1} was recorded higher number of branches (7.9) and found to be at par with 50 and 40 kg P ha^{-1} and significantly superior over control. Phosphorus improved the nutrient availability resulting greater nutrient uptake which might have increased the photosynthesis and translocation of assimilates to different parts for enhanced growth of number of primary and secondary branches. Similar results were confined by Singh and Sekhon (2007), Singh and Ahlawat (2007), Singh and Yadav (2008), Mahetale and Kushwaha (2011), Kumar *et al.,* (2012), Singh and Singh (2012), Malik *et al.,* (2013) and Singh *et al.,* (2014).

The application of 60 kg P ha^{-1} was recorded higher dry matter accumulation (34.9 g) and found significantly superior over without application of phosphorus.

Beneficial effect of P attributed towards root proliferation, nodulation and synthesis of protoplasm gave higher pace of dry matter accumulation. The results are in close conformity with the findings of Kumar *et al.,* (2012), Singh and Singh (2012), Malik *et al.,* (2013) and Singh *et al.,* (2014).

Yield parameters

The yield contributory attributes viz., Seed yield kg ha$^{-1,}$ seed yield plant^{-1}, test weight, straw yield kg ha^{-1} and harvest index.

The application of 60 kg P ha^{-1} recorded higher seed yield kg ha^{-1} (2613 kg ha^{-1}) followed by the application of 50 (2475 kg ha^{-1}), 40 kg P ha^{-1} (2231 kg ha^{-1}) and control (1828 kg mha^{-1}). Phosphorus plays a pivotal role in the higher yield, by stimulation of root development, energy transformation and metabolic processes in the plants, which turn, resulted in greater translocation of photosynthates towards the sink development. Ultimately the seed yield plant^{-1} was improved which resulted in higher seed yield (kg ha^{-1}) These results are in close conformity with the findings of Singh and Sekhon (2007), Singh and Yadav (2008), Deshbhratar *et al.,* (2010), Pramod *et al.,* (2012), Singh and Singh (2012), Malik *et al.,* (2013) Kumar and Singh (2014), Singh *et al.,* (2014), Aher *et al.,* (2015) and Kumar *et al.,* (2015).

The highest seed yield (kg ha^{-1}) obtained due to dual seed inoculation of *Rhizobium* + PSB (2660 kg ha^{-1}) followed by PSB (2279 kg ha^{-1}) and *Rhizobium* (1921 kg ha^{-1}). Combined effect *Rhizobium* + PSB improved N and P status of soil and ultimately increased N and P uptakes which enhanced yield attributes and yield of crop.

The results are close of conformity with the findings of Singh and Yadav (2008), Goud and Kale (2010), Subba *et al.,* (2011), Singh and Singh (2012), Malik *et al.,* (2013), Kumar *et al.,* (2015), Pandey and Kushwaha (2009), Reddy *et al.,* (2011) and Tiwari *et al.,* (2011).

The effect of phosphorus levels on mean seed yield plant^{-1} was found to be significant. The application of 60 kg P ha^{-1} had recorded highest seed yield plant^{-1} (62.5 g) followed by 50 (54.1 g), 40 (48.9 g) kg P ha^{-1} and control (40.6). Similar finding was reported by Kumar and Singh (2014), Singh *et al.,* (2014) and Aher *et al.,* (2015).

Table.1 Effect of phosphorus and biofertilizer on growth attributes of pigeonpea

Treatments	Plant height (cm)	Leaf area (dm^2)	No. of trifoliate leaves plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}
A) Phosphorus levels (kg ha^{-1})					
P_0 : Control	157.8	4.13	243.8	6.8	149.7
P_1 : 40	169.9	4.50	265.6	7.4	177.0
P_2 : 50	170.8	4.49	265.3	7.5	186.7
P_3: 60	173.8	4.56	268.6	7.9	188.1
SE m$\pm$	3.9	0.11	6.2	0.2	4.3
CD at 5 %	11.6	4.31	18.0	0.6	12.6
B) Biofertilizers					
B_1 : *Rhizobium*	162.6	4.26	251.5	6.9	165.8
B_2 : PSB	165.8	4.31	253.4	7.3	173.7
B_3 : *Rhizobium* + PSB	175.6	4.71	277.1	7.9	186.6
SE m$\pm$	3.4	0.09	5.3	0.2	3.7
CD at 5 %	10.1	0.27	15.6	0.5	10.9
Interaction (P x B)					
SE m$\pm$	6.9	0.18	10.7	0.4	7.5
C.D. at 5 %	NS	NS	NS	NS	NS
General Mean	**168.1**	**4.42**	**260.8**	**7.4**	**175.4**

