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Research Article

Influence of integrated nutrient management on yield, soil fertility status and changes in soil microbial population in soybean (*Glycine max*) - safflower (*Carthamus tingtrous*) sequence cropping

B.K. ARBAD AND SYED ISMAIL

Abstract : To study the effect of various fertilizer doses and FYM in soybean-safflower cropping system on soil properties, yield and soil microbial population the soil samples were drawn from the Research farm, Marathwada Agricultural University, Parbhani with an objective to study changes in soil quality and crop productivity under soybean safflower cropping system included with various combinations of N, P, K, Zn, S fertilizers with or without FYM treatments. Results from the study showed that significantly highest grain yield of soybean (28.47 q ha^{-1}) and safflower (16..33 q ha^{-1}) was noted in the treatment receiving 150 per cent NPK dose and it was at par with treatment receiving 100 per cent NPK with farmyard manure. The highest productivity was obtained when FYM @10 Mg ha^{-1} was applied along with 100 per cent NPK, indicating that NPK fertilizers alone did not provide adequate and balance nutrition to realise the potential yield of the crop. It was also observed that after harvest of 2nd trial application of farmyard manure with RDF increased the soil available N (240.52 kg ha^{-1}), P (18.51 kg ha^{-1}) K (795.44 kg ha^{-1}) content as compared to the initial value of experimental field. There was overall increase in the soil bacterial, actinomycetes and fungal population in treatment receiving FYM @ 10 Mg ha^{-1} alone or with chemical fertilizers and which were decreased in treatment receiving super optimal dose of chemical fertilize (150 % NPK) .

Key Words : Recommended dose of fertilizer, Soybean, Safflower, Farmyard manure, Yield, Microbial population, Soil properties

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INTRODUCTION

Oilseeds are energy rich crops, hence, the requirement of major nutrients including secondary and micronutrient is high. But the productivity of oilseeds (935 kg ha^{-1}) is still low as oilseeds are cultivated largely under rainfed (75.67%) area and under energy starved condition. Several long term fertilizers experiments in the country demonstrate that the use of NPK fertilizer alone leads to emergence of micro nutrient deficiencies, while integrated use of organics and inorganics sources of nutrients sustains crop productivity and improves soil health under most cropping systems (Tiwari, 2002). Normally soybean and safflower are grown as major *Kharif* and *Rabi* crops, respectively in the Marathwada region. Among the factors responsible for low productivity, inadequate fertilizer use and emergence of multiple-nutrient deficiencies due to poor recycling of organic sources and unbalanced use of fertilizer particularly micro-nutrient are important. Site specific nutrient management (SSNM) is gaining popularity of late due to its superiority over blanket nutrient recommendations as it takes into account site, season and crop growth variability to take crop decision. This approach enables farmers to apply the right amount of nutrients at the right time. Nutrient application thus matches the crop demands, thereby

MEMBERS OF RESEARCH FORUM

Author of the Correspondence :
B.K. ARBAD, Department of Soil Science, Marathwada Agricultural University, PARBHANI (M.S.) INDIA

Address of the Coopted Authors :
SYED ISMAIL, Department of Soil Science, Marathwada Agricultural University, PARBHANI (M.S.) INDIA

minimizing the risk of over application of fertilizer. It ensures balanced application of all nutrients to maintain productivity and soil quality over time (Tiwari, 2008). Higher dose of chemical fertilizer and agricultural chemicals but insufficient use of organics leads to negative results on fertility and productivity of soil. By and large, Indian soils showed either deficiency or inadequacy in cluster of major and micronutrients. Regular and prolonged exploitation of soil resources for crop cultivation without addition of fertilizers and in adequate supply of fertilizers create nutrient imbalance in soil. Due to continuous growing of legumes, regular application of P and N fertilizers, the native micro-nutrient content in soil often becomes inadequate (Singh *et al.,* 2008) for crops. Therefore, the present investigation was undertaken to evaluate the effect of chemical fertilizers alone and in combination with FYM or micronutrients on yield and soil microbial population in soybean-safflower cropping system.

