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Effect of phosphorus and biofertilizer on root nodulation and yield of pigeonpea (*Cajnus Cajan* L.)

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Abstract

A field experiment was conducted during rainy seasons of 2013-14 and 2014-15 at the Rajola Research Farm, Faculty of Agricultural Sciences, Department of NRM, Mahatma Gandhi Chitrakoot Gramodaya Vishwa Vidyalaya, Chitrakoot – Satna, Madhya Pradesh, India to study the effect of phosphorus levels in combination with biofertilizers on root nodulation of pigeonpea *Cajanus cajan* L.) Variety UPAS-120. Application of phosphorus up to P_{90} resulted in maximum root nodules (11.64 plant^{-1}), fresh and dry weight of nodules (962.2 and 257.2 mg plant^{-1}), respectively similarly, *Rhizobium* + PSB biofertilizers also produced lower root nodules (11.25 plant^{-1}), fresh and dry weight of nodules (959.7 and 252.6 mg/plant), respectively as well as fresh and dry weight of roots (13.23 and 1.80 g plant^{-1}, respectively) and the maximum seed yield was 16.1 (q ha^{-1}.).

Keywords: Biofertilizers, pigeonpea, root nodulation, phosphorus, *Rhizobium* and PSB

Introduction

Pulse crops contribute significantly to human nutrition, provide high quality fodder and enrich the soil fertility through diazotrophy (biological nitrogen-fixation). In India, pigeonpea occupies 3.93 million hectare area with 2.84 million tonnes production and an average productivity of 722 kg ha^{-1}. Madhya Pradesh is major producer of pigeonpea sharing 10.46% of the total production. Madhya Pradesh occupies 0.46 million hectare area with 0.33 million tonnes production and an average productivity of 716 kg ha^{-1}, which was less than national average productivity (G.O.I., 2015-16). Phosphorus (P) is one of the essential plant nutrients and plays an important role in nitrogen fixation of leguminous crops. It's increased the root growth and thus, it helps in absorption of different plant nutrients. In legumes, it also helps in better nodulation, which might result in more nitrogen fixation in plant roots. It is concerned, with the formation of meristmatic tissue and plays a fundamental role in number of enzymatic reactions. It is an essential component of DNA, RNA, which is needed for protein synthesis. It also plays a major role in energy transfer system (ADP, ATP). Obviously, phosphorus is essential for numerous metabolic processes. According to Deo and Khaldelwal (2009) Phosphorus is a key nutrient for increasing productivity of pulses and the most important single factor responsible for poor productivity of pulses. Phosphorus requirement per tonne yield production can be taken as 10 kg for cereals, 14 kg for grain legumes (Pulses) and 24 kg for oilseed (Tandon, 1987). Legumes are very important not only as food crops but possess high propensity to grow in depleted soils thereby serving as a medium of fertilizing succeeding crops through their unique symbiotic capability with nitrogen fixing Rhizobium bacteria which are inhabited in root nodules of the legumes, and the nitrogen balance in the soil is thereby preserved. Pigeonpea forms root nodules in association with Rhizobium sp. bacteria and is capable of fixing 41 to 280 kg/ha of nitrogen.

Material and methods

The experiment was conducted during two kharif (rainy) seasons of 2013-14 and 2014-15 at the Rajola Krishi Research Farm, Faculty of Agricultural Sciences, Mahatma Gandhi Chitrakoot Gramodaya Vishwa Vidyalaya, Chitrakoot – Satna, Madhya Pradesh, India. The soil of the field was sandy-loam having pH 7.7-7.8, electrical conductivity 0.28 to 0.30 dS/m, organic carbon 0.33-0.34%, available N 205 to 208.8 kg/ha, P2O5 15.38 to 16.44, K2O 237.6 to 242.0 kg/ha in both years. The treatments comprised four phosphorus levels (0, 30, 60 and 90 kg/ha) and four treatments of biofertilizers (no biofertilizer, Rhizobium, PSB and Rhizobium+ PSB alone as well as in combination). Thus, the sixteen treatment combinations were laid out in the field in a factorial randomized block design keeping three replications. Pigeonpea variety UPAS-120 has sown @ 15 kg seeds/ha in rows 60 cm apart on 21st July in 2013 and 2014. A uniform dose of 20 kg N and 20 kg K2O/ha was applied through urea and