Table.2 Effect of phosphorus and biofertilizer on yield attributes of pigeonpea

Treatments	Seed yield kg ha^{-1}	Seed yield plant^{-1}	Test weight (g)	Straw yield (kg ha^{-1})	Harvest index
A) Phosphorus levels (kg ha^{-1})					
P_0 : Control	1828	40.6	94.0	5684	24.33
P_1 : 40	2231	48.9	94.6	6836	24.60
P_2 : 50	2475	54.1	94.8	7564	24.65
P_3: 60	2613	62.5	94.9	8018	25.57
SE m$\pm$	63	1.4	0.40	173	-
CD at 5 %	184	4.1	NS	508	-
B) Biofertilizers					
B_1 : *Rhizobium*	1921	45.0	94.0	5991	24.28
B_2 : PSB	2279	50.1	94.7	7076	24.36
B_3 : *Rhizobium* + PSB	2660	59.5	94.9	8009	24.93
SE m$\pm$	55	1.2	0.34	150	-
CD at 5 %	159	3.5	NS	440	-
Interaction (P x B)					
SE m$\pm$	108	2.4	0.7	300	-
C.D. at 5 %	NS	NS	NS	880	-
General Mean	**2287**	**51.5**	**94.6**	**7026**	**24.63**

The mean seed yield plant^{-1} was found to be significant due to biofertilizer inoculations. The dual inoculation of *Rhizobium* + PSB produced highest mean seed yield plant (59.5 g) followed by alone seed inoculation PSB (50.1 g) and *Rhizobium* (45.0 g).

The effect of biofertilizer inoculation on mean test weight was not evident significant as test weight is a genetic character of pigeonpea variety (BSMR-853). However the highest test weight recorded by combined seed treatment of *Rhizobium* + PSB (94.9 g) as compared to individual seed inoculation of PSB (94.7 g) and *Rhizobium* (94.0 g).

The application of 60 kg P ha^{-1} produced higher straw yield (8018 kg ha^{-1}) than rest of phosphorus levels that was 50 (7564 kg ha^{-1}), 40 kg ha^{-1} (6836 kg ha^{-1}) and control (5684 kg ha^{-1}). Higher dose of phosphorus is significantly higher pace of growth in the plots enjoying surplus of phosphorus. Similar findings was reported by Kumar and Kushwaha (2006), Singh and Yadav (2008), Deshbhratar *et al.*, (2010), Mahetele and Kushwaha (2011), Kumar *et al.*, (2012), Singh and Singh (2012), Kumar and Singh (2014), Singh *et al.*, (2014) and Kumar *et al.*, (2015).

The straw yield was significantly influenced by biofertilizer inoculations. Maximum straw yield was obtained by dual seed inoculation of *Rhizobium* + PSB (8009 kg ha^{-1}) than alone inoculation of PSB (7076 kg ha^{-1}) and *Rhizobium* (5991 kg ha^{-1}). Similar results were reported by Singh and Yadav (2008), Singh and Singh (2012), Kumar *et al.*, (2015), Pandey and Kushwaha (2009).

The highest harvest index was obtained (25.57%) by application of 60 kg P ha^{-1} but differences between the harvest index was nearly same at all treatments. The results are close conformity to the findings of Mahetele and Kushwaha (2011), Singh and Singh (2012) and Ahet *et al.*, (2015).

Data on harvest index was shown that the there was no any significant effect by inoculation with biofertilizer. Dual seed inoculation of *Rhizobium* + PSB was recorded the highest harvest index (24.93%) followed by individual inoculation PSB (24.36%) and *Rhizobium* (24.28%). This may be happens due to the increased economic yield in comparison with biological yield. Increase in economic yield due to more availability of N and P. These results are close of conformity with the findings of for *Rhizobium* and PSB inoculation by Sing *et al.*, (1978) and Mahetele and Kushwaha (2011) respectively.

References

A.O.A.C 1975. Official Methods of Analysis in the association of Official Agricultural Chemist (A.O.A.C.), 12th Edn. Assoc. Official Agril. Chemist., Washington, D.C. pp: 564-596.

Anonymous, 2015 E-pulses data book, Indian Institute of Pulses Reasearch ICAR, India.

Deshbhratar, P.B., Singh, P.K., Jambhulka, A.P. and Ramteke, D.S. 2010. Effect of sulphur and phosphorous on yield, quality and nutrient status of pigeonpea *(Cajanus cajan) J. of Environ. Bio*. 31(6):933-937.

Gaud, V.V. and Kale, H.B. 2010. Productivity and profitability of pigeonpea under different sources of nutrients in rainfed condition of central India *J. of food Legumes*. 23 (3&4): 212-217.