EXPERIMENTAL METHODS

The field experiment on soybean - safflower cropping system was conducted during *Kharif* and *Rabi* season in the year 2007-08 and 2008-09 and on Vertisol and was laid out in randomized block design with twelve treatments replicated four times with a fix set of nutrient management. *viz*., 50 per cent NPK, 100 per cent NPK, 150 per cent NPK, 100 per cent NPK + hand weeding, 100 per cent NPK + $ZnSO_4$ @ 25 kg/ha, 100 per cent NP, 100 per cent N, 100 per cent NPK + FYM @ 10Mg ha^{-1}, T_9 - 100 per cent NPK-S, T_{10}- FYM @ 10Mg ha^{-1}, T_{11}- Control, T_{12}- Fallow plot without crop. Inorganic fertilizers were applied as per recommended dose of fertilizer and micronutrients through chemical fertilizer and FYM was incorporated @ 10Mg ha^{-1} time at sowing in *Kharif* season only. The 100 per cent RDF was 30-60-30 N-P-K kg ha^{-1} for soybean and 100 per cent RDF was 60-40 N-P kg ha^{-1} for safflower as potassium was not applied. The fertilizers used were urea, single super phosphate and muriate of potash. Diammonium phosphate was used in treatment 100 per cent NPK-S which is devoid of sulphur. As sulphur was supplied through single super phosphate. Zinc was applied through zinc sulphate @ 25 ha^{-1}. Soybean 'JS-335' and safflower 'Sharda' were raised during *Kharif* and *Rabi*, respectively with recommended package of practices. FYM pooled data showed 0.27 per cent N, 0.20 per cent P and 0.38 per cent K and was incorporated in soil 7 days before sowing. Sowing of soybean in both the year was done in 3rd week of June and harvesting in 2nd week of October whereas, safflower sowing was done in last week of October and harvesting in 2nd week of March.

The soil samples were collected after harvesting of safflower trial during 2009 for analysis of organic carbon, available N, P, K, S and DTPA extractable Zn as per standard procedure. The initial bulk soil samples were collected during first year from entire experiment field for basic soil analysis. The initial soil pH was found to 8.14, organic carbon 4.80 g kg^{-1}, available N 205.70 kg ha^{-1}, available P_2O_5 13.20 kg ha^{-1} and available K_2O content 740.19 kg ha^{-1}, available sulphur 25.05 kg ha^{-1} and DTPA extractable zinc was 1.25 mg kg^{-1}. Thus, the soil was clayey in texture, moderately alkaline in reaction, medium in available nitrogen and phosphorus and sufficient in available potassium, low in sulphur and zinc. The plot wise grain and straw yield of both the crops for both years were recorded. Soil microbial counts (bacteria, actinomycetes and fungi) were estimated using serial dilution method.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study have been presented under following heads :

Seed and straw yield of soybean and safflower:

The pooled grain and straw yield data of soybean (Table 1) revealed that grain and straw yield was increased significantly showing maximum yields with receiving 150 per cent RDF and was at par 100 per cent RDF with FYM. The higher grain yield due to inorganic alone and in combination with organic sources along with FYM might have increased due to sustained nutrient supply and also as result of better utilization of applied nutrients through improved microbial activity that involved in nutrient transformation and fixation similar findings were reported by Ravankar *et al.* (1995). Safflower crop also responded significantly to residual fertility grain yield and straw was increased from 0.97 tonnes ha^{-1} to 1.63 tonnes ha^{-1} and straw yield from 2.95 tonnes ha^{-1} to 5.15 tonnes ha^{-1} with the increase in soil fertility. Maximum grain and straw yield was observed in treatment receiving 150 per cent NPK but was at par with 100 per cent NP on residual effect of FYM. The results are in conformity with finding of Patel *et al*. (2007), who has reported that increase in groundnut yield due to the residual effect of FYM attributed to release of macro and micronutrients during mineralization and carbon which supplies energy to microbes for their activities and favour decomposition and organic matter also acts as source of energy for soil micro flora which brings about chelation of micronutrient cations.

