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Effect of Integrated Phosphorus Management on Yield, Nutrient Uptake of Soybean Grown on 'P' Deficient Soil

K.S. Dhadave*, R.V. Kulkarni, R.B. Pawar, D.S. Patil and G.G. Khot

Division of Soil Science and Agriculture Chemistry, College of Agriculture, Kolhapur, Mahatma Phule Krishi Vidhyapeeth, Rahuri, Maharashtra, India

**Corresponding author*

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A B S T R A C T

The field experiment was conducted during *Kharif* 2017 at Post Graduate Research Farm, College of Agriculture Kolhapur with the view to study the effect of integrated phosphorus management for yield, nutrient uptake of soybean grown on "P" deficient soil. The soil of experimental site was slightly alkaline in reaction, low in available nitrogen, low in available phosphorus and very high in available potassium. The field experiment was carried out in randomized block design with three replications and seven treatments *viz.* absolute control (T_1), General recommended dose of fertilizer (T_2), 100 % P_2O_5 through PMC (T_3), 100 % P_2O_5 through DAP (T_4), 25 % P_2O_5 through PMC + 75 % P_2O_5 through DAP (T_5), 50 % P_2O_5 through PMC + 50 % P_2O_5 through DAP (T_6), 75 % P_2O_5 through PMC + 25 % P_2O_5 through DAP (T_7). The result indicated that the application of 25 % P_2O_5 through PMC + 75 % P_2O_5 through DAP (T_5) recorded significantly higher plant height, number of branches per plant, number of grains per plant, number of pods per plant, yield, nutrient uptake and quality of soybean.

Introduction

Soybean (*Glysine max* (L.) Merill) a leguminous crop is one of the leading oil and protein containing crop of the world, it contains 40- 44 % protein, 20 % oil, 3.3- 6.4 % ash and 24-26 % carbohydrate, besides, it also contains various vitamins and minerals. Soybean protein is rich in valuable amino acid lysine (5 %) and can be put to a number of uses. A large number of Indian and Western dishes such as bread, *chappati*, milk sweets, pastries, etc. can be prepared with soybean. Among grain legumes, it is an economically important crop that can be grown in diverse environments throughout the world. It is rich in minerals such as phosphorus, calcium and vitamins (Vitamins B, C and E). Its oil is used as a raw material in manufacturing of antibiotics, paints, adhesive, lubricants, etc. Soybean being richest, cheapest and easiest sources of best quality protein, fat and also having a vast multiplicity of uses as food and industrial product is sometimes called as "Wonder Crop".

It built up soil fertility by fixing large amount of atmospheric nitrogen through the root nodules and also through the leaf fall on the ground at maturity.

In legumes, phosphorus stimulates rhizobial activity, nodule formation and thus helps in nitrogen fixation. It increases the water use efficiency, improves taste, storage quality and skin hardness. As phosphorus plays key role in photosynthesis, respiration, energy storage and transfer, cell division and enlargement, it has been shown to be important for growth development and yield of soybean (Katkar *et al.,* 2002). Efficiency of 'P' fertilizer throughout the world is around 10-25 % (Isherword, 1998), phosphatic fertilizers have low efficiency of utilization due to fixation in soil (Gaur, 1990) and poor solubility of native soil phosphorus, sometimes there is a build-up of insoluble phosphorus as a result of chemical phosphorus fixation (Dubey, 1997).

Root development, stack and stem strength, flower and seed formation of crop maturity and production, crop quality and resistance to plant diseases are the attributes associated with phosphorus nutrition. Phosphorus deficiency can limit nodulation in legumes and 'P' fertilizer application can overcome the deficiency (Carsky *et al.,* 2001).

