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IMPACT OF INTEGRATED PHOSPHORUS MANAGEMENT ON PIGEONPEA YIELD, MOISTURE USE EFFICIENCY AND SOIL FERTILITY STATUS ON *INCEPTISOLS* UNDER DRY LAND CONDITIONS

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ABSTRACT:
The present study was conducted at Zonal Agricultural Research Station, Solapur Maharashtra for five consecutive years from 2010-11 to 2014-15 to find out the impact of integrated phosphorus management on pigeonpea yield, moisture use efficiency and soil fertility status on *Inceptisols* under dry land condition. The treatment consist of T_1 : Control, T_2 :Recommended dose of $N:P_2O_5$ (25:50 kg ha^{-1})-chemical fertilizer, T_3 : Recommended dose of $N:P_2O_5$ (25:50 kg ha^{-1})-press mud cake, T_4 : 2/3rd of recommended dose of phosphorus - press mud cake+ 1/3rd of recommended dose of phosphorus- chemical fertilizer, T_5 : 1/2 of recommended dose of phosphorus - press mud cake+ 1/2 of recommended dose of phosphorus- chemical fertilizer, T_6 : 1/3rd of recommended dose of phosphorus - press mud cake + 2/3rd of recommended dose of phosphorus- chemical fertilizer. The basal dose of N @ 25 kg ha^{-1}, *Rhizobium* and *PSB* @ 25g kg^{-1}seed each seed treatment was given to all the treatment. The pooled results revealed that application of 50% recommended dose of phosphorus fertilizer through PMC (1.0 t ha^{-1}) + 50% recommended dose of phosphorus through chemical fertilizer was beneficial for increasing pigeon pea (9.07 q ha^{-1}) and straw (49.89 q ha^{-1}), moisture use efficiency (1.81 kg ha mm^{-1}) and improving nutrient fertility status of soil.

Key words: Dry land, Phosphorus, Pigeonpea Productivity, Press mud

INTRODUCTION:

Pigeon pea is the most important pulse crop of Scarcity zone of Maharashtra. The area of pigeon pea in Maharashtra is about 12.33 lakh hector with production 8.71 lakh tonnes and productivity 706 kg ha^{-1}(Anonymous, 2014). Productivity of pigeon pea is decreased continuously in intensively cultivated area due to use of imbalanced chemical fertilizers accompanied by restricted use of organic manures and bio fertilizers which have made the soil not only deficient in secondary and micronutrients but also deteriorate soil health causing a decline in crop response to recommended dose of fertilizers.

Present is a rising apprehension among the scientific group of people, environmentalists and policy makers about the safe disposal of the large amounts of organic wastes produced worldwide. Urbanization, industrialization, increasing food demand for growing human population, intensive use of relatively easily available and inexpensive chemical fertilizers and economic force are adding to the production and buildup of large amounts of organic wastes. In Pakistan, a few organic wastes such as farm waste, city waste (sewage and sludge), poultry litter and industrial wastes (food, sugar, cotton and rice industry) are recycled back by applying back to agricultural land but a significant amount of organic wastes. As a result recycling organic wastes by applying on to agricultural land seems to be the only best option in such scenario (Zaman et al., 2002; 2004). However, soil may not be regarded as a dumping place for organic wastes (Cameron et al., 1997).

Organic waste such as press mud or filter cake is a by product of sugar factories and characterized as a soft, spongy, amorphous and dark brown to brownish material. Press mud is reported to be a valuable resource of plant nutrients and may therefore affect physical, chemical and biological properties of a soil (Rangaraj et al., 2007; Kumar and Verma, 2002; Jamil et al., 2008; Muhammad and Khattak, 2009; Nehra and Hooda, 2002; Ramaswamy, 1999). Razzaq (2001) reported that continuous land application of sugarcane filter cake to agricultural crops for 5-6 years is likely to improve soil health by adding sulfur (S) and organic matter to soil. Therefore land application of press mud is becoming a common farm practice in the sub-continent countries of Pakistan and India.

Press mud cake is an important by product of sugar industries produced at 30-35 kg per tonne of cane crushed. About 5.2 million tonnes of press mud is produced in our country every year from 400 sugar factories. Therefore, press mud would be easily available to farmers. The composted press mud consists of nitrogen (1.66 %), phosphorus (2.25 %) potassium (1.9 %), organic matter (72 %), organic carbon (42 %), Ca (3.2 %), Mg (1.0 %), S (1.2 %) and micronutrients in considerable amounts .The inclusion of organic source of composted press mud in integrated nutrient management strategy acts to fulfill the requirement of macronutrient like phosphorus which requires double than nitrogen dose for pulse crop.