Soil-fertility status:

As per data recorded in Table 1, integrated nutrient management had significantly increased the organic carbon

Table 1 : Effect of inorganic levels and farmyard manure on grain and straw yield of soybean and safflower and soil fertility status after harvest of second cycle of soybean safflower cropping sequence

Treatments	Yield (tonnes ha^{-1})				After harvest of safflower (2009)					
	Soybean		Safflower		Available nutrients (kg ha^{-1})					DTPA (mg kg^{-1})
	Grain	Straw	Grain	Straw	OC (g kg^{-1})	N	P	K	S	Zn
50% NPK	2.09	3.21	1.34	4.07	5.18	200	14.53	748	28.60	1.08
100% NPK	2.53	3.83	1.44	4.64	5.37	222	16.73	767	30.44	1.06
150% NPK	2.85	4.28	1.63	5.15	5.71	236	18.33	788	33.08	1.01
100% NPK+HW	2.35	3.59	1.45	4.77	5.40	224	16.90	763	30.26	1.03
100% NPK+Zn	2.64	4.07	1.46	4.91	5.48	226	16.75	762	29.34	1.30
100% NP	2.33	3.65	1.23	4.07	5.26	219	16.71	740	29.83	1.08
100% N	1.98	3.04	1.16	3.85	5.09	211	10.52	736	21.05	1.10
100% NPK+FYM	2.84	4.31	1.60	4.81	6.01	240	18.51	795	34.73	1.29
100% NPK-S	2.44	2.70	1.36	4.39	5.32	228	16.88	785	19.41	1.02
FYM	2.33	3.57	1.13	3.41	5.98	221	17.80	760	28.75	1.18
Control	1.45	2.21	0.97	2.95	4.85	164	10.47	732	21.30	0.93
Fallow	-	-	-	-	5.57	202	13.40	760	24.90	1.25
Mean	2.35	3.59	1.34	4.28	5.45	216	15.63	760	27.64	1.11
S.E. ±	1.24	1.61	0.75	1.47	0.21	7.26	0.51	17.87	1.20	0.034
C.D. (P=0.05)	3.60	4.66	2.19	3.34	0.60	20.11	1.43	NS	3.32	0.096
Initial	--	--	--	--	4.80	205	13.20	740	25.05	1.25

NS=Non-significant

(6.01 g ha^{-1}), available nitrogen (240.52 kg ha^{-1}), phosphorus (18.51 kg ha^{-1}), potassium (795.44 kg ha^{-1}) and sulphur (34.73 kg ha^{-1}) content in soil as compared to initial values and control plot they declined significantly, due to varying fertility level. Whereas DTPA extractable Zn(1.30 mg kg^{-1}) was increased in plot receiving 100 per cent NPK with zinc sulphate @ 25kg ha^{-1} and there was decline in DTPA Zn as compared to initial value in all treatment except where FYM was incorporated. The fertility level of 10 Mg ha^{-1} FYM with 100 per cent NPK left the maximum organic carbon content

Table 2 : Bacterial, actinomycetes and fungal population in soil as influenced by nutrient management practices after harvest of 2nd trial of soybean and safflower (2008-09)

Treatments	Bacterial population (X x 10^5)		Actinomycetes population (X x 10^4)		Fungi population (X x 10^5)	
	After harvest of soybean	After harvest of safflower	After harvest of soybean	After harvest of safflower	After harvest of soybean	After harvest of safflower
T_1 – 50% NPK	105	41	401	338	22	22
T_2 – 100% NPK	64	32	297	271	23	20
T_3 – 150% NPK	52	21	229	198	17	19
T_4 – 100% NPK+HW	68	28	289	219	21	21
T_5 – 100% NPK+Zn	89	41	261	168	22	22
T_6 – 100% NP	122	23	317	291	24	21
T_7 – 100% N	134	32	376	287	20	20
T_8 – 100% NPK+FYM	138	53	438	364	27	23
T_9 – 100% NPK-S	81	37	269	269	21	20
T_{10} – FYM	140	58	431	389	29	25
T_{11} – Control	81	31	208	189	19	15
T_{12} – Fallow	68	21	210	190	22	17
Mean	95	35	310.50	264	22.50	20
S.E. ±	2.54	1.38	12.34	11.40	1.43	1.29
C.D. (P=0.05)	7.18	3.83	34.17	31.55	3.98	3.57