Diammonium phosphate (DAP) is the world's widely used phosphorus fertilizer, containing 18 % N and 46 % P_2O_5. Microorganisms play a key role in soil phosphorus availability to plant (Richardson, 2001). Press mud cake, a waste by product from sugar factories, is a soft spongy, amorphous and dark brown to brownish material containing sugar, coagulated colloids including cane wax, albuminoids, inorganic salt and soil particles. The press mud contains high percentage of organic carbon and it is a good source of organic matter, NPK and important micronutrients. It has established its importance in improving fertility, productivity and other physical properties of soil. The organic fraction of press mud cake contain 15-30 % fiber, 5-15 % crude protein, 5-15 % sugar, 5-15 % crude wax and fat, 10-20 % ash comprising oxides of Si, Ca, P, Mg and K (Diaz, 2016). This organic matter is highly soluble and readily available to the microbial activity in soil. In view of this, present investigation was undertaken on "Effect of integrated phosphorus management for yield, nutrient uptake of soybean grown on "P" deficient soil"

Materials and Methods

The experiment was conducted with seven treatments and three replication laid out in a randomized block design using soybean crop at Post Graduate Research Farm, College of Agriculture, Kolhapur, Maharashtra, India. The soil of the experiment site was sandy clay loam which was alkaline in reaction, low in available nitrogen (163.04 kg ha^{-1}), low in available phosphorus (10.28 kg ha^{-1}) and very high in available potassium (285.6 kg ha^{-1}). The treatments comprised of T_1: absolute control, T_2: General recommended dose of fertilizer, T_3: 100 % P_2O_5 through PMC, T_4: 100 % P_2O_5 through DAP, T_5: 25 % P_2O_5 through PMC + 75 % P_2O_5 through DAP, T_6: 50 % P_2O_5 through PMC + 50 % P_2O_5 through DAP, T_7: 75 % P_2O_5 through PMC + 25 % P_2O_5 through DAP. The organic source of phosphorus was press mud cake and inorganic source was Diammonium sulphur. Rhizobium and PSB were used as seed treatment (25g kg^{-2} seeds) for all treatments. N will be applied uniformly through urea to all treatments except control. At harvest, seed and straw yields were recorded. Plant samples were collected for chemical analysis of nitrogen, phosphorus, potassium in seed and straw samples. N was estimated by microkjeldahl method (Parkinson and Allen, 1975). For P and K, plant samples were digested in a diacid mixture and P in the extract was determined by vanadomolybdate yellow colour method (Piper, 1966) and K was estimated by flame photometer method (Chapman and pratt, 1961).

Results and Discussion

The data in Table 1 indicated that the plant height was found to be increased significantly due to integrated phosphorus management. The treatment T_5 recorded significantly highest plant height (83.38cm) but it was on par with T_2, T_4, T_6 and T_7. The treatment T_5 recorded significantly highest number of branches plant^{-1} (10.33) and it was on par with T_4 and T_6. The increase in plant height and number of branches plant^{-1} was due to integrated use of organic and inorganic phosphorus over control. These results were in confirmative with those reported by Maheshbabu *et al.,* (2008) application of recommended dose of fertilizer (40:80:25 N:P:K kg ha^{-1}) + FYM 5 t ha^{-1} in soybean recorded higher growth parameters, however it was at par with vermicompost (4 t ha^{-1}) + rock phosphate (176 kg ha^{-1})

The number of pods plant^{-1} of soybean increased significantly due to integrated use of phosphorus sources *viz*. organic and inorganic. The highest number of pods plant^{-1} recorded in treatment T_5 (77.67), however it was on par with T_2. The highest number of grains plant^{-1} was recorded in treatment T_5 (179.71). The all treatment showed increase in number of pods plant^{-1} and number of grains plant^{-1} except control. The similar types of results were obtained by Koushal and Parbjeet (2011) the highest number of pods plant^{-1} (80.40) in the treatment where 50 per cent recommended N applied through urea + 50 per cent N through FYM + PSB in soybean.

The grain and straw yield of soybean was increased significantly with the application of phosphorus in integrated manner through inorganic and organic sources. The significantly highest grain yield (27.68 q ha^{-1}) and straw yield (37.73 q ha^{-1}) was recorded in treatment T_5 and it was on par with T_2 and T_4. The significantly highest grain and straw yield obtained due to application of P_2O_5 through 75 % DAP and 25 % PMC. Because of use of phosphorus through organic and inorganic sources, there was proper supply of phosphorus throughout the growth stages of crop which might be probable reason. In case of grain and straw yield of soybean the all other treatments were superior over control. Jadhav *et al.,* (2011) reported that, application of NPK through 25 per cent organic + 75 per cent inorganic sources recorded the highest soybean grain yield (26.39 q ha^{-1}) and straw yield (15.09 q ha^{-1}) in integrated nutrient management.