The time when cost of chemical fertilizer is skyrocketing and not affordable by farmers in scarcity zone, press mud has promise as a source of plant nutrients. Therefore, considering rich source of phosphorus, compost press mud would be beneficial to reduce chemical dose of phophatic fertilizer. Hence the present investigation was undertaken with different proportion of composted press mud and phosphatic fertilizer along with recommended dose of nitrogen and rhizobium seed treatment in order to generate integrated nutrient management strategy for sustainable production of pigeon pea in scarcity zone of Maharashtra under dry land condition.

MATERIAL & METHODS:

A field experiment was conducted during *kharif* season for the year 2010-2011 to 2014-15 at Dry farming Research Station, Solapur, to study the effect of integrated phosphorus management on pigeon pea yield and soil properties on *Inceptisol* under dry land condition. The treatment consist of T_1 : Control, T_2 :Recommended dose of $N:P_2O_5$ (25:50 kg ha^{-1})-chemical fertilizer, T_3 : Recommended dose of $N:P_2O_5$ (25:50 kg ha^{-1})-press mud cake, T_4 : 2/3rd of recommended dose of phosphorus - press mud cake+ 1/3rd of recommended dose of phosphorus- chemical fertilizer, T_5 : 1/2 of recommended dose of phosphorus - press mud cake+ 1/2 of recommended dose of phosphorus- chemical fertilizer, T_6 : 1/3rd of recommended dose of phosphorus - press mud cake + 2/3rd of recommended dose of phosphorus- chemical fertilizer. The basal dose of N @ 25 kg ha^{-1}, *Rhizobium* and *PSB* @ 25g kg^{-1}seed each seed treatment was given to all the treatment. The total quantity of press mud cake and there composition was depicted in Table 1. The various yield parameters at harvest were recorded. The crop was harvested at their physiological maturity. The data on crop yield economics, moisture use efficiency (MUE) of grain which was computed as follows: grain yield (kg/ ha) / CUM (mm), Ph EC, organic carbon, soil available N, P and K were analyzed following the standard procedures (Jackson,1973). The soil of the experimental field was clay loam having organic carbon 0.49 %, available nitrogen 151 kg ha^{-1}, phosphorus 13 kg ha^{-1} and potash 620 kg ha^{-1}, EC 0.22 ds m^{-1} with pH 7.22.The data on yield and economics were recorded using standard procedures. The periodical soil moisture was determined by gravimetric method upto 45 cm (0-15cm, 15-30 and 30-45 cm) 15 days interval during the period of experimentation. It was converted into the soil water content (mm) on volume basis by considering the bulk density of the respective soil layers and depth and calculated as stated below.

$$\text{Soil water content (mm)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times \text{Bulk density} \times \text{Depth (cm)}$$

Moisture use efficiency (MUE) was calculated as ratio of grain yield (kg ha^{-1}) to the consumptive use of moisture (CUM) in mm and expressed as kg ha^{-1} mm^{-1}.

Nutrient composition on press mud -

The analytical data for the biocompost sample obtained from Siddeshwar Sugar Factory, Solapur showed that the values of pH- 8.05, EC- 11.20 dSm^{-1},nitrogen (1.66 %), phosphorus (2.25 %), potassium (1.9 %), calcium (3.2 %), magnesium(1.0 %), sulphur (1.2 %), copper 52 (mg kg^{-1}), zinc (mg kg^{-1}), manganese(mg kg^{-1}), iron-2000 (mg kg^{-1}), carbon 22.65(%), c/n ratio-(13.64), wax (0.3%) and moisture (70%).

Rainfall Pattern -

The rainfall distribution during 2010-11 to 2014-15 indicated that the total rainfall was surplus during 2010-11(+9.14%), 2011-12 (+5.59%) and deficit during 2012-13 (-25.98 %), 2013-14 (-7.64%) and 2014-15 (-16.28%). The deficit of rainfall either in *kharif* or *rab*i influenced the growth and yield of pigeonpea. The rainfall distribution at critical growth stages were depicted in Table 2.

