Effect of Integrated Application of Organic and Inorganic Sources Phosphorus on Soil Properties, Yield and Nutrient Uptake by Pigeonpea in Dryland Condition

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ABSTRACT: A field experiment was conducted for five consecutive *kharif* seasons (2010-11 to 2014-15) on Inceptisol at Zonal Agricultural Research Station farm Solapur to study the effect of integrated phosphorus application through inorganic and organic sources on soil properties, yield and nutrient uptake by pigeonpea under dryland conditions in scarcity zone of Maharashtra. Five year conjoint use of 50% recommended dose of phosphorus through PMC (25 kg/ha) + 50% recommended dose of phosphorus through chemical fertilizer (25 kg/ha) along with 25 kg N/ha through urea and seed treatment with each rhizobium and phosphate solubalizing bacteria (PSB) @ 25g/kg seed significantly improved the organic carbon and soil available N, P and K content over chemical fertilizers alone. Significantly higher yield (grain 9.07 q/ha and straw 49.89 q/ha) and total N P K uptake by pigeonpea (72.27, 12.00 and 75.53 kg/ha, respectively) with the application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizer treatment. The highest monetory returns (₹ 41737/ha), net returns (₹ 16649/ha) and B:C ratio of 1.62 were recorded in the same treatment. Thus, integrated application of inorganic and organic sources of phosphorus maximized yields of pigeonpea crop and improved the soil fertility in Inceptisol under dryland conditions in scarcity zone of Maharashtra.

Key words: Nutrient uptake, pigeonpea, PMC, soil properties, yield

Introduction

Pigeonpea is the most important crop of scarce zone of Maharashtra. The productivity of pigeonpea decreased continuously in intensively cultivated area due to imbalance nutrient application. This imbalanced and skewed application of N P K accompanied by restricted use of organic manures and micronutrients have made soils not only deficient in the nutrients but also deteriorated the soil health resulting in decline in crop response to the recommended dose of fertilizers. Under these circumstances integration of chemical and organic sources and their management have shown promising results not only in sustaining the productivity but have also proved to effective in maintaining soil health and enhancing nutrient use efficiency (Laxminarayana *et al.,* 2011, Kumar *et al.,* 2012). The supplementary and complimentary use of organic manures and inorganic fertilizers augment the efficiency of both the substances to soil and crop productivity.

The required amount of phosphorous nutrient may be supplied through both inorganic and organic source for pigeonpea under dryland conditions. The research work started with organic source alone and compared with integrated nutrient management and inorganics. The press mud compost as organic source can satisfactorily provide P to pulses. The nutrients in organic sources will be slowly available as the organic compounds mineralize N and other essential nutrients (Goswami, 2007). Among the major nutrient elements, phosphorous has special significance in increasing the pigeonpea yield under dryland conditions. Hence in this study the press mud compost was tried as source of phosphorous in alone and in different proportions with inorganic to get sustained optimum yield of pigeonpea in scarcity zone of Maharashtra under dryland conditions. The nutrient composest of press mud compost is given in Table 1a.

Materials and Methods

A field experiment was conducted at the Dry Farming Research Station, Solapur Maharashtra, during the *kharif* of 2010-11 to 2014-15. Pigeonpea (*Cajanus cajan* L.) cv. Vipula was grown on Inceptisol soil. The soil of the experimental field was *Vertic Haplustepts,* clayey in texture with slightly alkaline (pH 7.22) and free from excessive salt (0.22 dS/m), medium in organic carbon (0.49%) and low in available N (151kg/ha), P (12.7 kg/ha) and high in available K (620 kg/ha). The moisture content was at FC 205 mm and PWP 150 mm, respectively.

Table 1a : Composition of press mud compost (PMC)

Parameter	Values
Nitrogen (%)	1.66
Phosphorus (%)	2.25
Potassium (%)	1.99
Organic carbon (%)	22.65
Calcium (%)	3.2
Magnesium (%)	1.0
Sulphur (%)	1.2
Copper (mg/kg)	52
Zinc (mg/kg)	69
Manganese (mg/kg)	898
Iron (mg/kg)	2000
C:N ratio	13.64
Wax (%)	0.3

