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RESEARCH ARTICLE :

Effect of organic manuring and fertilization on soil fertility, yield attributes and productivity of soybean - safflower cropping system in Vertisol

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SUMMARY : Field experiments were conducted on Long-term fertilizer management at Research farm, Department of Soil Science and Agricultural Chemistry, VNMKV, Parbhani to study the effect of organic manures and fertilization on soil fertility and productivity under soybean-safflower cropping system since 2006-07 to 2012-13 on Vertisols. The 7th cycle data revealed that, the grain (26.58 and 18.52 q ha^{-1}) and straw (32.05 and 47.92 q ha^{-1}) yield of soybean and safflower were highest with 100% NPK+FYM@ 5 t ha^{-1} than other treatments. Similarly, increasing height, number of pods and number of capsules were observed significantly with NPK + FYM than other management practices. However, the sustainability yield index (SYI) of soybean and safflower were also recorded maximum with 100 % NPK + FYM @ 5 t ha^{-1} towards with 150% NPK. In contrast to soil fertility, significant enhancement in availability of N, P and K over its initial status with the application of optimal dose of fertilizer having 100 % NPK + FYM @ 5 t ha^{-1}, whereas availability of S and Zn was maintained by this treatment as compare to other. However, a significant build up of available Zn due the supply of zinc sulphate along with 100% NPK was noticed. On the basis of B : C ratio the treatment 100 % NPK + FYM @ 5 t ha^{-1} most beneficial for farmers than other treatment.

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BACKGROUND AND OBJECTIVES

Oilseeds occupy a significant place in India's national economy, next only to food grains. In India, oilseed production increased from a mere 10.83 mt in 1985-86 to 25.6 mt in 2012-13(Anonymous, 2013). Higher doses of chemical fertilizers and agricultural chemicals but insufficient use of organics leads to negative results on fertility, productivity and sustainability of soil. There is negative relationship between use of fertilizers and their rising prices particularly for small and marginal farm holders. Regular and prolonged exploitation of soil resources for crop cultivation without addition of fertilizers and inadequate supply of fertilizers creates nutrient imbalance in the soil. By and large, Indian soils showed either deficiency or

inadequacy in cluster of major and micronutrients. Augmentation or restoration of soil productivity can be achieved through addition of chemical fertilizer (off farm input), organic manures, wastes and residues as well as by improving nutrient cycling and propagation of nutrients efficient on farm inputs/cultivars. In this context the concept of integrated plant nutrient supply can be sound practice for sustainable agriculture (Katkar *et al.* 2006). Continuous application of organic and inorganic fertilizers on soybean and safflower shows that achieving nutritional balance between these two inputs results in better soil productivity and functionality than using either of them singly. The major role of organic material when combined with inorganic fertilizer is to increase the nutrient use efficiency of the inorganic fertilizer. Long-term fertilizer experiments (LTFE) give the valuable information of continuous application of fertilizer and manure in alone or in combination under intensive cropping systems. These experiments can be used for precise monitoring of changes in soil fertility and productivity and could be of paramount help in solving the complex problems (viz, nutrient mining, deficiency of nutrients, fixation of nutrients etc.) related soil fertility management. There is an apprehension that the use of chemical fertilizers over the years may impair soil fertility (Thakur *et al.*, 2011). Although, only use of chemical fertilizers is the fastest way of replenishing the nutrient depletion, but escalating fertilizer prices and limited inputs availability deter the farmers from using these inputs to the required level. Conjoint use of organic manures with chemical fertilizers is very essential as this not only higher the level of productivity but also improved soil health and enhanced nutrient use efficiency (Verma *et al.*, 2005). As information is lacking particularly in soybean-safflower system on effect of organic manure and fertilization on soil fertility and productivity by the crops under Long-term fertilizer experiment, hence the study was undertaken.