RESULTS & DISCUSSION:

Grain and straw yield -

The effect of integrated phosphorus management was found significant for grain, straw, and moisture use efficiency for grain by pigeonpea depicted in Table 3. In the pooled means the significantly higher grain (9.07 q ha^{-1}) and straw (49.89 q ha^{-1}) yield of pigeonpea was obtained by application of 1/2 of recommended dose of phosphorus through press mud cake + 1/2 of recommended dose of phosphorus through chemical fertilizer. Straw yield was on par with 2/3 RD of phosphorus through press mud cake+ 1/3 RD of phosphorus-chemical fertilizer (46.73 q ha^{-1}) followed by RD of $N:P_2O_5$ (25:50 kg N:P ha^{-1})-chemical fertilizer (46.53 q ha^{-1}) and $1/3^{rd}$ RD of phosphorus - press mud cake + $2/3^{rd}$ RD of phosphorus - chemical fertilizer ha^{-1} (45.65 q ha^{-1}). However, grain yield was found statistically significant over rest of the treatments. The superiority of the dual application of phosphorous and bacterial inoculation may be due to the promoting effects of the microorganisms of the inoculants on the native and applied nutrients. As well as may be due to the important role of phosphorous for helping the development of more extensive root system and thus enabling plants to extract water and nutrients from deeper depth. This, in turn, could enhance the plants to produce more assimilates which was reflected in high yield and its component reported by Habbasha *et al.* (2007), Solaiappan and Ramiah (1990) and Nimje (1995).

Moisture Use Efficiency -

The moisture use efficiency for grain was recorded the highest (1.81 kg ha mm^{-1}) in 1/2 of recommended dose of phosphorus through press mud cake + 1/2 of recommended dose of phosphorus through chemical fertilizer. The least value of moisture use efficiency for grain was recorded in control treatment (1.26 kg ha^{-1} mm^{-1}). Addition of organic sources improved the soil physical properties thereby increased the porosity and infiltration rate and conserving the moisture with increased water holding capacity of the soil under dry land conditions. The results are conformity with Patil *et al.* (2006) and Sharma *et al.*(2010).

Soil Fertility Status -

The organic carbon, electrical conductivity and available N, P and K in soil were significantly influenced due to integrated phosphorus management treatment over control at harvest of pigeonpea depicted in Table 4. The application of $2/3^{rd}$ RD of phosphorus - press mud cake + $1/3^{rd}$ RD of phosphorus - chemical fertilizer ha^{-1} and recommended dose of phosphorus - press mud cake $^{-1}$ treatments recorded significantly higher organic carbon (0.68 %) which was on par with½ RD of phosphorus through press mud cake + ½ RD of phosphorus through chemical fertilizers. Whereas in case of available N, P and K content in soil the application of ½ RD of phosphorus through press mud cake + ½ RD of phosphorus through chemical fertilizers recorded significantly higher values of N, P and K (189, 19.03 and 642 kg ha^{-1}respectively) and it was on par with $2/3^{rd}$ RD of phosphorus through press mud cake + 1/3 RD rd of phosphorus through chemical fertilizer for N, P , K and 1/3 RD rd of P through press mud cake +2/3 RD rd of P through chemical fertilizer for K only. However, soil pH didn't show any significant result and soil electrical conductivity show significant result. More (1994) who reported that the application of organic manures (FYM, Poultry manure and pressmud) decreased the soil pH while increased the electrical conductivity (EC) of the soil. Integrated management of phosphorus in combination with PMC and chemical fertilizer improved maximum P status in soil as compare to N and K because it is rich source of P than N and K. Application of PMC and organic sources increased NPK status in soil where as treatment T_3, T_4 and T_5 registered higher organic carbon in soil at harvest. These results are in accordance with the findings of (Rangaraj et al., 2007) who reported in their research experiment that agro industrial wastes (pressmud, coirpith and farmyard manure) as organic manures favorably improved soil organic matter, microbial population and enhanced the soil macro (N, P, K) and micro nutrients (zinc, copper, manganese and iron).

CONCLUSION:

Application of 50% recommended dose of phosphorus fertilizer through press mud cake (1.0 t ha^{-1}) + 50% recommended dose of phosphorus through chemical fertilizer was beneficial for increasing pigeonpea yield, moisture use efficiency and improving nutrient fertility status of soil.

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Table 1: Quantity of composted press mud cake added.

