Indian Journal of Agricultural Sciences **88** (10): 1593–6, October 2018/Article

Influence of bio-inoculant mediated organic nutrient management on productivity and profitability of pigeonpea (*Cajanus cajan*) in a semi-arid agro-ecology

GAURENDRA GUPTA[1], SHIVA DHAR[2], ANCHAL DASS[3], V K SHARMA[4], RAMESH K SINGH[5], ADARSH KUMAR[6], DINESH JINGER[7] and AMIT KUMAR[8]

ICAR–Indian Agricultural Research Institute, New Delhi 110 012

Received: 18 June 2018; Accepted: 11 July 2018

ABSTRACT

An experiment was conducted at ICAR–Indian Agricultural Research Institute, New Delhi during *kharif* season of 2016 and 2017 to study the influence of bio-inoculants (BI) mediated nutrient management on yield attributes, yields and economics of pigeonpea [*Cajanus cajan* (L.) Millsp.]. Experiment was conducted in randomized block design (RDB) with three replications consisting of nine nutrient management treatments, viz. Control, RDF (30: 60: 40 NPK), RDF + Bio-inoculant (BI), Vermicompost-VC (5 t/ha), FYM (5 t/ha), Leaf compost-LC (5 t/ha), VC + BI, FYM + BI and LC + BI. *Rhizobium leguminosarum*, PSB (*Pseudomonas putida*, *Pseudomonas striata*, *Bacillus subtilis*, *Bacillus megaterium*) and potassium solubilizers (*Bacillus mucilagenosus* and *Frateuria aurantia*) were used as bio-inoculants for seed treatment. Results indicate that BI mediated nutrient management significantly increased the pods/plant. Combined effect of inoculation and organic sources of nutrients was significantly higher while inoculation with RDF remained non-significant over sole organic sources of nutrients as well as RDF. Application of FYM with BI produced highest pods/plant, grains/pod and test weight. Application of FYM with BI produced highest seed (1.6; 1.7 t/ha), stover (6.33; 6.5 t/ha) and biological yields (7.93, 8.22 t/ha) respectively during 1st and 2nd year which was at par with yield under plots applied with vermicompost and BI. Gross returns, net returns and B: C were significantly affected by the treatments. Application of FYM with BI gave higher gross returns, net returns and B: C. Overall, Significantly higher pigeonpea productivity and profitability was achieved with organic nutrient source + BI over their sole application.

Key words: Bio-inoculants, Economics, Organic nutrient sources, Pigeonpea, Yield

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is cultivated over 3.88 m ha area with the production of 4.32 mt making India a world leader with a share of 74% and 63% in terms of area and production, respectively (Choudhary *et al*. 2015). India has made spectacular breakthrough in production and consumption of fertilizers during last four decades. However, the imbalanced and continuous use of chemical fertilizers in intensive cropping system has led to reduction in the crop yields and resulted in imbalance of nutrients in soil which has adverse effect on soil physico-chemical properties (Rahi and Choudhary 2014, Pawar *et al*. 2015). Use of organics build up the soil humus improving the soil physical and biological properties (Paul *et al*. 2016). Therefore, organic nutrient management systems are needed to maintain agricultural productivity and protect the environment. Sole fertilizer use cause leaching and runoff of nutrients, especially nitrogen (N) and phosphorus (P), leading to environmental degradation (Dass *et al*. 2014). Bio-inoculants are important components of integrated nutrients management which can reduce the ill effects of sole application of chemical fertilizers. These potential bio-inoculants would play key role in productivity and sustainability of soil and also protect the environment as eco-friendly and cost-effective inputs for the farmers (Pawar *et al*. 2015). But use of organics alone does not result in spectacular increase in crop yields due to their low nutrient content and also availability during initial 3 years (Sharma *et al*. 2010). The organic manure and biofertilizers on the otherside provide a good substrate for crop growth and

[1]Ph D Student (e mail: guptagaurendra@gmail.com), Division of Agronomy; [2]Principal Scientist (e mail: drsdmisra@gmail.com), Division of Agronomy; [3]Principal Scientist (e mail: anchal_d@rediffmail.com), Division of Agronomy; [4]Principal Scientist (e mail: vksharma.iari@gmail.com), Division of SSAC; [5]Ph D Student (e mail: rksv1990@gmail.com), Division of Agronomy; [6]Ph D Student (e mail: adarsh20149@gmail.com), Division of Agronomy; [7]Ph D Student, (e mail: dineshjinger28@gmail.com), Division of Agronomy; [8]Ph D Student (e mail: amitkumaricar13@gmail.com), Division of Agronomy.

