Indian Journal of Agronomy **60** (3): 436–442 (September 2015)

Research Paper

Integrated nutrient management for enhancing productivity and profitability of long-duration pigeonpea (*Cajanus cajan*) under rainfed condition

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Received : March 2013; Revised accepted : July 2015

ABSTRACT

A field experiment was carried out during rainy (*kharif*) season for 4 consecutive years 2008 to 2012 at Dholi, Bihar to assess the effect of integrated nutrient management on productivity and profitability of pigeonpea [*Cajanus cajan* (L.) Millsp.] under rainfed condition. Plant height, yield indices, viz. branches/plant, pods/plant, 100-seed weight, leaf area index, fruiting efficiency (15.6%), grain (2.01 tonnes/ha.) and stalk yields, harvest index, protein content, water-use-efficiency (2.9 kg grain/ha/mm), production efficiency (8.3 kg/ha/day), NPK uptake, net returns (67.55×10^3 /ha) and benefit: cost ratio (2.9) were significantly higher at recommended dose of fertilizer (RDF) than 50% RDF. Application of farmyard manure (FYM) 5.0 tonnes/ha besides increasing these indices significantly also enhanced nodules number and dry-weight/plant, *Rhizobium* and phosphate-solubilizing bacteria (PSB) count, phosphorus-solubilizing efficiency and acetylene reduction activity than no FYM. Seed inoculation with *Rhizobium* + PSB and *Rhizobium* + PSB + plant-growth promoting rhizobacteria (PGPR) were found equally effective and significantly enhanced branches/plant and pods/plant, fruiting efficiency, grain and stalk yields, harvest index, production efficiency, NPK uptake, number and dry- weight of nodules/plant, *Rhizobium* and PSB count, phosphorus-solublizing and acetylene reduction activity, net return and benefit: cost ratio than uninoculated condition. Application of FYM 5.0 tonnes/ha together with 50% RDF resulted in significantly higher grain yield of pigeonpea (2.08 tonnes/ha) than RDF alone (1.90 tonnes/ha). Likewise, seed inoculation with *Rhizobium* + PSB (1.95 tonnes/ha) and *Rhizobium* + PSB + PGPR (2.02 tonnes/ha) fertilized with 50% RDF recorded similar grain yield to that of RDF alone (2.01 tonnes/ha). Application of RDF, FYM 5.0 tonnes/ha and seed inoculation with biofertilizers, increased organic carbon, available N, P and K contents and reduced the bulk density of the soil over compared with initial soil value.

Key words : Integrated nutrient-management, Phosphate-solubilizing bacteria, Pigeonpea, Plant growth promoting rhizobacteria, Production efficiency, Rainfed, *Rhizobium*, Water use-efficiency

Long-duration pigeonpea is cultivated mostly on marginal land as mono/mixed crop without any fertilizer under rainfed conditions of Bihar. Its productivity is very low (0.7 tonne/ha) compared to its potential yield (2.8 tonnes/ha). Although a number of factors are responsible for low productivity, imbalanced fertilization is important one. Imbalanced application of fertilizer results in poor yields, deterioration of soil fertility and emergence of multiple nutrients deficiencies. Situation therefore warrants for adoption of organic based resources that supply nutrients to the plants through microbial mediation and in the process enrich soil organic carbon and microbial balance. Of the organic based resources, farmyard manure is important source of organic manure which not only provides balanced nutrition to the plant but also sustains crop productivity, provides good substrate for growth of micro-organism, maintain favourable nutritional balance and soil physical properties (Mahetele and Kushwaha, 2011) but their availability is seriously constrained due to its alternative use as fuel. Biological uptake of essential plant nutrients resulting immobilization and chemical precipitation gradually depletes the available nitrogen and phosphorus which can be replenished by using N-fixer (*Rhizobium*), phosphate-solubilizing bacteria (PSB) as seed dressers in nodulating legumes. Inoculation of pulses with PGPR and *Rhizobium* causes growth stimulation of plant and enhances crop yields (Sharma *et al.,* 2007). The synergism has also been reported between *Rhizobium* species and

