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Phosphorus Management in Greengram-Safflower Sequence on Shrink-Swell Soils of Maharashtra

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A study was conducted on phosphorus management in greengram-safflower sequence at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during 2006-2007 in shrink-swell soil. The twelve treatments and three replications designed in RBD consisted of 100% RDF (20:40:20 NPK kg ha^{-1} to greengram and 25:25:25 NPK kg ha^{-1} to safflower), 50% recommended P, No P, 50% recommended P + PSB (25 g kg^{-1} seed), 5 t FYM ha^{-1}, 5 t FYM ha^{-1} + PSB applied in various combinations to greengram in *kharif* and safflower in *rabi* season. The results indicated that the treatment receiving 50 per cent P (20 kg ha^{-1} to greengram and 12.5 kg ha^{-1} to safflower) + PSB along with recommended dose of nitrogen (20 kg ha^{-1} to greengram and 25 kg ha^{-1} to safflower) and potassium (20 kg ha^{-1} to greengram and 25 kg ha^{-1} to safflower) to greengram and safflower was found to be beneficial in improving the soil fertility status, comparable crop productivity and economic returns with 100 per cent recommended phosphorus to both the crops.

Key words: Greengram-Safflower, Phosphorous,soil fertility.

Phosphorus is one of the major essential element required by the crop and is the key nutrient for increasing productivity of pulses in general and legumes in particular. It plays an important role in uniform grain filling besides a constitutent of ADP and ATP energy bonds. In black cotton soils, phosphorus gets fixed as calcium and magnesium phosphate and become unavailable to crop. The requirement of P by legume crops is generally doubled than N and K. However, the utilization efficiency of P is very low compared to N and K. Phosphorus availability is a major nutritional constraint limiting crop production in the Vertisols of central India (Subba Rao *et al.,* 1998).

Legume-safflower cropping sequence is recommended for the Vertisols region for realizing higher production and profit besides improving soil fertility (Hegde, 2000). Appropriate nutrient management is the key to enhance safflower productivity in such cropping sequence on sustainable basis. Because of nitrogen fixation, legumes are independent for their nitrogen nourishment and leave a sustainable amount of nitrogen residues to succeeding crop. Safflower is an important oilseed crop of the semi-arid tropics. N and P deficiencies in Vertisol in which safflower is grown are common (Hegde, 2003). The component crops grown in a sequence remove considerable amount of nutrients from the soil.

Greengram (*Vigna radiata* L.) is an excellent source of high quality protein and high nutritional value among pulses. It occupies a prominent place and is gaining increasing popularity by virtue of its high nutritional value, short growth period, low production cost and adaptability to off season. The productivity of greengram and safflower crops is low in central India compared to National average. The reasons for this low productivity is imbalanced fertilization particularly P in a low native P black soils. Therefore present investigation was planned to study the phosphorus management on crop productivity, economics and residual soil fertility in greengram-safflower sequence on shrink-swell soils under semi-arid conditions of central India.

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Materials and Methods

The experiment was conducted on shrink-swell soil with twelve treatments with three replications laid out in a randomized block design using greengram (Kopergaon)–safflower (AKS-207) in cropping sequence as test crops at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2006-7. The soil was low in available nitrogen (181 kg ha^{-1}) and phosphorus (10.2 kg ha^{-1}) and high in available potassium (348 kg ha^{-1}).

Recommended doses of fertilizer (as per national recommendation) 20:40: 20 NPK kg ha^{-1} (greengram) and 25:25: 25 NPK kg ha^{-1} (safflower) and PSB 25 g kg^{-1} seed were applied. A common dose of recommended nitrogen and potassium was applied to all inorganic treatments. The farmyard manure was applied every year one month before sowing of the crop as per treatments. Soil samples (0-15 cm) from the experimental field were collected before sowing and after harvest of greengram and safflower in each treatment. These samples were analysed for organic carbon by rapid titration method (Walkley and Black, 1934), available N by alkaline permanganate method (Subbiah and Asija, 1956). Available P was estimated by Olsen's method (Olsen *et al*., 1954) and available K by ammonium acetate extraction method (Jackson, 1967).