RESOURCES AND METHODS

The Long-Term Fertilizer Experiment was started in 2006-07 at Research Farm (76°46' E longitude and 19°16' N latitude and an elevation of 408.46 m above the mean sea level) Department of Soil Science and Agricultural Chemistry, with soybean-safflower cropping system. The farm represented semiarid tropic region with the hot summers and mild winters and the annual maximum temperature during study areas (2012-13) ranged from 29.1°C to 42°C and minimum temperature ranged 9.2°C to 27.8°C in the month of December and May in the year 2012-13. A total annual rainfall was 720.5 mm. The experiment framed in randomized block design (RBD) with twelve treatments and four replications. The treatments consisting *viz.*, T_1-50% NPK, T_2-100%NPK, T_3-150% NPK, T_4-100% NPK+ Hand weeding, T_5-100% NPK+25 kg $ZnSO_4$ ha^{-1}, T_6-100% NP, T_7-100% N, T_8-100% NPK+FYM@ 5 t ha^{-1}, T_9-100% NPK-Sulphur, T_{10}-Only FYM@ 10 t ha^{-1}, T_{11}-Absolute control and T_{12}-Fallow. The crops soybean and safflower were raised during *kharif* and *rabi season,* respectively with recommended package of practices. Soybean and safflower crops were sown with (45 to 5 cm) and (45 to 10 cm) spacing between row to row and plant to plant, respectively. The 100% NPK was 30:60:30 kg ha^{-1} for soybean and 60:40:00 kg ha^{-1} for safflower, respectively. The fertilizers used were urea, single super phosphate (SSP) and muriate of potash. FYM was applied before 15 days of sowing only for rainy season crop and NPK applied through straight fertilizers urea, single super phosphate and muriate of potash as per treatments. Whereas, in T_9 treatment diammonium phosphate was used in place of SSP to avoid sulphur application. In T_4 treatment only two hand weeding were taken for weed control, without use of any weedicide. Inorganic fertilizers were applied as per recommended dose of fertilizer and micronutrients through chemical fertilizer $ZnSO_4.5H_2O$ and FYM was incorporated @ 5 Mg ha^{-1} at sowing time in *Kharif* season only. The soil of experimental field was Clayey in texture and alkaline reaction with pH 8.1, EC 0.218 dSm^{-1}, organic carbon 5.50 g kg^{-1} and free $CaCO_3$ content 8.5 %. The initial status of available N, P_2O_5, K_2O and S were 216.0, 16.0, 766.0 and 30.50 kg ha^{-1}, respectively, whereas available Zn was 0.98 mg kg^{-1} before start of the study during *Kharif* season 2006-07. All the properties of soil and plant were determined by standard methods of soil and plant analysis Jackson (1973)**.** The data was subjected to statistical analysis by the method described by Panse and Sukhatme (1985). In the present study, the average yield of soybean and safflower crops individually and sustainability yield index (for 2012-13 considering average and equivalent soybean and safflower grain yield) for each treatment were defined as the goals because the farmers like to get more productivity from each unit land using following equation stated by (Singh *et al.*, 1990; Sharma *et al.*, 2005).

$$SYI\ Z \frac{Y\ J \pm}{Y_{max}}$$

Where, '*Y*' was average yield of the treatment, '*ó* 'was treatment standard deviation and Y_{max} was maximum yield in the experiment over the year.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

Crop productivity, Yield attributes Economics and Sustainability :

The conjunctive use of organic manures with chemical fertilizers *i.e.* 100%NPK+FYM@ 5 t ha^{-1} recorded highest grain and straw yield of soybean and safflower (*viz.* 26.58 and 18.52 q ha^{-1}, grain) and (*viz.* 32.05 and 47.92 q ha^{-1} straw) as compared to chemical fertilizer treatments T_3 and T_5 *i.e.*150% NPK and100% NPK + $ZnSO_4$@ 25 kg ha^{-1} but these treatments were found at par with each other. However, lowest yield was noted in T_{11} *i.e.* absolute control treatment. Moreover, maximum height, number of pods and number of capsules

Table 1 : Productivity and sustainability of soybean and safflower as influenced by different nutrient management practices under soybean-safflower cropping sequence