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PSB in urdbean (Prasad *et al.,* 2002). The productivity of pigeonpea can be increased by inoculation of bioculture prepared from *Rhizobium*, phosphate-solubilizing organism and plant-growth-promoting rhizobacteria and co-inoculation of these 3 biocultures has shown encouraging result in sustaining the crop productivity and improving soil fertility (Govindan and Thirumurugan, 2005). At present, when sustainability of the crop and soil productivity is burning issue, the use of organics and inorganics needs to be emphasized more efficiently than conventionally managed systems (Mader *et al.,* 2002). Under present scenario where food and nutritional security are under threat, it has become imperative to ameliorate the soil-plant-atmosphere as a whole rather than feeding the crop alone. With this background, the present investigation was undertaken to achieve maximum productivity without deteriorating the soil fertility with the optimum use of organic, inorganic and biofertilizer in long-duration pigeonpea.

MATERIALS AND METHODS

The field experiment was conducted during the rainy (*kharif*) season for 4 consecutive years 2008 to 2011 at Research Farm of Tirhut College of Agriculture, Muzaffarpur, Bihar (25°98' N, 85°76' E and an altitude of 51.3 mean sea-level) on sandy-loam soil. The soil was low in organic carbon (0.34%), available nitrogen (158.6 kg/ha), phosphorus (12.0 kg/ha) and potassium (54.7 kg/ha) with pH 8.1. Treatments comprised 2 levels of fertilizers (recommended dose of fertilizers (20 kg N + 40 kg P + 20 kg K/ha) and 50% recommended dose of fertilizers), 2 levels of FYM (0 and 5 tonnes/ha) and 3 biofertilizers (control, *Rhizobium* + PSB and *Rhizobium* + PSB + PGPR) under randomized block design (factorial) with 3 replications. Pigeonpea seeds as per treatment were inoculated with carrier-based *Rhizobium*, PSB and PGPR, each at the rate of 3.5 g/kg seed and mixed well to ensure the inoculums to stick on to the surface of the seeds. The treated seeds were dried in shade for an hour and used for sowing. An un-inoculated check was also maintained. The strains of *Rhizobium*, PSB and PGPR were the same for all the 4 seasons of experimentation. The FYM (containing 0.90% N, 0.48% P, 0.94% K) was broadcast on the soil surface and mixed thoroughly as per treatment before sowing. Pigeonpea variety 'Bahar' was sown in rows 60 cm apart in the first week of August and harvested in the third week of April in all the years. Plant-to-plant distance of space 20 cm was maintained by thinning plants 3 weeks after sowing. The crop was fertilized with urea, diammonium phosphate and muriate of potash. Full doses of nitrogen, phosphorus and potassium as per treatment were applied at the time of sowing. One hand weeding was done 25 days after sowing. The crop received 680.9, 623.3, 641.0 and 648.3 mm rainfall in 2008, 2009, 2010 and 2011, respectively, during the crop-growth period. The initial and final bulk density, pH, organic carbon, N, P and K contents of soil were analysed by core sampler, glass electrode *p*H meter, Walkley and Black, alkaline permagnate, Olsen's and flame photometric methods respectively. *Rhizobium* and PSB populations were determined by plate count method (Ravina *et al.* 1992). One gram of collected soil was diluted 10^4 to 10^6 dilutions and 1 ml solution was spread on 2 petriplates containing respective medium. Total *Rhizobium* and PSB populations were enumurated using yeast extract, manitol agar media and Pikosvia medium respectively. Plates were inoculated at 28°C. Colony-forming units (CFU) were recorded after 48 hours, the average number of microbes per gram oven dry weight of soil was calculated as:

CFU= Bacterial plate count × dilution factor oven dry-weight of soil

For quantification of phosphate-solubilization, Pikovskaya (1948) method was adapted. Acetylene reduction activity of fresh and healthy nodule was determined by the method of Hardy *et al.* (1968) on thermofisher chemito GC, model GC ceres 800 + with fused silica capillary column BPX-5 (30 m × 0.32 mm × 0.25 micro) a flame isonization detector and HP Compaque Intel Pentium computer installed with software iris 32. Peaks were automatically integrated and the ethylene amount calculated.