MOP as basal in all the treatments in 60 cm apart open furrows just before sowing of seed on the same furrow. Among the phosphorus levels all were applied as basal through single superphosphate having 16% P2O5. Seed will have treated with Thirum fungicides @ 3 g/kg seed and Rhizobium biofertilizer @ 20 g/kg seed at the time of before sowing, with as per treatment. The PSB (Phosphate-solubilizing bacteria) biofertilizer was also applied in the same furrows @ 20 g/kg seeds mixed with farm yard manure in third treatment. The fourth treatment was the combined application of both the biofertilizers in furrows. The pigeonpea was grown as per recommended package of practices. Seed protein was estimated by multiplying % N content with 6.25 [A. O. A. C. (1997]. Three plants at random were uprooted from each plot causing minimum damage to the roots at flowering stage of the crop. The roots were thoroughly washed with a jet of water, and then nodules were removed from the roots with the help of forceps. The effective root nodules were counted and data recorded for three plants uprooted from the each plot. The fresh weight of nodules and roots were recorded with balance thereafter, these roots and nodules were dried separately at 50-700C for 2 - 3 days. Then oven dry weight of roots and nodules were recorded.

Results and discussion

The perusal of two years data indicate that the formation of root-nodules/plant was found to stimulate significantly due to applied phosphorus levels and biofertilizers. The treatment interactions were found to be non-significant (Table-1) the highest phosphorus level (P90) brought about maximum root-nodules (11.6/plant) which was significantly superior to rest of the phosphorus levels in both the years. As regards with the biofertilizer treatments, Rhizobium + PSB resulted in significantly highest root-nodules (11.3/plant) being significantly superior to the other treatments. The second best treatment was Rhizobium biofertilizer alone. PSB applied alone also exerted less influence. The lowest 7.0 nodules/plant were formed in control treatment. The treatment interactions were found to be non-significant however, P90 with combination of two biofertilizers). The P-levels and biofertilizer treatments exerted significant influence upon the fresh and dry weight of root nodules as well as roots/plant. However the treatment interactions were found to be almost non-significant in case of fresh and dry weight of roots. The increasing P-levels only up to P60 brought about significant rise in all these parameters. Further increase in P-level up to P90 resulted in almost non-significant rise in these parameters as compared to P60. Thus the maximum pooled values in case of P90 were 962.2 mg fresh weight and 257.2 mg dry weight of root nodules/plant. Similarly, fresh and dry weights of roots were 13.89 and 1.89 g/plant, respectively. All these values were closely followed by P60. Dual biofertilizers registered significantly higher fresh and dry weight of root nodules and roots/plant as compared to the single biofertilizers and control treatments. The respective values were 959.7 and 252.3 mg, 13.23 and 1.80g/plant. As already stated the treatment interactions were almost non-significantly in case of root weight however, the maximum fresh and dry weight of root

Table 1: Effect of phosphorus levels and biofertilizers on root nodulation and root growth in two subsequence years and pooled value