Treatments details	Soybean yield (q ha^{-1})		Safflower yield (q ha^{-1})		Sustainable yield index (SYI)		
	Grain	Straw	Grain	Straw	Soybean	Safflower	Soybean + Safflower
T_1-50%NPK	20.36	23.82	14.93	40.15	0.509	0.605	0.554
T_2-100%NPK	23.85	28.20	16.60	44.84	0.626	0.669	0.650
T_3-150%NPK	26.30	31.49	18.36	48.99	0.713	0.802	0.755
T_4-100%NPK+HW	23.66	27.48	16.35	44.42	0.631	0.650	0.645
T_5-100%NPK+Zn	24.84	30.16	17.13	46.37	0.653	0.708	0.681
T_6-100%NP	22.51	27.25	14.75	40.96	0.546	0.634	0.588
T_7-100%N	14.20	18.79	11.81	33.22	0.164	0.316	0.231
T_8-100%NPK+FYM	26.58	32.05	18.52	47.92	0.781	0.819	0.803
T_9-100%NPK (-) S	22.99	27.95	15.34	41.42	0.560	0.626	0.593
T_{10}-FYM	19.62	24.21	13.15	34.96	0.426	0.511	0.467
T_{11}-Control	11.62	14.70	10.78	28.91	0.156	0.295	0.218
Mean	21.50	26.01	15.25	41.09	-	-	-
SE ±	0.96	1.09	0.68	2.01	-	-	-
CD (P=0.05)	2.68	3.05	1.91	5.60	-	-	-

Table 2 : Productivity and sustainability of soybean and safflower as influenced by different nutrient management practices under soybean-safflower cropping sequence (Pooled)

Treatments details	Soybean height (cm)	Safflower height (cm)	No. of pods plant^{-1}	No of capsules plant^{-1}
T_1-50%NPK	36.13	75.49	29.56	16.14
T_2-100%NPK	46.93	78.63	36.79	17.80
T_3-150%NPK	48.27	81.33	44.86	23.44
T_4-100%NPK+HW	44.69	77.61	41.38	19.75
T_5-100%NPK+Zn	45.81	78.95	42.79	21.23
T_6-100%NP	42.47	75.60	36.21	19.87
T_7-100%N	28.60	63.72	18.75	15.81
T_8-100%NPK+FYM	50.54	79.58	47.47	24.54
T_9-100%NPK (-) S	40.71	75.21	34.72	17.68
T_{10}-FYM	31.03	74.56	33.84	18.16
T_{11}-Control	25.68	67.51	15.38	14.87
Mean	40.08	75.29	34.70	19.03
S.E. ±	1.63	3.02	1.67	0.98
CD (P=0.05)	4.73	8.72	4.84	2.84

were observed significantly with NPK + FYM than other management practices. Treatment T_3 and T_5 were found to be closely at par with each other. On the basis of B : C ratio the treatment 100 % NPK + FYM @ 5 t ha^{-1} most beneficial for farmers than other treatment. In case of only inorganic application of 150 % NPK was found to be more B : C ratio than other treatment and most feasible for farmers. Applying organic manures with chemical fertilizers *i.e.* 100 % NPK+FYM@ 5 t ha^{-1} recorded significantly more SYI (0.781, 0.819 and 0.803) as compared to chemical fertilizer treatments T_3 and T_5 *i.e.*150% NPK and 100% NPK + $ZnSO_4$@ 25 kg ha^{-1} for sustainability yield index (SYI) of soybean, safflower and soybean + safflower (Table 1, 2 & 3). The data

Table 3 : Soybean and safflower gross monetary returns, net monetary return and benefit cost ratio as influenced by different nutrient management practices