Net returns were calculated by substracting cost of cultivation from gross returns. Net benefit: cost ratio was calculated by dividing the net returns with cost of cultivation. Production efficiency was calculated by dividing the crop yield of pigeonpea by duration of crop remained in the field, which was expressed as kg/ha/day. Profitability was worked out by dividing the net return (₹/ha) of different treatments by duration of crop remained in the field, which was expressed as ₹/ha/day. For economic analysis the prevailing prices of the inputs and produce during the period of the experiment were considered.

RESULTS AND DISCUSSION

Growth and yield attributes

Fertilizer levels exerted significant effect on plant height and yield indices of pigeonpea (Table 1). Application of recommended dose of fertilizer (RDF) significantly enhanced plant height and yield indices, viz. branches/plant, pods/plant and 100-seed weight, over 50% RDF. Similarly, incorporation of 5.0 tonnes FYM/ha significantly increased the plant height, branches/plant, pods/plant and 100-seed weight over no-FYM. Seed inoculation with biofertilizers proved superior to untreated control

with respect to plant height and yield-contributing characters. Combined inoculation of seed with *Rhizobium* + PSB + PGRP registered taller plant, higher number of branches and pods/plant and this treatment was similar to co-inoculation of *Rhizobium* + PSB, and both proved significantly superior to uninoculated control. The increase in plant height and yield indices under RDF, 5.0 tonnes FYM and combined inoculation of seed with bioinoculants might be owing to adequate quantities of plant nutrients supplied to the crop as per need during the growth period, resulting in favourable increase in growth and development of crop plant which leads towards an increase in plant height and yield indices.

Fruiting efficiency

Fruiting efficiency of pigeonpea enhanced significantly at RDF, application of 5.0 tonnes FYM/ha and combined use of *Rhizobium* + PSB + PGPR compared to 50% RDF, no-FYM and uninoculated control (Table 1). Higher fruiting efficiency in these treatments might be owing to improved physico-chemical property of the soil which provides adequate quantity of nutrients and water to the crop plant which resulted in decreased flower dropping and increased pod-bearing capacity of the plant.

Production and water-use efficiency

Production and water use efficiency were significantly higher at RDF than 50% RDF (Table 1). Similarly, these parameters also increased significantly with 5.0 tonnes/ha FYM and combined inoculation of seed with *Rhizobium* + PSB + PGPR as compared to no FYM and uninoculated control. The increase in water-use efficiency under these treatments was achieved owing to increase in grain yield per unit of water used.

Nodulation

Numbers of nodules/plant and dry weight of nodules were not significantly influenced by fertilizer levels (Table 2). However, FYM significantly affected the number of nodules and dry-weight of nodules. Significantly higher number and dry weight of nodules/plant were recorded with 5.0 tonnes FYM/ha over no-FYM. This might be due to contribution of FYM towards an increase in plant nutrition. Tiwari *et al.* (2011) also reported beneficial effect of FYM on number and dry-weight of nodules in pigeonpea. Inoculation of

Table 1. Plant height, yield indices, fruiting efficiency and grain yield of pigeonpea as influenced by integrated nutrient management (pooled mean of 4 years)