Khan, A.A., Jilani, G and Akhtar, M.S. 2009. Phosphorus solubilising bacteria: occurance, mechanism and their role in crop production. *J. Agric. Biol. SCI.* 1:48-52.

Khan, M.S., Zaidi, A and Wani, P.A. 2007. Role of phosphate-solubilising micro-organisms in sustainable agriculture-A Review. *Agronomy for sustainable Development* 27:29-43.

Kuamr Sandeep, Tomar Tejveer Singh, Tomar Savita and Singh Subey, 2015. Effect of phosphorus and biofertilizers in pegeonpea and its residual effect on the productivity of wheat under pigeonpea-wheat cropping system. *Ann. Agric. New Series Vol.* 36 (1) 38-43.

Kumar Subhodh and Singh, B.P. 2014. Productivity and profitability of pigeon pea (*Cajanus cajan* L. Millsp.) genotypes as influenced by phosphorous and sulphur fertilization. *The J. of Rural and Agril. Res*. 14 (1): 23-27.

Kumar Sudhir, Tomar Jaibir, Kishore Raj Giri, Kumar Arvind and Singh Subodh. 2012. Effect of phosphorus and sulphur on growth and yield of pigeonpea (*Cajanus cajan*). *Advance Research J. of crop improvement Vol.* 3(3) 50-52.

Mahetele Devendra and Kushwaha, H.S. 2011. Productivity and profitability of pigeon pea as influenced by FYM, PSB and phosphorus fertilization under rainfed condition J. *of Food Legumes*. 24(1): 72-74.

Malik, Singh Jitendra Kumar, Thenua Ravindra, O.V.S. Kumar and Anil 2013. Response of Pigeonpea (*Cajanus cajan*) + Mungbean (*Phaseolus radiatus*) intercropping system to phosphorus and biofertilizers. AGRIS 36(4): 323-330.

Nahas, E. 1996. Factor determining rock phosphate solubilisation by microorganisms isolated from the soil. *World. J. Microb. Biotechnol* 12:18-23.

Pandey, R. and Kushwaha, H.S. 2009. Integrated nutrient management for sustaining the productivity of pigeonpea (*Cajanus cajan*) based intercropping systems under rainfed condition. *Indian J.of Food Legume Vol.22* (4): 304-305.

Pramod kumar, Rana, K.S. and Rana, D.S. 2012. Effect of planting systems and phosphorus with biofertilizers on the performance of sole and intercropped pigeonpea (*Cajanus cajan)* under rainfed conditions. *Indian J. of Agronomy*; vol.57 (2).

Reddy, A.S., Babu, S.R. Reddy, M.C.S., Khan, M.M. and Rao, M.M. 2011. Integrated nutrient management in pigeonpea (Cajanus cajan). Int. J. of Applied Bio. Pharm. Tech. Vol.2 (2): 476-480.

Singh Amitesh Kumar and Singh, R.S. 2012. Effect of phosphorus levels and yield of long duration pigeon pea (*Cajanus cajan* Millsp.) *J. of Food Legumes* 25(1): 73-75.

Singh Guriqbal and Sekhon, H.S., 2007. Effect of phosphorus and sulphur application on yield and yield attributing characters in pigeon pea-wheat cropping system *J. of Food Legumes* 20(2): 212-213.

Singh, P.K., Subodh Kumar, Arvind Kumar and Sachin Kumar, 2014. Effect of phosphorus and sulphur fertilization on growth, yield, nutrient uptake, their recovery and use efficiency by pigeonpea (*Cajanus cajan* Millsp.) genotypes *Asian J. of Bio. And Life Sci*.: 70-76.

Singh, R.S. and Yadav, M.K, 2008. Effect of phosphorus and biofertilizers on growth, yield and nutrient uptake of long duration pigeon pea under rainfed condition *J. of Food Legumes* 21(1): 46-48.

Subba Rami Reddy, A., Babu Sateesh, J., Reddy Chandra Sekhar M., Khan Mujeeb an Md., Rao Murali M. 2011. Integrated Nutrient Management in pigeonpea (*Cajanus cajan* Millsp.). *Int. J. of Applied Bio. and Pharamceutical Tech.* 02(2):467-470.

Swarup, A. 2002. Lessons from long term fertilizers experiments in improving fertilizer use efficiency and crop yields. *Fertilizer news*, 47(12): 59-73.

Tiwari, D., Sharma, B.B. and Singh, V.K., 2011. Effect of integrated nutrient management in pigeonpea based intercropping system. *J. of Food Legume*. 24 (4): 304-305.