Treatments	Number of Nodules/plant			Nodules fresh weight (mg/plant)			Nodules dry weight (mg/plant)			Root fresh weight (g/plant)			Root dry weight (g/plant)			Seed yield (q/ha)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Phosphorus levels (kg/ha)																		
Control	7.6	7.8	7.7	649.0	709.7	679.3	165.4	188.8	177.1	6.5	8.0	7.3	1.0	1.0	1.0	10.5	10.2	10.3
P_{30}	9.1	10.1	9.6	835.6	877.5	856.5	212.2	233.4	222.8	8.5	10.4	9.5	1.3	1.3	1.3	12.8	14.1	13.5
P_{60}	9.8	10.6	10.2	907.9	946.3	927.1	234.3	261.2	247.7	12.6	14.3	13.5	1.8	1.8	1.8	15.4	16.3	15.8
P_{90}	11.4	11.9	11.6	930.4	993.9	962.2	240.1	274.3	257.2	12.7	15.1	13.9	1.8	1.9	1.9	15.7	16.4	16.1
CD P=0.05)	0.5	0.4	0.4	87.2	60.3	51.4	21.1	16.3	12.6	0.9	1.0	0.7	0.1	0.1	0.1	0.8	0.7	0.5
Biofertilizers																		
Control	7.0	7.4	7.2	675.0	726.4	700.7	174.8	197.6	186.2	8.0	9.3	8.7	1.2	1.2	1.2	11.7	12.4	12.0
Rhizobium	9.9	10.5	10.2	842.1	926.5	884.3	217.2	251.3	234.3	9.8	11.3	10.6	1.4	1.5	1.4	13.1	14.1	13.6
PSB	10.1	10.9	10.5	845.2	915.8	880.5	215.4	248.6	232.0	10.8	12.5	11.6	1.5	1.6	1.6	14.3	14.7	14.5
Rhi+PSB	10.9	11.6	11.3	960.7	958.7	959.7	244.6	260.1	252.4	11.8	14.6	13.2	1.7	1.9	1.8	15.2	15.9	15.6
CD (P=0.05)	0.5	0.4	0.4	87.2	60.3	51.4	21.1	16.3	12.6	0.9	1.0	0.7	0.1	0.1	0.1	0.8	0.7	0.5
PxB Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

nodules and roots/plant were observed in case of P60 or P90 with dual biofertilizers. That means in case of root nodules weight, P90 + Rhiz + PSB performed the best, whereas in case of roots weight P60 + Rhiz + PSB gave the maximum weight.

The grain yield of pigeonpea variety, UPAS-120 was found to deviate significantly in both the years due to phosphorus levels and biofertilizer treatments but not due to their interactions. The higher phosphorus level only up to P60 increased the grain yield significantly (15.4 to 16.3 q/ha) over the preceding P-levels. The yield remained at par with P90. The lowest yield was found to be 10.2-10.5 q/ha in case of P0 (control treatment). That means the increase in yield was 4.88 to 6.08 q/ha due to P60 over P0 in both the years amongst the biofertilizers treatments, dual biofertilizers brought about highest grain yield (15.23 to 15.90q/ha), being significantly superior to all the remaining biofertilizer treatments. The increase in grain yield due to dual biofertilizers was 3.52 to 3.55 q/ha over control treatment. The treatment combinations were found to be non-significant. However, dual biofertilizers with higher levels of phosphorus further raised this parameter. Rhizobium + PSB biofertilizers with P60 to P90 resulted in equally highest pooled grain yield from 15.6 to 16.1 q/ha over all the remaining treatments. On the other hand, the lowest grain yield (10.3 to 12.0 q/ha) was recorded from P0 without biofertilizer treatment (absolute control) in both the years.

Conclusion

To study the effect of phosphorus levels in combination with biofertilizers on root nodulation of pigeonpea Cajanus cajan L.) Variety UPAS-120. Application of phosphorus up to P90 resulted in maximum root nodules (11.64/plant), fresh and dry weight of nodules (962.2 and 257.2 mg/plant), respectively similarly, Rhizobium + PSB biofertilizers also produced lower root nodules (11.25/plant), fresh and dry weight of nodules (959.7 and 252.6 mg/plant), respectively as well as fresh and dry weight of roots (13.23 and 1.80g/plant, respectively). The maximum seed yield was 16.66 (q/ha.)

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