The experiment was laid out in randomized block design and replicated four times. The treatments comprised of T_1: control (Po); T_2: Recommended dose of N:P_2O_5 (25:50 kg/ha) through chemical fertilizer; T_3: Recommended dose of phosphorus P_2O_5 @ 50 kg/ha through PMC; T_4:2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus through chemical fertilizer ; T_5: 1/2 of recommended dose of phosphorus through PMC + 1/2 of recommended dose of

phosphorus through chemical fertilizer ; T_6: 1/3rd of recommended dose of phosphorus through PMC + 2/3rd of recommended dose of phosphorus-chemical fertilizer. The recommended dose of N @ 25 kg/ha was applied as basal through urea. The rhizobial cultures and PSB each @ 25g/kg seed as seed treatment was given to all the treatments. The P was applied through PMC and single super phosphate as per treatments except T_1- control. Rainfall data received during the five years are given in Table 1b and Figure 1. The data on crop yield, economics, moisture use efficiency (MUE), nutrient uptake (N, P, K), soil available nutrient status (N, P, K) and organic carbon content were reported by following the standard procedures of chemical analysis (Jackson 1979 and Page *et al.,* 1982). The moisture use efficiency and P use efficiency was calculated as per the following formula:

MUE = Kg grain yield/ha/CUM (mm).

PUE (Kg grain/Kg P) = [Grain yield (F)-grain yield (C)] / Fertilizer P applied

where F and C are fertilizer treated and control plot respectively.

Results and Discussion

Effect on yield and MUE

The pooled analysis of five years data showed that the yield of pigeonpea was significantly influenced by the treatments. (Table 2). Application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through

Table 1b : Year wise seasonal distribution of rainfall (2010-11 to 2014-15)

Season	2010-11		2011-12		2012-13		2013-14		2014-15	
	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days
Pre-monsoon	60.7	6	91.7	7	32.7	8	68.9	4	153.3	11
kharif	609.5	38	514.4	29	335.6	21	446	33	362.3	23
Rabi	117.1	14	155.6	7	165.7	9	152.5	11	88.3	5
Total	787.3	58	761.7	43	534.0	38	666.9	48	603.9	39

Normal rain fall-721.4 mm, Pre-monsoon-70 mm, *Kharif*- 420.7 mm, *Rabi*-230.3 mm.

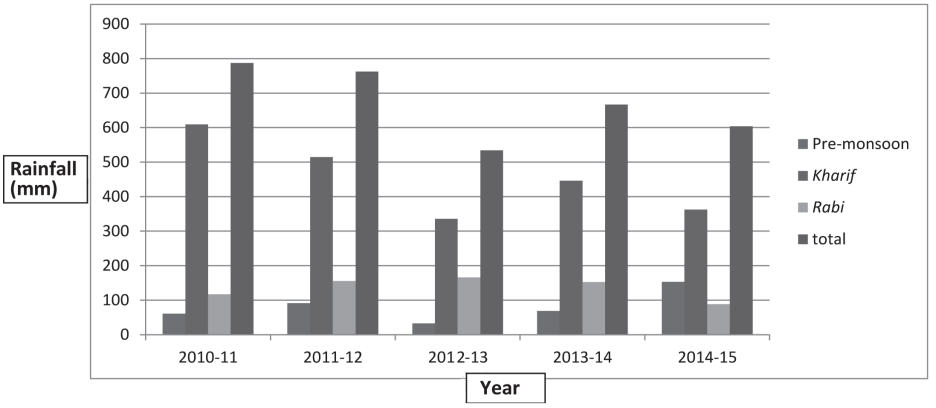

Fig. 1 : Year wise seasonal distribution of rainfall

Table 2 : Influence of integrated application of phosphorus through inorganic and organic sources on yield, moisture use efficiency (MUE) and total nutrient uptake (grain + straw) of pigeonpea (pooled data of five years)

Treatments	Yield (q/ha)		MUE (kg/ha mm)	Total uptake (kg/ha)			PUE (kg grain/kg P)
	Grain	Straw		N	P	K	
Control	6.06	33.37	1.26	45.04	6.56	48.83	0.00
RD of N:P_2O_5 (25:50 kg N:P/ha)-chemical fertilizer	8.30	46.54	1.65	67.50	10.42	69.63	4.48
Recommended dose of phosphorus-PMC/ha	7.31	41.15	1.41	57.40	8.43	61.07	2.50
2/3rd RD of phosphorus-PMC + 1/3rd RD of phosphorus-chemical fertilizer/ha	8.21	46.73	1.66	65.13	10.02	68.40	4.30
50% RD of phosphorus-PMC + 50% RD of phosphorus-chemical fertilizer/ha	9.07	49.89	1.81	72.27	12.00	75.53	6.02
1/3rd RD of phosphorus-PMC + 2/3rd RD of phosphorus-chemical fertilizer/ha	7.95	45.65	1.61	63.45	9.46	68.03	3.78
SE±	0.26	1.61	-	2.12	0.54	2.64	-
CD at 5%	0.76	4.76	-	6.25	1.60	7.77	-