The data in Table 2 indicated that the per cent N, P and K content of soybean increased due to integrated nutrient management of phosphorus through organic and inorganic sources. The highest N content recorded in grain was 7.00 % and in straw 0.51 % and in case of P content in grain was 0.55 % and in straw 0.23 % as well as K content recorded in grain was 1.62 % and in straw 1.50 %.

There was no significant effect of integrated nutrient management of phosphorus on nutrient concentration in grain and straw of soybean. Similar results obtained were corroborating with those reported by Devi *et al.,* (2012) and Dhage *et al.,* (2014).

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Table.1 Effect of integrated phosphorus management on growth and yield attributing characters and yield of soybean

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of grains plant^{-1}	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1 - Absolute control	65.90	7.07	31.67	80.40	18.48	25.37
T_2 - GRDF	76.55	9.33	72.37	140.35	24.54	34.87
T_3 - 100 % P_2O_5 through PMC	68.73	8.20	41.95	83.60	20.66	29.90
T_4 - 100 % P_2O_5 through DAP	76.44	9.73	68.13	131.47	25.36	34.97
T_5 - 25 % PMC + 75 % DAP	83.38	10.33	77.67	179.71	27.68	37.73
T_6 - 50 % PMC + 50 % DAP	74.13	9.67	63.80	102.73	23.37	32.79
T_7 - 75 % PMC + 25 % DAP	80.00	9.27	53.77	98.10	21.69	30.10
SE$\pm$	3.46	0.23	1.74	8.04	1.02	1.51
CD at 5 %	10.65	0.71	5.35	24.76	3.15	4.66

Table.2 Effect of integrated phosphorus management on per cent N, P and K content in grain and straw of soybean.

Treatments	Total N (%)		Total P (%)		Total K (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1- Absolute control	6.83	0.46	0.51	0.21	1.50	1.48
T_2- GRDF (General Recommended Dose of Fertilizer)	7.00	0.49	0.55	0.23	1.62	1.49
T_3- 100 % P_2O_5through PMC	6.97	0.47	0.52	0.22	1.51	1.48
T_4- 100 % P_2O_5 through DAP	6.98	0.50	0.53	0.23	1.57	1.49
T_5- 25 % PMC + 75 % DAP	6.99	0.51	0.55	0.23	1.60	1.50
T_6- 50 % PMC + 50 % DAP	6.86	0.48	0.53	0.23	1.59	1.49
T_7- 75 % PMC + 25 % DAP	6.89	0.47	0.52	0.22	1.55	1.48
SE$\pm$	0.13	0.21	0.01	0.03	0.03	0.01
CD at 5 %	NS	NS	NS	NS	NS	NS

Table.3 Effect of integrated phosphorus management on per cent NPK content in grain and straw of soybean

Treatments	N		P		K	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1 - Absolute control	130.02	11.58	9.20	5.42	27.10	37.46
T_2 - GRDF (General Recommended Dose of Fertilizer)	162.48	16.97	13.30	8.01	39.50	52.07
T_3 - 100 % P_2O_5 through PMC	141.56	13.97	10.37	6.64	31.55	44.27
T_4 - 100 % P_2O_5 through DAP	171.82	17.50	13.19	7.86	40.86	52.10
T_5 - 25 % PMC + 75 % DAP	183.12	19.25	15.73	8.82	45.35	56.60
T_6 - 50 % PMC + 50 % DAP	165.66	15.62	12.83	7.45	35.65	48.83
T_7 - 75 % PMC + 25 % DAP	144.67	14.15	11.09	6.88	34.83	44.66
SE$\pm$	3.37	0.73	0.51	0.37	1.49	2.36
CD at 5 %	10.39	2.26	1.56	1.14	4.58	7.26

Table.4 Effect of integrated phosphorus management on total uptake of NPK (kg ha^{-1}) and oil and protein content (%) in soybean