Results and Discussion

Grain and straw yield of greengram

The grain yield(Table 1) was significantly higher i.e. (9.90 q ha^{-1}) in treatment T_2 receiving 100% P and it was found to be at par with most of the treatments except treatments receiving 50 per cent P (T_3 and T_4) and control (T_1 and T_6) treatments. The treatment T_6 (control) recorded the lowest grain yield (7.83 q ha^{-1}).

The highest straw yield (9.85 q ha^{-1}) was recorded with the application of 100% P (T_{10}) and it was found at par with the treatments T_2, T_9, T_{11}, T_5 and T_{12}. The lowest straw yield (6.56 q ha^{-1}) was observed in control. The higher grain and straw yields observed in the treatments T_2 and T_{10} receiving 100 % P, might be due to phosphatic fertilizer (100%) which helps to increase the yield of legumes by mobilizing the unavailable P in soil and make it available to crop. The results are in conformity with Sarkar *et al*. (1993) and Singh and Pareek (2003).

Seed and straw yield of safflower

The data presented in Table 1 showed that the seed yield of safflower was significantly higher (13.35 q ha^{-1}) in treatment T_8 receiving 100% P and it was found to be at par with the treatments T_7, T_2, T_5, T_3, T_{12} and T_6. The lowest seed yield (9.46 q ha^{-1}) was recorded in treatment T_1(control).

Table 1. Effect of phosphorus management on grain and straw yield (q ha^{-1})of greengram and safflower

S. No.	Treatment		Greengram		Safflower	
	Greengram	Safflower	Grain	Straw	Seed	Straw
T_1	Control	Control	7.91	6.56	9.46	33.89
T_2	100% P	100% P	9.90	9.50	12.40	42.09
T_3	50% P	100% P	8.45	7.01	12.12	42.23
T_4	50% P	50% P	8.30	7.73	11.17	40.60
T_5	50% P + PSB	50% P + PSB	8.81	9.06	12.15	43.26
T_6	Control	100% P	7.83	7.17	11.90	44.64
T_7	5 t FYM ha^{-1}	100% P	8.46	7.69	13.16	44.6
T_8	5 t FYM/ha + PSB	100% P	8.70	7.93	13.35	44.15
T_9	100% P	50% P	9.79	9.50	10.08	41.81
T_{10}	100% P	Control	9.57	9.85	10.55	39.53
T_{11}	100% P	5 t FYM ha^{-1}	9.48	9.24	11.48	40.57
T_{12}	100% P	5 t FYM ha^{-1} + PSB	9.59	8.96	11.76	41.55
			0.49	0.53	0.63	1.11
			1.44	1.56	1.86	3.25

The highest straw yield (44.64 q ha^{--1}) was recorded in treatment T_6 receiving 100% P and it was found at par with most of the treatments except treatments T_4 and T_{11} receiving 50% P and 5 t FYM ha^{-1} and treatment T_1 and T_{10} (control). While the lowest straw yield (33.89 q ha^{-1} and 39.53 q ha^{-1}) was found in treatments T_1 and T_{10} (control) respectively. The similar results were also reported by Kumpawat (2006).

Economics of various treatments in greengram-safflower sequence

The data in respect of gross monetary return (GMR), cost of cultivation (CC), net monetary return (NMR) and benefit cost ratio (B:C) as influenced by different treatments are presented in Table 2. The highest GMR (Rs. 50562) was obtained in treatment T_2 receiving 100% P to both crops, followed by treatment T_{12} (Rs. 48521) which received 100% P to greengram and 5 t FYM with PSB to safflower. The lowest GMR (Rs. 39629) were obtained in control treatment (T_1). Similarly, highest NMR (Rs. 37784) was obtained in treatment T_2 followed by T_9 (Rs. 35518), while lowest NMR (Rs.21164) was obtained in control.