Treatment	Plant height (cm)	Branches/ plant	Leaf-area index (LAI)	Pod length (cm)	Pods/ plant	Grains/ pod	100-seed weight (g)	Grain yield (t/ha)	Stalk yield (t/ha)	Harvest index (%)	Protein content in grain (%)	Fruiting efficiency (%)	Water-use efficiency (kg grain/ ha/mm)	Production efficiency (kg/ha/ day)
Fertilizer level														
50 % RDF	214.7	18.5	3.1	5.3	223.7	4.4	11.6	1.91	8.14	19.0	18.8	13.5	2.6	7.5
RDF	219.5	21.3	3.4	5.6	237.3	4.7	12.4	2.10	8.83	19.2	19.4	15.6	2.9	8.3
SEm±	1.7	1.1	0.1	0.3	4.7	0.2	0.2	0.06	0.21	0.1	0.1	1.0	0.1	0.2
CD (P=0.05)	3.6	2.2	0.1	NS	9.7	NS	0.5	0.12	0.44	0.2	0.3	2.1	0.2	0.5
Level of FYM														
0	213.2	17.0	3.1	5.2	218.3	4.2	11.3	1.82	7.79	18.9	18.6	12.3	2.5	7.2
5.0 tonnes/ha	221.0	22.8	3.4	5.7	242.7	4.9	12.7	2.19	9.18	19.3	19.7	16.7	3.0	8.6
SEm±	1.7	1.1	0.1	0.3	4.7	0.2	0.2	0.06	0.21	0.1	0.1	1.0	0.1	0.2
CD (P=0.05)	3.6	2.2	0.1	NS	9.7	0.4	0.5	0.12	0.44	0.2	0.3	2.1	0.2	0.5
Biofertilizers														
Control	213.3	17.8	3.1	5.3	220.2	4.3	11.7	1.89	8.06	19.0	18.9	12.9	2.6	7.4
Rhizobium + PSB	217.9	20.7	3.3	5.5	233.9	4.6	12.1	2.03	8.56	19.2	19.2	15.2	2.8	8.0
Rhizobium+PSB+PGPR	220.1	21.3	3.3	5.6	237.5	4.7	12.3	2.10	8.83	19.2	19.3	15.6	2.9	8.3
SEm±	2.1	1.4	0.1	0.4	5.6	0.2	0.3	0.07	0.26	0.1	0.2	1.3	0.1	0.3
CD (P=0.05)	4.4	2.8	0.2	NS	11.6	NS	NS	0.15	0.53	0.2	0.3	2.6	0.3	0.6

RDF, Recommended dose of fertilizer; FYM, farmyard manure; PSB, phosphate-solubilizing bacteria; PGPR, plant growth promoting rhizobacteria

seed with *Rhizobium* + PSB and *Rhizobium* + PSB + PGPR significantly improved the number of nodules/plant and dry weight of nodules over the control. Soil fertility was improved with the combined inoculation of *Rhizobium* + PSB and *Rhizobium* + PSB + PGPR, which was reflected in terms of higher number of nodules along with their dry weight. Tilak *et al.* (2006) reported higher number of nodules under inoculated conditions than uninoculated control.

Grain and stalk yields

Application of RDF significantly increased grain and stalk yields and harvest index over 50% RDF (Table 1), might be owing to supply of adequate quantities and balanced proportion of plant nutrients to the crop as per need which increased availability of these nutrients to plants resulting in favourable increase in plant height, yield-contributing characters and finally grain and stalk yields. Goud and Kale (2010) also reported higher grain yield of pigeonpea at 18:46:20:20 kg N, P, K and S/ha over 9:23:10:10 kg N, P, K and S/ha. Incorporation of 5.0 tonnes FYM/ha enhanced the grain and stalk yields and harvest index significantly over no-FYM. The increase in grain yield and stalk yield was 20.6%, 17.8% and in harvest index 1.9%. Application of FYM improved the physical condition and nutrient contents of the soil, thereby increased the growth, yield contributing parameters and finally the grain yield. Seed inoculation with bio-inoculants influenced the grain, stalk yields and harvest index significantly over no inoculation. Use of *Rhizobium* + PSB + PGPR and *Rhizobium* + PSB recorded significantly higher grain and stalk yields and harvest index over no-inoculation. Thus, combined inoculation of *Rhizobium*, PSB and PGPR improved the nutrient status of soil through their synergistic effect on nitrogen fixation and solubilization of native soil phosphorus which increased availability and uptake of these nutrients by the crop plant resulted in enhanced yield indices and grain yield of the crop. Singh and Singh (2012) also reported that dual inoculation of seed with PSB + PGPR significantly increased grain, stalk yields and harvest index over inoculation of PSB, PGPR alone and control (without seed inoculation). Guggari and Kalaghatagi (2005) reported that application of biofertilizer alone resulted in 12.8% higher

