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Research Article

EFFECT OF LONG-TERM FERTILITY MANAGEMENT PRACTICES ON SOIL, CROP QUALITY AND PRODUCTIVITY OF SOYBEAN GROWN IN VERTISOLS OF WESTERN MADHYA PRADESH

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Abstract- The present investigation was carried out in kharif 2009 under All India Coordinated Research Project for Dry land Agriculture, College of Agriculture, Indore. The experiment was aimed to evaluate the effect of inorganic fertilizers with or without organic manure on soil and crop quality, growth and productivity and to workout the economic viability soybean utilizing a permanent manurial trial on soybean in rainfed Vertisols. The results revealed that the highest soybean seed yield (2600kg ha^{-1} during 2009 and 2205 kg ha^{-1} on the basis of 18 years average) was recorded due to half of the recommended dose of N and P + 6 t FYM per ha. The highest gross and net returns were also obtained due to this treatment comprising of 50% of RDF + 6t FYM ha^{-1} followed by recommended dose of fertilizers, pure organic and lowest in case of control. The highest sustainability yield index (SYI) of 0.46 was obtained due to the treatment of FYM @ 6 t per ha + N20P13,FYM and crop residue added treatments gave higher mean weight diameter (MWD) in comparison to chemical fertilizer added treatments. Addition of organics along with chemical fertilizers reduced the bulk density. The porosity ranged from 46.97 per cent to 55.60 per cent in different treatments and was highest in the treatment of FYM @ 6 t per ha + N20P13.

Keywords- Organic, Inorganic, Soybean, Soil health.

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Introduction

The state of Madhya Pradesh is known as soybean state as it contributes 58 and 55 per cent of the total area and production of soybean of the country respectively. The national average productivity of last 17 years of India and Madhya Pradesh was 985 kg per ha and 939 kg per ha, respectively. In spite of availability of improved varieties with yield potentials of 2.5 to 3.0 t/ha, the low productivity in the state and country calls for optimizing it through efficient nutrient management. The lack of integrated nutrient management approach coupled with unbalanced nutrition not only limits the productivity, but also leads to deterioration in soil quality. This has reflected in degradation of soil quality and environments as well as sustainability of yield levels of crop plants [1]. However, soil quality has been conceived as one of the major functional factors in limiting the yield of crops. To over come this problem, the integrated nutrient management system (INM) is advocated for nutrient management in cropping systems. The basic concept of the INM is to maintain soil fertility for sustained crop productivity on long-term basis and also reduce fertilizer input cost. Integrated nutrient management (INM) has shown its potential in increasing crop productivity may be due to the combined effect of nutrient supply, synergism and improvement in soil physical and biological properties and also in crop physiological processes. Therefore, it has been realized that there is a need for an assessment on crop specific land quality so that the yield diminishing factors can be identified. The need for development of a land quality index with reference to type of land use was stressed [2]. The present study was carried out in a permanent manurial trial, which is running since 1992 in Vertisols at Indore with specific objectives to assess soil quality and the impact on physiological processes of soybean, crop quality and growth and productivity of soybean as influenced by long term fertility treatments.

Material and Methods

The present investigation on soil and crop quality assessment as influenced by treatment under permanent manurial trial on soybean in rainfed Vertisols was carried out during kharif 2009 under All India Coordinated Research Project for Dryland Agriculture, College of Agriculture, Indore. The permanent manurial trial was laid out in randomized block design with nine treatments and three replication. The initial soil status of experimental site has pH-7.6, EC-0.22 dSm^{-1} [3] , Organic carbon- 0.38 % [4], Av.N-180.13 (kgha^{-1}) [5], Av. P -5.98 kg ha^{-1} [6], Av. K -761.0 kgha^{-1} [7], Av. S -12.58 kg ha^{-1} [8]. The treatments comprised of T_1 control, T_2 N20P13 (20 kg N + 13 kg P/ha), T_3 N30P20 (30 kg N and 20 kg P/ha), T_4 N40P26 (40 kg N and 26 kg P/ha), T_5 N60P35 (60 kg N and 35 kg P/ha), T_6 FYM 6 t per ha + N20P13, T_7 N20P13 + soybean crop residues 5 t per ha^{-1} T_8 FYM 6 t per ha^{-1} and T_9 soybean crop residues 5 t per ha. FYM was applied during rainy season only and surface mulching between crop rows with soybean crop residues was resorted to after crop emergence. The sources of N, P and K used were urea, single super phosphate (SSP) and muriate of potash. The gross and net plot size were 10 m x 7.2 m and 9.0 m x 6.6 m, respectively.