Treatments	N	P	K	Oil content	Protein content
T_1 - Absolute control	141.60	20.78	64.56	19.01	39.02
T_2 - GRDF (General Recommended Dose of Fertilizer)	179.45	30.27	91.57	19.76	39.97
T_3 - 100 % P_2O_5 through PMC	155.53	24.34	75.82	19.13	39.77
T_4 - 100 % P_2O_5 through DAP	189.32	30.69	92.96	19.93	39.87
T_5 - 25 % PMC + 75 % DAP	202.37	34.98	101.96	19.95	39.90
T_6 - 50 % PMC + 50 % DAP	181.28	28.45	84.48	19.51	39.15
T_7 - 75 % PMC + 25 % DAP	158.82	25.24	79.49	19.33	39.37
SE$\pm$	3.72	1.16	3.62	0.74	0.76
CD at 5 %	11.47	3.57	11.16	NS	NS

The data in Table 3 indicated that the uptake for N, P and K in grain and straw in soybean increased significantly due to integrated nutrient management of phosphorus through organic and inorganic sources. The significantly higher nitrogen uptake in grain (183.12 kg ha^{-1}) and in straw (19.25 kg ha^{-1}) was recorded in treatment T_5, in case of N content in straw treatment T_5 was on par with treatment T_4. Significantly higher phosphorus uptake in grain (15.73 kg ha^{-1}) and in straw (8.82 kg ha^{-1}) was recorded in treatment T_5, but P uptake in straw was highest in T_5 and it was on par with treatment T_2 and $T_4$and significantly higher potassium uptake from grain (45.35 kg ha^{-1}) and from straw (56.60 kg ha^{-1}) was recorded in treatment T_5, however it was on par with treatment T_4. The all other treatments were superior over control. It indicates that application of 'P' through organic and inorganic sources seems to be beneficial for availability of NPK nutrient in soil as well as for uptake by plants.

The data in Table 4 indicated that the total uptake of NPK of soybean increased significantly due to integrated phosphorus management through organic and inorganic sources. The significantly higher nitrogen uptake (202.37 kg ha^{-1}), phosphorus uptake (34.98 kg ha^{-1}) and potassium uptake (101.96 kg ha^{-1}) was recorded in treatment T_5. The potassium uptake highest in T_5 but it was on par with treatment T_2 and T_4. Increase in uptake of NPK might be due to proper management of key element phosphorus through organic and inorganic sources which was responsible for release of phosphorus in early growth stages of crop. Virkar and Thumbare (2011) reported application of recommended dose of fertilizers + 5 t FYM + bio fertilizers to soybean recorded significantly higher total uptake of nitrogen (225.54 kg ha^{-1}), phosphorus (30.08 kg ha^{-1}) and potassium (93.30 kg ha^{-1}) by seed and straw of soybean. Thakur *et al.*, (2009) found that, the uptake of nitrogen (113.64 kg ha^{-1}), phosphorus (9.38 kg ha^{-1}) and potassium (36.66 kg ha^{-1}) in seed as well as total uptake of nitrogen (140.82 kg ha^{-1}), phosphorus (13.28 kg ha^{-1}) and potassium (86.61 kg ha^{-1}) was maximum with application of 75 per cent of recommended dose of fertilizer coupled with phospho-compost @ 3 t ha^{-1} and was significantly superior over all other treatments.

The data in Table 4 indicated that the oil content of soybean was affected non-significantly due to integrated phosphorus management through organic and inorganic sources and it was ranged between 19.01 % and 19.95 %. The higher oil content (19.95 %) was recorded in treatment T_5. Jadhav *et al.*, (2007) reported that in soybean grain, higher crude protein (39.18 %) and per cent oil content (19.54 %) was recorded with combine application of organic, inorganic and bio fertilizers. The protein content of soybean was not affected significantly due to integrated nutrient management of phosphorus through organic and inorganic sources and it was ranged between to 39.02 % and 39.97 %. The highest protein content was recorded in treatment T_2 (39.97 %). These results were in close conformity with the findings reported by Khaim *et al.*, (2013) that is application of 75 % recommended dose of inorganic fertilizer + 1 t ha^{-1} poultry manure recorded higher protein and oil content in soybean than other treatments.

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