favourable nutrient supply environment to the crops (Choudhary *et al*. 2010). Balanced and efficient fertilizer application, combining inorganic fertilizers, organics and biofertilizers are essential in realizing the higher yield and reducing cost of crop production (Dass *et al.* 2014). Since, organic manures are the storehouse of all essential nutrients besides providing substrate for other bio-inoculants (Choudhary and Suri 2018). Thus, the basic concept of integrated nutrient management is to supply the required essential plant nutrients for sustaining the desired crop productivity with minimum deleterious effect on soil health environment (Suri and Choudhary 2013). Moreover, there is a dire need to enhance the pulse production to ensure the food and nutritional security *vis-à-vis* agricultural sustainability in the country by employing advanced production technologies (Choudhary 2013, Choudhary and Suri 2014). Thus, present investigation dealt with the effect of judicious use of inorganic and organic nutrient inputs on crop productivity and profitability of pigeonpea crop.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* seasons of 2016 and 2017 at the research farm of ICAR-IARI, New Delhi [28.40°N latitude; 77.12°E longitude; 229 m altitude]. Crop experienced the mean maximum temperature 34.3 and 33.5°C, mean minimum temperature 22.8 and 22.1°C, total rainfall 665.8 and 707.4 mm during 2016 and 2017 respectively. The soil of experimental site was sandy clay loam in texture, low in organic carbon (0.40%) and $KMnO_4$ oxidizable N (164.5 kg/ha), medium in 0.5 N $NaHCO_3$ extractable P (14.5 kg/ha), high in 1.0 N NH_4OAC extractable K (292.5 kg/ha) and slightly alkaline in reaction (pH 7.8). Nine nutrient management treatments, viz. Control, recommended dose of fertilizers (RDF) (30: 60: 40 NPK), RDF + Bio-inoculant (BI), Vermicompost (VC) (5 t/ha), FYM (5 t/ha), Leaf compost (LC) (5 t/ha), VC + BI, FYM+ BI and LC+ BI were compared in randomized block design and replicated thrice. At the time of field preparation, the recommended dose of fertilizers (30:60:40 kg N, P_2O_5 and K_2O/ha), FYM (5 t/ha), VC (5 t/ha), LC (5 t/ha), Biofertilizers (2.5 packet each of *Rhizobium* and PSB and one bottle of K solubilizers) were assigned as per treatment. NPK were supplied basally through urea, diammonium phosphate and muriate of potash, respectively. Pigeonpea seeds were treated with *Rhizobium*, PSB @ 25 g/kg seed and K solubilizing microbes @ one liquid bottle of 5 ml/kg seed. For weed management, pendimethalin 30 EC @ 0.9 kg/ha as pre-emergence was applied and one hand weeding was carried out at 45 DAS. The crop was sprayed with dimethoate 30 EC (Rogor) @ 250 ml a.i./ha (0.025%) and monocrotophos @ 300 ml a.i./ha (0.03%) to control insect-pests. Zineb (0.2%) was applied to control certain fungal diseases like leaf spot. Crop was harvested, dried and threshed and the observations were recorded using standard procedures (Rana *et al*. 2014). The data were analyzed statistically following standard procedure (Rana *et al*. 2014).