Table 2. Number and dry weight of nodules, microbial populations, nutrients uptake by pigeonpea and economics as influenced by integrated nutrient management (pooled mean of 4 years)

Treatment	Nodules/ plant	Dry weight of nodule (mg)	*Rhizobium* population (cfu/g soil $\times 10^7$)	PSB population (cfu/g soil $\times 10^6$)	PSE (%)	Acetylene reduction activity (milli mole/ g/hr)	N uptake by grain + stalk (kg/ha)	P uptake by grain+ stalk (kg/ha)	K uptake by grain+ stalk (kg/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio	Profitability (₹/ha/day)
Fertilizer level												
50% EDF	16.6	24.1	3.1	2.4	35.9	3.3	128.6	36.0	97.6	60.40	2.6	237.8
RDF	15.8	23.4	2.4	2.2	30.6	2.7	146.9	39.7	107.7	67.55	2.9	265.9
SEm±	0.5	0.7	0.3	0.1	2.3	0.4	3.7	1.0	3.1	1.83	0.1	8.0
CD (P=0.05)	NS	NS	NS	NS	4.7	NS	7.7	2.1	6.5	3.79	0.2	16.5
Level of FYM												
0	14.7	22.3	2.3	1.9	26.8	1.8	121.8	34.4	92.6	57.37	2.6	225.9
5.0 tonnes/ha	17.7	25.2	3.2	2.6	39.8	4.1	153.6	40.8	112.5	70.59	2.9	277.9
SEm±	0.5	0.7	0.3	0.1	2.3	0.4	3.7	1.0	3.1	1.83	0.1	8.0
CD (P=0.05)	0.9	1.4	0.6	0.2	4.7	0.9	7.7	2.1	6.5	3.79	0.2	16.5
Biofertilizer												
Control	10.5	19.1	1.4	1.8	26.1	0.3	126.5	35.6	95.8	58.76	2.5	231.3
Rhizobium + PSB	18.7	25.7	3.3	2.5	35.2	2.2	140.4	38.3	103.7	64.78	2.8	255.1
Rhizobium +PSB+PGPR	19.4	26.5	3.5	2.6	38.5	6.4	146.3	39.3	108.4	68.39	2.9	269.3
SEm±	0.6	0.8	0.4	0.1	2.8	0.5	4.5	1.3	3.8	2.24	0.1	10.2
CD (P=0.05)	1.1	1.7	0.7	0.3	5.7	1.1	9.4	2.6	7.9	4.64	0.2	21.4

PSB, Phosphate-solubilizing bacteria; RDF, recommended dose of fertilizer; PSE, phosphorous solubilizing efficiency

grain yield over absolute control.

Interaction between fertilizer and FYM levels was found to be significant with respect to grain yield (Table 3). Significantly higher grain yield was obtained when 50% RDF was applied with 5.0 tonnes FYM/ha compared to RDF alone. This might be owing to FYM applied in the soil act as slow-release source of nutrient, form different complexes with metal cations present in the soil and restricts their losses from the system which leads steadily supply of nutrients in adequate amount and balanced proportion to the crop plant attributed to overall improvement in crop growth, yield attributes and finally the grain yield. Goud and Kale (2010) also recorded higher pigeonpea yield under combined application of organic and inorganic fertilizers. Similarly, interaction between fertilizer levels and seed inoculation with biofertilizers was also found significant with respect to grain yield (Table 3). Combined inoculation of seed with *Rhizobium* + PSB + PGPR at 50% RDF and RDF resulted in significantly higher grain yield than uninoculated control at same fertilizer levels. Seed inoculated with *Rhizobium* + PSB + PGPR or *Rhizobium* + PSB combined with 50% RDF provided similar grain yield to that without seed treatment with RDF. This might be owing to enhanced fertility status and physical property of the soil.