Year	Total N (%)	Total P (%)	Total K (%)	Total C (%)	C:N	Quantity added for 50 kg P_2O_5 ha^{-1}
2010-11	2.39	2.40	2.72	25.79	10.79	2083
2011-12	1.26	2.23	1.46	20.13	15.98	2242
2012-13	1.21	2.45	1.40	20.03	16.55	2041
2013-14	1.76	2.12	2.06	22.55	12.81	2358
2014-15	1.67	2.05	2.31	24.74	14.81	2439
Mean	1.66	2.25	1.99	22.65	14.19	2233

Table 2: Year wise seasonal distribution of rainfall (2010-11 to 2014-15)

Sr. No.	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
1.	Pre- monsoon	60.7	6	91.7	7	32.7	8	68.9	4	153.3	11
2.	*kharif*	609.5	38	514.4	29	335.6	21	446	33	362.3	23
3.	*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.

Table 3. Effect of integrated phosphorus management on moisture use efficiency, grain and straw yield of pigeonpea

Tr. No.	**Grain yield (kg ha^{-1})**						**Straw yield (q ha^{-1})**						**MUE (kg ha^{-1} mm^{-1})**
	2010-11	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**Pooled Mean**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**Pooled Mean**	
T_1	6.86	5.97	5.91	5.82	5.74	6.06	46.1	41.4	20.88	30.80	27.65	33.37	1.26
T_2	9.33	9.46	7.21	7.83	7.65	8.30	60.0	62.6	25.41	45.55	39.16	46.54	1.65
T_3	7.55	7.85	6.44	7.54	7.18	7.31	49.9	53.6	23.86	42.09	36.32	41.15	1.41
T_4	7.93	8.94	7.45	8.33	8.39	8.21	53.6	60.8	26.08	48.08	45.08	46.73	1.66
T_5	7.77	10.62	8.34	9.53	9.10	9.07	53.5	65.8	27.73	52.71	49.72	49.89	1.81
T_6	8.27	8.69	7.34	8.01	7.44	7.95	58.7	61.6	25.02	44.99	37.96	45.65	1.61
SE$\pm$	0.26	0.41	0.23	0.42	0.45	0.26	2.83	2.15	0.83	2.04	2.33	1.61	-
CD 5%	0.79	1.24	0.69	1.27	1.36	0.76	8.51	6.50	2.44	6.14	7.01	4.76	-
CV(%)	10.54	15.60	10.44	10.72	11.93	-	13.67	-	-	10.99	11.83	-	-

T_1 : Control, **T_2** :Recommended dose of N:P_2O_5 (25:50 kg ha^{-1})-chemical fertilizer, **T_3** : Recommended dose of N:P_2O_5 (25:50 kg ha^{-1})-press mud cake, **T_4** : 2/3rd of recommended dose of phosphorus - press mud cake+ 1/3rd of recommended dose of phosphorus- chemical fertilizer,**T_5** : 1/2 of recommended dose of phosphorus - press mud cake+ 1/2 of recommended dose of phosphorus- chemical fertilizer, **T_6** : 1/3rd of recommended dose of phosphorus - press mud cake + 2/3rd of recommended dose of phosphorus- chemical fertilizer.

Table 4. Effect of integrated phosphorus management on soil fertility status at harvest of pigeonpea(pooled data of five years)

Tr.No.	pH (1:2.5)	Electrical conductivity (dS m^{-1})	Organic carbon (%)	Available nutrient (kg ha^{-1})		
				Nitrogen	Phosphorus	Potassium
T_1	7.30	0.33	0.53	140	8.99	580
T_2	7.37	0.35	0.64	166	14.81	623
T_3	7.30	0.36	0.68	156	16.41	611
T_4	7.29	0.30	0.68	184	17.67	635
T_5	7.33	0.32	0.66	189	19.03	642
T_6	7.32	0.34	0.62	178	16.86	636
SE$\pm$	0.026	0.01	0.01	1.42	0.50	6.05
CD 5%	NS	0.03	0.03	4.18	1.48	17.84

T_1 : Control, **T_2** :Recommended dose of N:P_2O_5 (25:50 kg ha^{-1})-chemical fertilizer, **T_3** : Recommended dose of N:P_2O_5 (25:50 kg ha^{-1})-press mud cake, **T_4** : 2/3rd of recommended dose of phosphorus - press mud cake+ 1/3rd of recommended dose of phosphorus-chemical fertilizer,**T_5** : 1/2 of recommended dose of phosphorus - press mud cake+ 1/2 of recommended dose of phosphorus-chemical fertilizer, **T_6** : 1/3rd of recommended dose of phosphorus - press mud cake + 2/3rd of recommended dose of phosphorus-chemical fertilizer.