Results and Discussion

Crop Growth: The observations on growth parameters of soybean as influenced by various treatments [Table-1] revealed that the differences in plant height, number of branches and pods per plant, total dry matter per plant, seed yield per plant and test weight were statistically significant. The highest value of most of these growth parameters was recorded on combined application of FYM @ 6 t per ha plus 50% of RDF i.e. N20P13, the lowest were in control. The maximum plant height was recorded in T_6 (54.07cm) followed by T_5 (53.23 cm), T_7 (48.53 cm), T4 (47.80 cm), T9 (47.53), T_3 (46.0 cm), T_8 (44.0 cm), T_2 (41.93 cm) treatment which

were statistically at par with all the treatments except treatment T_1 Control and T2 (N20 P13.) Almost similar trend was observed in case of no. of branches plant^{-1}, pods plant^{-1}, DM and yield per plant and test weight. Chaturvedi and Chandel (2005) [9] also reported that the integrated use of recommended dose of fertilizer with supplementary nutrients increased the growth and yield attributes of soybean significantly. Supplementing the soil with organic sources improved the general soil environment, physico-chemical and biological conditions and thus the soil quality, these findings are also in agreement [10, 11], which helped to improve the soybean growth and yield contributing characters. Application of vermicompost significantly increased the growth attributes and yield of maize [12].

Table-1 *Plant growth and yield attributes of soybean as influenced by different treatments at harvest.*

S. No	Treatment	Plant height (cm)	Branch (No/ plant)	Pods (No/ Plant)	Total dry matter (g/plant)	Yield (g/ plant)	Test weight (g/100 seeds)
T_1	Control	36.67	2.60	24.63	14.11	6.6	9.20
T_2	N20 P13	41.93	3.07	33.73	19.47	8.9	10.80
T_3	N30 P20	46.00	3.60	41.47	20.17	10.3	11.57
T_4	N40 P26	47.80	3.60	41.13	21.87	11.2	11.87
T_5	N60 P35	53.23	3.93	45.27	24.69	12.9	11.73
T_6	FYM 6t/ha + N20 P13	54.07	4.13	48.13	24.11	13.4	12.91
T_7	Residues @ 5t/ha + N20 P13	48.53	2.93	42.03	20.71	11.3	10.97
T_8	FYM @ 6t/ha	44.00	3.87	42.73	23.30	11.4	11.47
T_9	Residues @ 5t/ha	47.53	3.47	41.73	21.94	11.0	11.40
	SEm (±)	2.99	0.26	1.52	1.83	1.2	0.60
	CD (p = 0.05)	8.97	0.79	4.56	5.47	3.5	1.79

Yield and Economics: Data on yield of soybean [Table-2] revealed that the highest seed yield (2,600 kg/ha) was recorded due to half of the recommended dose (N20 P13) + 6 t FYM / ha which was significantly superior over N30P20 (2,122 kg/ha), N20P13 (1,862 kg/ha) and control (1,357 kg/ha) and was on par with other treatments. All the fertility treatments produced significantly higher (37 to 92 %) seed yield over control. A trend similar to seed yield was noted in case of straw yield. The superiority of application of FYM @ 6 t per ha in combination with N20P13 gets confirmation from highest mean seed yield over 18 years of this long-term experiment, which was 2,205 kg per ha (63 % higher) over control. The application of FYM played beneficial effect to supply of all nutrients to crops [13, 14]. The economic evaluation of the treatments brought out that the application of FYM @ 6 t per ha + N20P13 yielded highest gross returns (Rs 63,020/ha), net returns (Rs 47,110/ha), which was statistically superior to control and surface mulching with soybean residues @ 5 t per ha in conjunction with N20P13, mulching with soybean residues @ 5 t per ha and control. Rest of the treatments was at par. The highest sustainability yield index (SYI) values (0.46) was also associated with combined application of FYM @ 6 t per ha + N20P13, and lowest in case of control (0.26).

Table-2 *Seed and straw yield of soybean as influenced by different treatments.*

Treatment	Yield (kg/ha) Seed	Cost of Cultivation (Rs/ha)	Returns (Rs/ha)		Mean yield over 18 years (kg/ha)	SYI
			Gross	Net		
Control	1357	9000	40521	27583	1350	0.26
N20 P13	1862	9288	57708	44357	1737	0.33
N30 P20	2122	9415	59166	45632	1901	0.37
N40 P26	2380	9555	59375	45639	2016	0.41
N60 P35	2374	9835	60208	46070	2109	0.44
FYM 6t/ha + N20 P13	2600	11068	63020	47110	2205	0.46
Residues @ 5t/ha + N20 P13	2313	12860	55937	37451	1907	0.36
FYM @ 6t/ha	2389	10792	58437	42924	1980	0.39
Residues @ 5t/ha	2261	12822	57500	39068	1769	0.33
SEm (±)	122	-	2061	2061	-	
CD (p = 0.05)	**365**	**-**	**6179**	**6179**	**-**	