RESULTS AND DISCUSSION

Yield attributes

Bio-inoculant mediated nutrient management significantly affected the pods/plant among the yield attributes, whereas the grains/pod and test weight were non-significantly affected due to different treatments during both the years of experiment (Table 1). Application of FYM along with biofertilizers has resulted in highest number of pods/plant of pigeonpea which was at par with the application of vermicompost (VC) + BI during both the years of experiment. Effect of BI with RDF as well as with organic sources on pods/plant was found significant over sole application of RDF and organic sources. Among organic sources of nutrients, FYM followed by VC and leaf compost (LC) under both, inoculated as well as un-inoculated have resulted in higher pods/plant. The enhancement in yield attributing characters might be due to improved microbial activity in the rhizosphere with the application of organic manure and biofertilizer in conjunction which resulted in balanced nutrient supply, good microbial activity, optimum moisture availability, anti-pathogenic activity resulting in better growth, yield attributes and yield (Reddy *et al.* 2011). *Rhizobium* helps in faster root nodulation and facilitates nitrogen fixation in the roots of the plant while phosphate solubilizing bacteria solubilize applied and native unavailable-P into available forms for improvement in growth and yield (Suri and Choudhary 2013). Pandey *et al*. (2015) also reported that seed inoculation with biofertilizers was superior to un-inoculated treatments with respect to yield-contributing characters. Inoculation of pigeonpea crop with biofertilizers and FYM significantly affected the yield attributes such as pods/plant, seeds/pod and test weight compared to sole FYM and RDF treatments (Sharma *et al.* 2012).

Yield

Influence of different BI mediated nutrient management treatments on seed, stover and biological yields was

Table 1 Effect of bio-inoculant mediated nutrient management on yield attributes of pigeonpea

Treatment	Pods/plant		Grains/pod		Test weight (g)	
	2016	2017	2016	2017	2016	2017
Control	51	49	2.6	2.6	69.2	70.3
RDF (30: 60: 40 NPK)	82	86	3.6	3.5	71.8	72.1
RDF + BI	95	102	3.8	3.4	72.0	72.5
Vermicompost (5 t/ha)	96	105	3.4	3.6	73.0	72.7
FYM (5 t/ha)	79	83	3.4	3.4	69.8	71.2
Leaf compost (5 t/ha)	65	66	3.3	3.4	68.8	69.4
Vermicompost + BI	109	121	3.7	3.6	72.8	74.1
FYM + BI	112	124	3.5	3.8	73.6	75.6
Leaf compost + BI	81	85	3.7	3.5	70.9	71.3
SEm±	4	5	0.4	0.2	1.2	1.3
CD (P= 0.05)	12	15	NS	NS	NS	NS

Table 2 Effect of bio-inoculant mediated nutrient management on seed, stover and biological yield of pigeonpea

Treatment	Seed yield (t/ha)		Stover yield (t/ha)		Biological yield (t/ha)		Harvest index (%)	
	2016	2017	2016	2017	2016	2017	2016	2017
Control	0.84	0.83	3.34	3.70	4.18	4.53	20.1	18.5
RDF (30: 60: 40 NPK)	1.23	1.32	5.09	5.60	6.32	6.92	19.5	19.1
RDF + BI	1.40	1.45	5.57	5.70	6.97	7.15	20.1	20.3
Vermicompost (5 t/ha)	1.42	1.47	5.63	6.11	7.04	7.58	20.1	19.4
FYM (5 t/ha)	1.19	1.24	4.40	5.07	5.59	6.31	21.3	19.6
Leaf compost (5 t/ha)	1.02	1.00	4.43	4.33	5.45	5.33	18.7	18.8
Vermicompost + BI	1.59	1.68	6.13	6.30	7.71	7.98	20.5	21.1
FYM + BI	1.60	1.71	6.33	6.51	7.93	8.22	20.2	20.8
Leaf compost + BI	1.20	1.28	4.67	5.21	5.87	6.50	20.4	19.8
SEm±	0.05	0.06	0.15	0.17	0.17	0.20	0.7	0.7
CD (*P*= 0.05)	0.16	0.19	0.44	0.51	0.52	0.59	NS	NS

significant while, on harvest index, it was non-significant during both the years (Table 2). FYM along with BI has produced highest seed, stover and biological yield of pigeonpea which was at par with yields under VC + BI. Effect of BI with organic sources on seed, stover and biological yields was found significant over sole application of organic sources of nutrients. However, BI effect on seed, stover and biological yields at RDF was significant during first year while, non-significant during second year of experiment. Among the BI organic treatments, FYM+BI followed by VC+BI and LC+BI application have resulted in higher seed, stover and biological yields of pigeonpea. However, among the sole organic sources of nutrients, VC followed by FYM and leaf compost has resulted in higher seed, stover and biological yields of pigeonpea. The increase in grain yield under inoculated treatments over un-inoculated may be attributed to vigorous root development, better N fixation and better development of plant growth leading to better development of yield attributes and finally higher grain yield. Paul *et al*. (2016) reported also an increase in pigeonpea yield by application of FYM and bio-inoculants as compared to un-inoculated treatments. Similarly, Sharma *et al*. (2012) and Rathod *et al.* (2015) revealed that combined inoculation of *Rhizobium* + PSB + plant growth promoting rhizobacteria and FYM out-performed in terms of yield attributes and seed yield over both control and sole FYM.