Protein content

Protein content in grain was significantly influenced by fertilizer levels, FYM and biofertilizers (Table 1). Application of RDF resulted in significantly higher protein content than 50% RDF. Similarly, use of 5.0 tonnes FYM/ha significantly enhanced protein content over no-FYM. Here, it may be pointed out that nitrogen is a basic constituent of protein and addition of higher dose of nitrogen through inorganic and organic sources increases nitrogen availability and nitrogen-use efficiency, thereby accelerating protein synthesis. Seed inoculation with *Rhizobium* + PSB and *Rhizobium* + PSB + PGPR had definite gain in protein content in grain over the control, which in terns besides increasing the nitrogen content of the soil might have improved the size and weight of grain. With increase in grain size, the increase in content of protoplasm is also possible (Black, 1957).

NPK uptake

Application of RDF recorded significantly higher NPK uptake by pigeonpea than 50% RDF (Table 2). This could be attributed to the fact that added fertilizers enhanced availability of these nutrients to the plant. This might has resulted in profuse shoot and root growth, and thereby activating greater absorption of these nutrients from the soil. Shivran and Ahlawat (2000) also recorded higher nutrient uptake at higher fertilizer level in pigeonpea–wheat cropping system. Similarly, uptake of these nutrients were significantly higher with the application of 5.0 tonnes FYM/ha over the control. This might be attributed to addition of additional quantity of nutrients in the soil and increased their availability to the crop plants through enhanced microbial activity of the soil. Mathan *et al*. (1994) also reported that combined uses of organic and inorganic sources of nutrients enhanced nutrients uptake by pigeonpea. Combined inoculation of *Rhizobium* + PSB + PGPR and *Rhizobium* + PSB recorded significantly higher NPK uptake by the crop than the uninoculated control. This is mainly owing to the reason that *Rhizobium* inoculation fixes atmospheric nitrogen through nodules of the plant and PSB-solubilizing native phosphorus, bringing more phosphorus to soil solution. Higher NPK uptake in combined inoculation of *Rhizobium* + PSB + PGPR is due to their additive effects (Prasad *et al.*, (2002).

Economics

Application of RDF fetched higher net returns and benefit: cost ratio over 50% RDF (Table 2). Similarly, use of 5.0 tonnes FYM/ha obtained significantly higher net returns and benefit: cost ratio over no-FYM. Combined inoculation of *Rhizobium* + PSB + PGPR registered higher net returns and benefit: cost ratio, being similar to co-inoculation of *Rhizobium* + PSB and both recorded significantly higher values over the uninoculated control. Very low increment in cost of production and higher yield levels owing to combined inoculation of these bioinoculants resulted higher economic returns over the control. Kumar and Rana (2007) recorded higher monetary returns at higher fertility level in pigeonpea + greengram intercropping system. Singh and Yadav (2008) obtained the maximum net returns and benefit: cost ratio under combined inoculation of *Rhizobium* + PSB together with 60 Kg P_2O_5.

Soil physico-chemical property

Bulk density, organic carbon, available nitrogen, phosphorus and potassium content of the soil after harvest of pigeonpea were influenced by fertilizer levels, FYM and seed inoculation with biofertilizers over the initial status (Fig. 1). Application of RDF reduced the bulk density and improved the available N, P, K contents of the soil over 50% RDF and initial soil value. The improvement in nutrient status of the soil may be ascribed to more biomass (leaves, root etc.) added by the pigeonpea. Shivran and Ahlawat (2000) reported also improvement in fertility status of the soil through addition of fertilizers. Application of 5.0 tonnes FYM/ha reduced the bulk density, pH of the soil and increased the organic carbon, available N, P, K

Table 3. Interaction effect of fertilizer × FYM levels and fertilizer levels × bioinoculants on grain yield (tonnes/ha) of pigeonpea (pooled mean of 4 years)

Fertilizer level	FYM level		Bio-inoculants		
	0	5.0 tonnes/ha	Control	*Rhizobium* + PSB	*Rhizobium* + PSB + PGPR
50% RDF	1.73	2.08	1.76	1.95	2.02
RDF	1.90	2.30	2.01	2.11	2.18
SEm±		0.08			0.10
CD (P=0.05)		0.17			0.21

PSB, Phosphorus-solubilizing bacteria; PGPR, plant growth promoting rhizobia; RDF, recommended dose of fertilizer