The trend of various treatments in respect of B:C ratio was similar to that of GMR, NMR and productivity also. The highest B:C ratio (4.0) was obtained in treatment T_2 and T_{10} receiving 100% P to both crops. The increase in B:C ratio was ascribed to significant increase in productivity of crops over other treatments. The results are in conformity with the findings of Tomar and Tiwari (1990) and Jadhao *et al*. (1994).

Higher crop productivity and maximum B:C ratio were obtained in treatments receiving 100 per cent recommended P followed by 50 per cent P + PSB to both crops.

Fertility status of soil at harvest of greengram

Organic carbon is an indication of organic fraction in soil formed due to the microbial decomposition of organic residue. The data (Table 3) pertaining to the organic carbon content of soil as influenced by different treatments was statistically non significant and it ranged from 4.6 to 5.2 g kg^{-1} indicating that the highest (5.2 g kg^{-1}) organic carbon content was recorded in treatments T_5 and T_8 (50 per cent P + PSB and 5 t FYM ha^{-1} + PSB, respectively). This might

Table 2. Effect of phosphorus management on economics of greengram-safflower sequence

S. No.	Treatment: Greengram	Treatment: Safflower	Total productivity	GMR Rs. ha^{-1}	CC Rs. ha^{-1}	NMR Rs. ha^{-1}	B:C ratio
T_1	Control	Control	1736	39629	10565	29164	3.7
T_2	100% P	100% P	2233	50562	12775	37784	4.0
T_3	50% P	100% P	2054	45306	12338	32968	3.7
T_4	50% P	50% P	1947	43499	12065	31434	3.6
T_5	50%P+ PSB	50% P + PSB	2099	46695	12265	34430	3.9
T_6	Control	100% P	1972	43069	11533	31436	3.7
T_7	5 t FYM ha^{-1}	100% P	2166	47137	14033	33104	3.4
T_8	5 t FYM ha^{-1}+ PSB	100% P	2202	47969	14133	33836	3.4
T_9	100% P	50% P	2084	48018	12502	35518	3.9
T_{10}	100% P	Control	2015	46703	11807	35096	4.0
T_{11}	100% P	5 t FYM ha^{-1}	2098	47809	14307	33502	3.3
T_{12}	100% P	5 t FYM ha^{-1} + PSB	2135	48521	14407	34114	3.4

be due to PSB inoculation. Malewar and Hasnabade (1995) also recorded maximum organic carbon in the treatments containing chemical feritlizers combined with biofetilizers.

The available N status of soil was significantly influenced by different treatments. The highest available N (215 kg ha^{-1}) was observed in treatment T_5 (50 % P + PSB) which was found at par with treatment T_{11}, T_{12} and T_2 while, lower values of available N (179 and 180 kg ha^{-1}) were observed in control treatments T_1 and T_6 respectively. The higher values of available N over the initial value might be due to symbiotic nitrogen fixation, which improve the available nitrogen status in soil by growing leguminous crop like greengram. The residual effect of leguminous crops improves the total and available nitrogen status of soil (Sharma *et al.,* 1986).

The available P status of soil at harvest of greengram was found superior (15.3 kg ha^{-1}) in treatment of 50% P + PSB (T_5) followed by treatment T_{12} (15 kg ha^{-1}). This might be due to PSB, which enhances the availability of phosphorus, which favoured the root growth by development of phosphorus solubilizing microorganisms in root zone of crop. However, all 100% P (T_2, T_9, T_{10}, T_{11} and T_{10}) treatments were found to be at par with the treatment T_5. Similar results were also given by Abraham and Lal (2003).

Table 3. Effect of phosphorus management on residual soil fertility after harvest of greengram and safflower