Use of VC, FYM and LC in absence of bio-inoculants could produce only 1.42, 1.19, and 1.02 t/ha (first year) and 1.47, 1.24 and 1.0 t/ha (second year) seed yield, respectively, indicating that organics applied alone might not fully support high productivity levels. However, when the bio-inoculants were applied in conjunction with VC, FYM and LC, the respective seed yield was improved and attained the beneficial productivity level. The rate of increase in seed yield under inoculated VC, FYM and LC treatment over the un-inoculated VC, FYM and LC treatment was 11.9, 34.2 and 17.6% (first year) and 14.2, 37.9 and 28.0% (second year), respectively. Highest pigeonpea yield was registered under FYM+BI because of annual carbon and nutrient inputs were relatively higher in treatments involving FYM which resulted in good fruiting ability that results higher pods/plant and ultimately higher yield.

Table 3 Effect of bio-inoculant mediated nutrient management on economics of pigeonpea

Treatment	Cost of cultivation ($\times 10^3$ ₹/ha)		Gross returns ($\times 10^3$ ₹/ha)		Net returns ($\times 10^3$ ₹/ha)		B: C	
	2016	2017	2016	2017	2016	2017	2016	2017
Control	25.5	26.3	48.9	52.8	23.4	26.6	1.92	2.01
RDF (30: 60: 40 NPK)	29.9	31.0	72.5	83.2	42.6	52.1	2.42	2.68
RDF + BI	30.1	31.2	81.9	90.6	51.8	59.4	2.72	2.90
Vermicompost (5 t/ha)	50.5	51.3	82.8	92.4	32.3	41.1	1.64	1.80
FYM (5 t/ha)	35.5	36.3	68.7	77.6	33.3	41.3	1.94	2.14
Leaf compost (5 t/ha)	45.5	46.3	60.4	63.2	14.9	16.9	1.33	1.37
Vermicompost + BI	50.7	51.4	92.1	104.3	41.4	52.9	1.82	2.03
FYM + BI	35.7	36.4	93.5	106.3	57.8	69.8	2.62	2.92
Leaf compost + BI	45.7	46.4	69.8	80.4	24.1	33.9	1.53	1.73
SEm±			2.8	3.5	2.8	3.5	0.08	0.10
CD (*P*= 0.05)			8.5	10.6	8.5	10.6	0.23	0.30

Economics

Economic parameters, viz. gross returns, net returns and B: C were affected significantly due to different treatments. Highest cost of cultivation (₹ 50.7×10^3 and 51.4×10^3/ha during 2016 and 2017, respectively) incurred under VC + BI treatment which might be due to relatively higher cost of VC. FYM + BI treatment resulted in higher gross returns, net returns and B: C (₹ 93.5×10^3, and 106.3×10^3; 57.8×10^3 and 69.8×10^3; 2.62 and 2.92 during 2016 and 2017, respectively). Effect of bio-inoculants with organic sources on gross returns, net returns and B: C was found significant over sole application. However, bio-inoculation effect on seed yield at RDF was significant during first year while, non-significant during second year of experiment as compared to sole RDF. Highest gross returns, net returns and B: C under FYM + BI treatment might be due to higher seed yield of pigeonpea coupled with relatively lower cost of FYM. BI treatments have out-performed over the un-inoculated treatments w.r.t. profitability which might be due to much lesser cost incurred for bio-inoculant culture application. These findings are in accordance with the result of Chaudhari *et al.* (2017).

Conclusion

Combined effect of bio-inoculation with organic sources of nutrients was significantly higher while, inoculation with RDF was non-significant as compared to sole organic sources of nutrients as well as RDF. Bio-inoculant mediated nutrient management significantly increased the pods/plant. Application of FYM with bio-inoculant produced highest pods/plant, grains/pod and test weight seed, stover and biological yield; gave higher gross returns, net returns and B: C ratio.