in soil might be due to high C:N ratio of FYM resulting in organic carbon build up in soil and higher available N, P, K, S and DTPA extractable Zn might due to increased activity of micro organism leading to greater mineralization of applied and inherent nutrients. The use of fertilizer alone helps in increasing carbon content of soil due to higher biomass which might be due to the differential rate of oxidation of organic matter by microbes (Trehan, 1997). The reduction in control plot may be due to the fact that crops are grown in this treatment and their grain and straw are harvested, where as in case of fallow plots, the biomass produced is incorporated in the soil itself as reported by Bharadwaj and Omanwar (1994). It was also evident that application of phosphorous in conjunction with nitrogen improved the available nitrogen status of the soil as compared to the application of N alone and was also noted by Sheeba and Chellamuthu (1996). Among the inorganic fertilizers, continuous application of N or NP had depressive effect on the available K content of the soil which may be due to nutrient imbalance in soil. This is in consonance with the findings of Bharadwaj *et al*. (1982). The application of 100 per cent NPK with FYM resulted in significantly higher available S content than the control due to application of single super phosphate and FYM which contained about 12 and 0.05-0.31 per cent of sulphur, respectively (Sachan, 1994). Ingle *et al*. (2006) reported that in wheat, application of Zn in combination with recommended dose of NPK increased available N, P and K over 100 per cent of NPK. The higher availability of Fe and Zn in soil under FYM was mainly due to its functions in mobilizing the native Fe and Zn and chelation of Fe and Zn was reported by Patil *et al*. (2007).

Soil microbial population:

Data presented in Table 2 show that bacteria, actinomycetes and fungal population in soil was influenced by nutrient management practices after harvest of 2nd trial of soybean and safflower. After the harvest of soybean the bacterial population was found significantly highest in treatment receiving only FYM @ 10 Mg ha^{-1} (140 x 10^5 CFU g^{-1}soil) and was at par with treatment receiving 100 per cent NPK with FYM. However, after harvest of safflower bacterial population was though lowered but was as in same trend as that of soybean. The incorporation of FYM increased the soil microbial biomass than the chemical fertilizers. Higher biomass was recorded in plots receiving FYM and inorganic N in the present study reflects the effect of FYM which serves as a source of carbon and nutrients. Better plant growth also contributes to higher microbial biomass as reported by Manna and Ganguly (2001). Further soil actinomycetes after the harvest of soybean was noticed highest (438 x10^4 CFU g^{-1} soil) in treatment receiving 100 per cent NPK with FYM and found at par with FYM treated plots, whereas after harvest of safflower actinomycetes population was noticed maximum (389 x 10^4 CFU g^{-1}soil) on residual effect of FYM applied plots and was at par with 100 per cent NP on residual effect of FYM. It seems that although organic carbon is the major constituent of food supply for microbes, but inorganic nutrients are also beneficial for increasing actinomycetes population. The results are in conformity with finding of Patil and Varade (1988). After harvest of soybean fungi population was significantly highest (29 x 10^5 CFU g^{-1}soil) in treatment receiving only FYM and was found at par with treatment receiving 100 per cent NPK with FYM (28 x 10^5 CFU g^{-1}soil) and after harveste of safflower fungal population was lowered but was in trend of soybean. The results are in conformity with finding of Badole (2000) who reported that application of FYM helped higher fungal population as compared to inorganic sources. FYM stimulates fungal growth with higher order, which is mainly attributed to dead food material available from FYM.

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