chemical fertilizer recorded maximum grain (9.07 q/ha) and straw yield (49.89 q/ha). The straw yield was on par with 2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus through chemical fertilizer and recommended dose of N:P_2O_5 (25:50 kg/ha) through chemical fertilizer and 1/3rd of recommended dose of phosphorus through PMC + 2/3rd of recommended dose of phosphorus through chemical fertilizer. However, grain yield was found significant over rest of the treatments. The higher yield in the organics applied plot might be attributed to better supply of nutrients by conducive physical environment leading to better root activity and higher nutrient absorption, which resulted in better plant growth and superior yield. (Manjunath *et al.,* 2006, Acharya *et al.,* 2012 and shahid *et al.,* 2013). The MUE of grain was recorded maximum (1.81 kg/ha/mm) due to application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizer and lowest was recorded in the control treatment (1.26 kg/ha/mm).

Effect on nutrient uptake

Nutrient uptake (N, P and K) by pigeonpea increased significantly with the addition of press mud compost along with chemical fertilizers over control (Table 2). Application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizer recorded significantly higher N (72.27 kg/ha), P (12.00 kg/ha) and K (75.53 kg/ha) uptake, respectively. However N and P uptake were on par with application of recommended dose of N:P_2O_5 (25:50 kg/ha) through chemical fertilizer and in case of K uptake, it was also on par with recommended dose of N:P_2O_5 (25:50 kg/ha) through chemical fertilizer, 2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus- chemical fertilizer and 1/3rd of recommended dose of phosphorus through PMC + 2/3rd of recommended dose of phosphorus through chemical fertilizers treatments. The increase in NPK uptake by pigeonpea with integrated application of nutrients may be due to improvement of soil environment which encouraged proliferation of roots resulting in more absorption of water and nutrients from larger areas and depth. Moreover, organic manures after decomposition released nutrients which becomes available to plants and thus increased NPK concentration. The higher nutrient uptake with organic manures might be attributed to solubilization of native nutrients, chelation of complex intermediate organic molecules produced during decomposition of organic manures, their mobilization and accumulation of different nutrients in different plant parts. These results are in agreement with the findings of Noor, (2008) and Mujumdar *et al.* (2007) in soybean, Kumari and Ushakumari (2002) in cowpea. Application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizer recorded maximum phosphorus use efficiency (6.02 kg grain/kg P).

Soil chemical properties

The data regarding chemical properties at harvest of pigeonpea (Table 3) revealed that continuous use of chemical fertilizers and their combination with organics did not change the pH of soil at five years. Regarding the EC, the application of 2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus through chemical fertilizer recorded significantly lowest EC (0.30 dS/m) followed by 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizers (0.32 dS/m). The organic carbon content increased significantly with the application of press mud compost alone and along with graded doses of chemical fertilizers (Table 3). The highest build up of organic carbon in soil was recorded in treatment of 100% recommended dose of phosphorus through PMC/ha and 2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus through chemical fertilizer (0.68%) which was at par with 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizers (0.66%). Thus, integrated application of organics with chemical fertilizers recorded higher values of organic carbon compared to the application of chemical fertilizers alone. The increase in organic carbon content in manurial treatment combination is attributed to direct addition of organic manure in soil which stimulated growth and activities of microorganisms and also due to better root growth, resulting in higher production of biomass, crop stubbles and residues. The subsequent decomposition of their materials might have resulted in enhanced carbon content of soil. Similar results were also reported by Srilatha *et al.* (2013), Mohorana *et al.* (2012).

Soil available nutrients

Application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizers was significantly superior to rest of treatments in increasing soil available nitrogen (189 kg/ha). This increase may be attributed to increased microbial activity under INM treatments which favoured N mineralization (Table 3). The increase in available N status due to organic manure application would also be due to the multiplication of soil microbes leading to enhanced conversion of organically bound N into inorganic forms and rapid mineralization. These results are in line with the findings of Sharma *et al.* (2013) and Thamaraiselvi *et al.* (2012) who also observed the available N content in soil increased with the use of recommended dose of N fertilizer in combination with manure.