REFERENCES

Chaudhari D T, Vekariya P D, Vora V D, Talpada M M and Sutaria G S. 2017. Enhancing productivity of groundnut based intercropping systems under rainfed conditions of Gujarat. *Legume Research: An International Journal* **40** (3): 520–5.

Choudhary A K and Suri V K. 2014. Scaling-up of pulse production under frontline demonstration technology transfer program in Himachal Himalayas, India. *Communications in Soil Science and Plant Analysis* **45** (14): 1934–48.

Choudhary A K and Suri V K. 2018. Low-cost vermi-composting technology and its application in bio-conversion of obnoxious weed flora of north-western Himalayas into vermi-compost. *Communications in Soil Science and Plant Analysis,* **49** (12): 1429–41.

Choudhary A K, Rahi S, Singh A and Yadav D S. 2010. Effect of vermicompost and biofertilizers on productivity and profitability in potato in north-western Himalayas. *Current Advances in Agricultural Sciences* **2** (1): 18–21.

Choudhary A K, Rana D S, Bana R S, Pooniya V, Dass A, Kaur R, Rana K S. 2015. *Agronomy of Oilseed and Pulse Crops*. Post Graduate School, IARI, New Delhi and ICAR, DARE, New Delhi, India, p 218.

Choudhary A K. 2013. Technological and extension yield gaps in pulses in Mandi district of Himachal Pradesh. *Indian Journal of Soil Conservation* **41** (1): 88–97.

Dass A, Suri V K and Choudhary A K. 2014. Site-specific nutrient management approaches for enhanced nutrient-use efficiency in agricultural crops. *Research and Reviews*: *Journal of Crop Science and Technology* **3** (3): 1–6.

Pandey I B, Pandey R K, and Kumar R. 2015. Integrated nutrient management for enhancing productivity and profitability of long duration pigeonpea under rainfed condition. *Indian Journal of Agronomy* **60** (3): 436–42.

Paul J, Choudhary A K, Sharma S, Savita, Bohra M, Dixit A K and Kumar P. 2016. Potato production through bio–resources: Long–term effects on tuber productivity, quality, carbon sequestration and soil health in temperate Himalayas. *Scientia Horticulturae* **213**: 152–63.

Pawar A, Ismail S and Harkal S R. 2015. Role of zinc solubilizing microorganisms in enhancing Zn availability and enzyme activity in cotton. (*In*) National Seminar on Developments in Soil Science.

Rahi S and Choudhary A K. 2014. *On–Farm* participatory technology development on integrated nutrient management for enhanced crop and rainwater productivity in garlic (*Allium sativum* L.) in north-western Himalayas. *Journal of Agrometeorology* **16** (Special Issue-I): 296–7.

Rana K S, Choudhary A K, Sepat S, Bana R S and Dass A. 2014. *Methodological and Analytical Agronomy,* p 276. Post Graduate School, IARI, New Delhi.

Rathod P S, Sharma A, Patil D H and Dodamani B M. 2015. Performance of pigeonpea under different sources of nutrients in rainfed conditions of Karnataka. *Journal of Food Legumes* **28** (2): 43–5.

Reddy A S R, Reddy M C S, Babu J S, Khan M M and Rao M M. 2011. Integrated nutrient management in pigeonpea (*Cajanus cajan*). *International Journal of Applied Biology and Pharmaceutical Technology* **2** (2): 467–70.

Sharma A, Rathod P S and Chavan M. 2010. Integrated nutrient management in pigeonpea (*Cajanus cajan*) based intercropping systems under rainfed conditions. *Karnataka Journal of Agricultural Sciences* **23** (4): 584–9.

Sharma A, Rathod P S, Dharmaraj P S and Chavan M. 2012. Response of biofertilizers in pigeonpea based intercropping systems under rainfed conditions. *Karnataka Journal of Agricultural Sciences* **25** (3): 322–5.

Suri V K and Choudhary A K. 2013. Effects of vesicular arbuscular mycorrhizae and applied phosphorus through targeted yield precision model on root morphology, productivity and nutrient dynamics in soybean in an acid Alfisol. *Communications in Soil Science and Plant Analysis* **44** (17): 2587–2604.