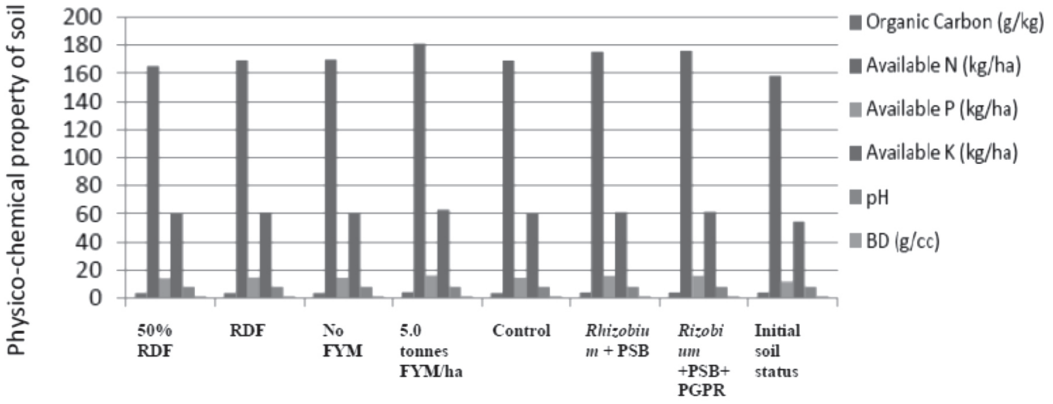

Fig. 1. Effect of nutrient management on physico-chemical property of soil.

contents of the soil over no-FYM. This might be owing to addition of FYM that directly resulted in an increase in organic carbon content of the soil, while increase in nitrogen content as a result of organically bound nitrogen converted to mineralizable form of nitrogen, phosphorus as a result of organic material reducing phosphorus-fixing capacity of the soil and available K due to release of non-exchangeable K from the soil. This released K and also applied K not only met crop requirement but also build up available K content of the soil. Seed inoculation with biofertilizers reduced the bulk density and enhanced organic carbon and available N, P, K contents of the soil over uninoculated control. The magnitude of increase in available N, P, K contents were higher under combined inoculation of *Rhizobium* + PSB + PGPR, while bulk density and organic carbon content were similar under *Rhizobium* + PSB + PGPR and *Rhizobium* + PSB inoculation. Biofertilizers enhanced soil fertility by solubilizing unavailable sources of elemental nitrogen, bound phosphorus and non-exchangeable potassium into available forms to facilitate the plant to absorb them (Singh and Yadav, 2008; Goud and Kale, 2011).

Microbial populations and activity

Rhizobium, phosphate solubilizing bacteria (PSB) populations and acetylene reduction activity were not significantly influenced by fertilizer levels, while phosphorus solubilizing efficiency (PSE) was reduced significantly at RDF than 50% RDF (Table 2). However, populations of these micro-organism, phosphorus solubilizing efficiency and acetylene reduction activity were significantly enhanced with the application of 5.0 tonnes/ha FYM over no-FYM. The populations and activity of these micro-organisms were significantly influenced by seed inoculation with bioinoculants. *Rhizobium,* PSB populations, phosphorus-solubilizing efficiency and acetylene reduction activity were significantly higher under combined inoculation of *Rhizobium* + PSB and *Rhizobium* + PSB + PGPR over the uninoculated control. This might be owing to the fact that FYM provided a good substrate for these micro-organisms and combined inoculation released growth-promoting substances and suppressed pathogens which lead to promote proliferation of beneficial organisms and their efficiencies in *rhizosphere.*

Application of RDF, 5.0 tonnes FYM/ha and seed inoculation with *Rhizobium* + PSB + PGPR improved the physio-chemical property of the soil and enhanced productivity and profitability of pigeonpea. Use of 5.0 tonnes FYM/ha together with 50% RDF resulted in significantly higher grain yield than the application of RDF alone.

Hence 50% recommended dose of chemical fertilizers could be saved with the application of 5.0 tonnes FYM/ha.

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