Tr. No.	Treatment details		Monetary return of soybean (Rs ha^{-1})			Monetary return of safflower (Rs ha^{-1})			Pooled B:C Ratio
	Soybean	Safflower	GMR	NMR	B:C ratio	GMR	NMR	B:C ratio	
T_1	50%NPK	50%NP	54972.83	31812.83	2.37	44756.44	26177.44	2.41	2.39
T_2	100%NPK	100%NP	63868.42	39698.42	2.64	48406.82	28988.82	2.49	2.57
T_3	150%NPK	150%NP	70398.24	45218.24	2.80	55980.73	35723.73	2.76	2.78
T_4	100%NPK+ HW	100%NP+ HW	64177.96	39307.96	2.58	47339.02	27921.02	2.44	2.51
T_5	100%NPK+Zn	100%NP+ Residual Zn	65865.69	41115.69	2.66	50592.08	31174.08	2.61	2.63
T_6	100%NP	100%NP	57788.17	33850.17	2.41	46411.94	26993.94	2.39	2.40
T_7	100%N	100%N	28905.14	6391.14	1.28	28267.66	10799.66	1.62	1.45
T_8	100%NPK+FYM	100%NP+Residual FYM	75557.24	48187.24	2.76	56957.48	36700.48	2.81	2.79
T_9	100%NPK-S	100%NP-S	58856.82	34693.82	2.44	45948.40	26491.40	2.36	2.40
T_{10}	FYM	Residual FYM	48737.81	23737.81	1.95	39425.73	21785.73	2.24	2.09
T_{11}	Absolute control	Absolute control	28330.28	6060.28	1.27	27108.81	9468.81	1.54	1.40
Mean			56132.60	31824.87	2.29	44654.10	25656.83	2.33	2.31
S.E. ±			3521.11	3521.11	0.15	2283.13	2283.13	0.12	0.11
C.D. (P=0.05)			10169.70	10169.70	0.45	6594.17	6594.17	0.35	0.32

Table 4 : Soil fertility status after harvest of 7th cycle as influenced by different nutrient management practices under soybean-safflower cropping sequence (2013)

Treatment details	pH	Change	EC	Change	OC (g kg^{-1})	Change	Available nutrients (kg ha^{-1})								DTPA Zn (mg kg^{-1})	Change
							N	Change	P_2O_5	Change	K_2O	Change	S	Change		
T_1-50%NPK	8.11	+0.01	0.233	+0.015	5.87	+0.37	219.06	+3.06	16.37	+0.37	766.65	+0.65	25.46	-5.04	0.77	-0.21
T_2-100%NPK	8.15	+0.05	0.245	+0.027	6.05	+0.55	228.78	+12.78	17.89	+1.89	775.49	+9.49	28.12	-2.38	0.81	-0.17
T_3-150%NPK	8.21	+0.11	0.253	+0.035	6.32	+0.82	253.85	+37.85	19.61	+3.61	805.69	+39.69	31.33	+0.83	0.79	-0.19
T_4-100%NPK+HW	8.16	+0.06	0.234	+0.016	6.21	+0.71	226.48	+10.48	18.10	+2.1	775.40	+9.4	28.22	-2.28	0.82	-0.16
T_5-100%NPK+Zn	8.19	+0.09	0.245	+0.027	6.23	+0.73	233.56	+17.56	18.47	+2.47	776.33	+10.33	29.31	-1.19	1.33	+0.35
T_6-100%NP	8.17	+0.07	0.239	+0.021	5.63	+0.13	223.39	+7.39	18.05	+2.05	766.15	+0.15	25.73	-4.77	0.76	-0.22
T_7-100%N	8.14	+0.04	0.232	+0.014	5.54	+0.04	214.56	-1.44	15.56	-0.44	753.55	-12.45	23.21	-7.29	0.74	-0.24
T_8-100%NPK+FYM	7.95	-0.15	0.235	+0.017	6.62	+1.12	269.67	+53.67	19.90	+3.9	810.35	+44.35	32.13	+1.63	1.08	+0.1
T_9-100%NPK (-) S	8.16	+0.06	0.231	+0.013	5.64	+0.14	228.04	+12.04	17.81	+1.81	767.19	+1.19	23.10	-7.4	0.78	-0.2
T_{10}-FYM	7.90	-0.2	0.215	-0.003	6.43	+0.93	227.52	+11.52	19.28	+3.28	768.42	+2.42	30.12	-0.38	0.93	-0.05
T_{11}-Control	8.15	+0.05	0.225	+0.007	5.45	-0.05	182.36	-33.64	12.71	-3.29	734.71	-31.29	22.37	-8.13	0.69	-0.29
T_{12}-Fallow	8.08	-0.02	0.226	+0.008	5.54	+0.04	208.45	-7.55	15.92	-0.08	765.26	-0.74	24.39	-6.11	0.87	-0.11
Mean	8.11	-	0.234	-	5.96	-	226.31	-	17.47	-	772.10	-	26.96	-	0.86	-
S.E. ±	0.023	-	0.0035	-	0.049	-	4.67	-	0.36	-	6.08	-	0.43	-	0.006	-
CD (P=0.05)	0.068	-	0.010	-	0.141	-	13.46	-	1.04	-	17.52	-	1.23	-	0.018	-
Initial	8.10	-	0.218	-	5.50	-	216.00	-	16.00	-	766.00	-	30.50	-	0.98	-