A significant reduction in available P content (8.99 kg/ha) of soil observed under recommended dose of nitrogen @ 25 kg/ha alone occurred due to removal of P by crops in absence of external source of P (Table 3). Incorporation of 1/2 recommended dose of phosphorus through PMC + 1/2 of recommended dose of phosphorus through chemical fertilizers recorded significantly higher available P (19.03 kg P/ha) content as compared to all other treatments except 2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus through chemical fertilizers treatment (17.67 kg P/ha). Both the treatments were on par with each other. The increased in availability of soil available P with organic could be ascribed to their solubilizing effect on the native insoluble P fractions through release of various organic acids, thus resulting into significant improvement in soil available P status of soil (Urkurkar *et al.,* 2010). Incorporation of press mud compost

Table 3 : Influence of integrated application of phosphorus to pigeonpea through inorganic and organic sources on soil chemical properties of the post-harvest soil under dryland conditions (pooled data of five years)

Treatments	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Control	7.30	0.33	0.53	140	8.99	580
RD of N:P_2O_5 (25:50 kg N:P/ha)-chemical fertilizer	7.37	0.35	0.64	166	14.81	623
Recommended dose of phosphorus-PMC/ha	7.30	0.36	0.68	156	16.41	611
2/3rd RD of phosphorus-PMC + 1/3rd RD of phosphorus-chemical fertilizer/ha	7.29	0.30	0.68	184	17.67	635
50% RD of phosphorus-PMC + 50% RD of phosphorus-chemical fertilizer/ha	7.33	0.32	0.66	189	19.03	642
1/3rd RD of phosphorus-PMC + 2/3rd RD of phosphorus-chemical fertilizer/ha	7.32	0.34	0.62	178	16.86	636
SE±	0.026	0.01	0.01	1.42	0.50	6.05
CD at 5%	NS	0.03	0.03	4.18	1.48	17.84

along with inorganic P might have increased the availability of P to crop and mineralization of organic-P due to microbial action and enhanced mobility of P (Tiwari *et al.,* 2010). The improvement in soil available P with press mud compost (PMC) addition and there by retardation of P fixation by organic matter formed during PMC decomposition (Ali *et al.,* 2009).

The soil available K content of pigeonpea was significantly influenced due to different treatments over control (Table 3). Application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizers recorded significantly highest soil available K (642 kg/ha) content. However, it was at par with 2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus through chemical fertilizers (635 kg/ha) and 1/3rd of recommended dose of phosphorus through PMC + 2/3rd of recommended dose of phosphorus through chemical fertilizers treatments (636 kg/ha). The increase in available K under integrated treatments might be due to addition of organic matter that reduced the K fixation and released K due to interaction of organic matter with clay. The increase in the availability of K through addition of PMC may also be due to the decomposition of organic matter accompanied by the release of appreciable quantities of CO_2, which when dissolved in water forms carbonic acid, which is capable of decomposing certain primary minerals and release of nutrients (Urkurkar *et al.,* 2010).

Economics

Data pertaining to influence of inorganic and organic source of phosphorus nutrient on economics of pigeonpea cultivation presented in Table 4. The results showed that the application of 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizers recorded highest gross monetory (₹ 44326/ha) and net returns (₹ 17026/ha), respectively with B:C ratio of 1.62.

Table 4 : Economics of pigeonpea as influenced by integrated application of phosphorus through inorganic and organic sources under dryland conditions (pooled data of five years)

Treatments	Cost of cultivation (₹/ha)	Gross monetary returns (₹/ha)	Net returns (₹/ha)	B : C ratio
Control	25428	29554	4126	1.16
RD of N:P_2O_5 (25:50 kg N:P/ha)-chemical fertilizer	28053	40369	12316	1.44
Recommended dose of phosphorus-PMC/ha	26545	35675	9130	1.34
2/3rd RD of phosphorus-PMC + 1/3rd RD of phosphorus-chemical fertilizer/ha	27047	40201	13154	1.48
50% RD of phosphorus-PMC + 50% RD of phosphorus-chemical fertilizer/ha	27300	44326	17026	1.62
1/3rd RD of phosphorus-PMC + 2/3rd RD of phosphorus-chemical fertilizer/ha	27551	38918	11367	1.41
SE±	-	1190	-	-
CD at 5%	-	3536	-	-

DF through chemical fertilizer (P base)- ₹ 2625/- & RDF through PMC (P base)- ₹ 1117/-

Average price of pigeon pea grains: ₹ 4290/- & Average price of pigeon pea straw: ₹ 113/-

Conclusion

It may be concluded from the present study that basal application of recommended dose of 50 kg P_2O_5/ha through 50% recommended dose of phosphorus through PMC + 50% recommended dose of phosphorus through chemical fertilizers/ ha along with 25 kg N/ha through urea and seed treatment with each of rhizobium and PSB @ 25 g/kg seed not only produced the higher yield, nutrient uptake by pigeonpea but also improved the soil fertility as compared to application of chemical fertilizers alone in Inceptisol of scarcity zone of Maharashtra.

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