	Treatment		OC	Available nutrients (kg ha^{-1})			OC	Available nutrients (kg ha^{-1})		
	Greengram	Safflower	(g kg^{-1})	N	P	K	(g kg^{-1})	N	P	K
T_1	Control	Control	4.6	179	10.3	347	4.7	178	9.8	351
T_2	100% P	100% P	4.8	213	14.2	389	4.9	218	13.2	395
T_3	50% P	100% P	4.9	197	11.7	379	5.1	220	13.6	391
T_4	50% P	50% P	4.9	199	11.5	375	4.9	199	11.8	388
T_5	50% P + PSB	50% P + PSB	5.2	215	15.3	390	5.5	228	14.3	411
T_6	Control	100% P	4.6	180	10.3	349	4.8	218	13.9	365
T_7	5t FYM ha^{-1}	100% P	5.0	195	12.4	350	5.2	220	14.3	381
T_8	5t FYM ha^{-1}+ PSB	100% P	5.2	199	14.4	362	5.4	221	14.0	390
T_9	100% P	50% P	4.8	204	14.6	387	4.9	218	11.1	406
T_{10}	100% P	Control	4.9	210	14.8	384	4.9	217	9.8	395
T_{11}	100% P	5 t FYM ha^{-1}	5.0	215	14.9	388	5.1	221	12.3	410
T_{12}	100% P	5 t FYM ha^{-1} + PSB	4.9	214	15.0	380	4.9	223	13.5	403
	SE(m)$\pm$		0.01	1.3	0.4	3.8	0.01	1	0.2	1
	CD at 5%		NS	3.6	1.3	11	0.03	3	0.5	4

The highest available K (390 kg ha^{-1}) in soil was observed in treatment T_5 receiving 50% P + PSB and it was found to be at par with the treatments T_2, T_{11}, T_9, T_{10} and T_{12}, receiving 100% P. The treatment T_1 recorded the lowest K content in soil (347 kg $ha^{-1)}$. Similar trends were also reported by Abraham and Lal (2003).

Fertility status of soil at harvest of safflower

The inclusion of legumes in cropping system significantly improved the soil fertility. The data presented in Table 4 revealed that the fertility status of soil after harvest of safflower was significantly influenced due to incorporation of organic manures and inorganic fertilizers along with biofertilizer. The organic carbon content of experimental site at harvest of safflower responded significantly to integrated phosphorus management and ranged from 4.7 to 5.5 g kg^{-1}. The higher organic carbon content (5.5 g kg^{-1}) was recorded in treatment T_5 (50% P + PSB) and was found superior to all other treatments. The higher values of organic carbon content at harvest of safflower might be due to residual effect of greengram grown in kharif season. These results are in conformity with the results recorded by Thomas and Lal (2003).

The available N in soil at harvest of safflower varied from 178 to 228 kg ha^{-1}. The maximum available N (228 kg ha^{-1}) was observed in treatment T_5 (50% P + PSB) which was superior over all treatments. This might be due to synergistic effect of biofertilizers. The lowest available N (183 kg ha^{-1}) was noticed in treatment T_1. Similar trend increase in available N was reported by Sharma *et al*. (1986) and Singh *et al*. (1996).

The data indicated that the different treatments had significant effect on the available phosphorus status of soil which ranged between 9.8 to 14.3 kg ha^{-1}. The highest available phosphorus (14.3 kg ha^{-1}) was observed in treatment T_5 receiving 50% P + PSB. This might be due to beneficial effect of seed inoculation with PSB which improved the available P status in soil by increasing fertilizer use efficiency. However, treatments T_7, T_8 and T_6 (100% P) were found to be at par with treatment T_5. Similar results were also reported by Carrie and Lamb (2003).

The data on available potassium status of soil at harvest of safflower varied significantly from 351.28 to 410.08 kg ha^{-1}. The highest available K status (410 kg ha^{-1}) was found in treatment T_5 receiving 50% P + PSB and it was found statistically at par with treatment T_{11} (5 t FYM ha^{-1}). Meshram *et al*. (2004) also recorded similar results.

Hence, it can be concluded that the treatment receiving 50 per cent P (20 kg ha^{-1} to greengram and 12.5 kg ha^{-1} to safflower) + PSB along with recommended dose of nitrogen (20 kg ha^{-1} to greengram and 25 kg ha^{-1} to safflower) and potassium (20 kg ha^{-1} to greengram and 25 kg ha^{-1} to safflower) to greengram and safflower was found to be beneficial in improving the soil fertility status, and obtaining higher crop productivity and economic returns.

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