indicated that imbalanced fertilizer application and no fertilization caused decline in SYI due to decline in soil quality (*i.e.* continuous nutrient mining reflects decline in content of quality indicators of soil), which is also evident from the data on physical, chemical and biological properties of soil which could not sustain the yields of soybean and safflower. According to Kang *et al*. (2005) additional application of FYM@ 10 t ha^{-1} before sowing of corn made the system more sustainable than application of 100% NPK under corn-wheat cropping system in *Typic Ustochrept.* The higher grain yield due to inorganic and in combination with organic sources along with FYM might be due to sustained nutrient supply and also as a result of better utilization of applied nutrients by contributing higher biomass and involved in nutrient transformation and fixation (Murthy, 2011; Naik *et al.* 2012).

Soil fertility :

The long-term data indicated that to build up of soil fertility *vs.* pH, EC, OC, available NPKS and Zn were significantly improved with the integrated use of FYM and recommended dose of fertilizer (100% NPK) as compared to the other treatments (Table 2). However, maximum contribution of Zn (+0.35) was recorded with the supplying 25 kg $ZnSO_4$ ha^{-1} along with 100% NPK but depletion of Zn in soil due to unused any Zn sources. Continuous growing of soybean-safflower without application of sulphur containing fertilizers (100%NPK-Sulphur *i.e.* use of 100 % N-Urea, P-DAP, K-MOP) caused decline in available S (-7.4) in the soil followed by and 100% N alone (-7.29) and 50% NPK (-5.04), whereas absolute control treatment was noticed higher reduction in available S (-8.13). Further, the application of recommended dose of fertilizer with organic manure *i.e.* 100% NPK+FYM@ 5 t ha^{-1} to soybean crop followed by 100% NPK to safflower contributed considerably higher balance in available S (+1.63) over its initial status than other treatments. Continuous application of 100% N alone and 50% NPK caused an increase in yield over control but response exhibited declining yield with time due to imbalance use of nutrients (Table 4). Katkar *et al*. (2011) had conducted a long term experiment initiated in 1988 at Akola (MS) with sorghum-wheat cropping system on Vertisol. After 20 years of experimentation, they observed slight decrease in pH and EC of soil, whereas they noticed increase in organic carbon, availability of N, P, K and S significantly with the application of 100% NPK + FYM@ 10 t ha^{-1} over control. Thakur *et al*. (2011) in long-term fertilizer experiments with soybean-wheat cropping sequence in Vertisols, found that conjoint use of FYM with 100% NPK significantly improved organic carbon content and available N, P, K, S and Zn status of soil over its initial values, thereby indicating significant contribution towards sustaining the soil health.

Conclusion :

It can be concluded from the above finding that under continuous cropping with soybean-safflower system over 7 year, conjoint use of organic manure (FYM) along with 100% NPK was significantly superior over rest of the treatments with respect to sustainable crop productivity, higher monetary return and buildup soil fertility. Amongst different nutrient management supply systems, application of only chemical fertilizers 150% NPK was also noted to be better option for nutrient management through inorganics for carbon improvement in soil and more economical Vertisols.

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