Soil quality assessment under different treatments

Effect on soil physical properties: To evaluate the long-term effect of various treatments on mean weight dry matter, bulk density and surface soil porosity, surface soil samples were analyzed and data is presented in [Table-3]. The effect of treatments in long-term on soil (0-15 cm) physical properties revealed that the maximum mean weight diameter (MWD) was recorded by application of FYM @ 5 t per ha + N20P13 (1.11 m) and minimum in case of control (0.51 m). In general, the FYM and crop residue added treatments gave higher MWD (0.94-1.11 m) in comparison to chemical fertilizer added treatment (0.73-0.87 m) and control (0.51 m). The bulk density was found to get reduced irrespective of the fact that organic material was applied alone or in combination with inorganic (1.18-1.22 mg/m^3). The soil porosity ranged from 46.7 to 55.6 per cent in different treatments and was highest (55.6%) when FYM @ 6 t per ha + N20P13 was applied. The changes in soil properties due to different treatments are the cumulative effect of 18 previous seasons as the site of each treatment was fixed. The FYM and inorganic fertilizer applications might have resulted in higher SOM due to increased root biomass and acted as a binding agent which improved the aggregate MWD [15,16]. The average MWD was highest in FYM + NPK treatment followed by 100% NPK and lowest MWD was in non-treated control plots in rice–wheat system as well as in maize–wheat system obtained by Rasool et al. [17]. In contrast, significant decrease in bulk density was reported in maize–wheat rotation in China after 13 years of application of NPK+ manure compared to non-treated control and NPK treatment [18]. Annual additions of barnyard manure for 100 years in continuous wheat, corn and timothy cropping systems resulted in decline in BD [19] and increase total porosity due to increased SOM [20].

Table-3 *Soil physical properties recorded at flowering stage of soybean*

Treatment	Mean weight diameter (mm)	Bulk density (Mgm^{-3})	Porosity (%)
Control	0.51	1.39	46.7
N20 P13	0.73	1.36	47.9
N30 P20	0.78	1.38	46.7
N40 P26	0.77	1.37	48.7
N60 P35	0.87	1.32	50.2
FYM 6t/ha + N20 P13	1.11	1.18	55.6
Residues @ 5t/ha + N20 P13	0.98	1.20	54.4
FYM @ 6t/ha	0.94	1.21	54.0
Residues @ 5t/ha	0.90	1.22	53.6

Soil microbial biomass

Soil microbial biomass carbon was determined by fumigation method and data are presented in [Fig-1]. It is evident from the fig that the highest MBC was recorded in T6- FYM 6 t /ha + T2 followed by T7-Residues 5t /ha + T2, T9 –Residues 5t /ha, T8-FYM 6t /ha, T5-N60 P35, T4-N40 P26, T3-N30 P20, T2- N20 P13 and lowest in T1 i.e. control. Soil microbial population increased in organically amended as compared to inorganic which may be due to the addition of organic amendments that might have large impact on the size and activity of microbial population [21]. Long-term stubble retention, reduced tillage systems and maturing have been shown to increase microbial biomass carbon and microbial activity in soil [22].

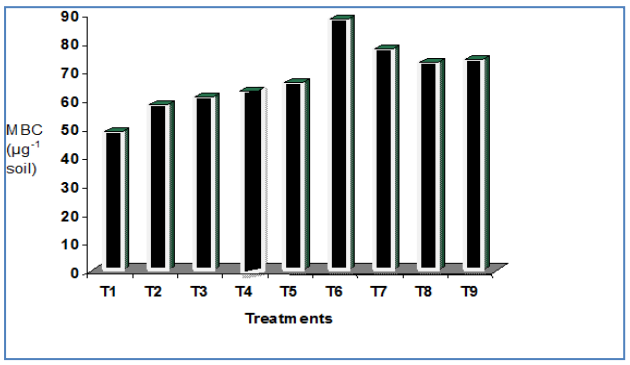

Fig-1 Effect of different fertility treatments on Microbial Biomass Carbon (MBC)

Soil quality evaluation: The soil quality changes evaluated quantitatively for all the nine treatments using the soil data analyzed [Table-4] during this study clearly indicated slight changes in soil pH, organic carbon, plant available nitrogen, phosphorus and potash in a span of 18 year. These parameters were used for calculation of soils quality changes. Soil quality evaluations indicated that the quality of soil had improved in the treatments which compressed of application of organics as compared to control as the values of RSQI were above zero. The relative soil quality index under different treatments was increased by 11 units in the treatments which were comprised of addition of organics (alone or in combination of inorganic) as compared to 7.75 units in treatments where chemical fertilizers were applied. In case of treatment N20P13, the increase was 1.75 units only. Under all the treatments soil belongs to class III having minimum value 66.5 under control. This value increased due to other treatments the maximum improvement was observed due to addition of organics in the soil. This indicated that the addition of organic matter improved soil quality as compared to chemical fertilization alone. On the basis of the criteria on soil quality assessment given by [23, 24], we conclude that there was a great increase in soil quality in the treatments FYM @ 6t per ha + N20P13, soybean residues @ 5 t per ha + N20P13, FYM @ 6 t per ha and soybean residues @ 5 t per ha due to addition of organics (alone or in combinations of inorganic, while this increase was moderate in the treatments N30 P20 , N40 P26 and N60 P35 . The increase in soil quality in case of inorganic fertilization with 50 per cent of RDF was slight.

Table-4 *Soil quality assessment due to various treatments*

Parameters	Treatments								
	Control	N20 P13	N30 P20	N40 P26	N60 P35	FYM 6t/ha + N20 P13	Residues @5t/ha +N20 P13	FYM @ 6t/ha	Residues@ 5t/ha
Soil depth (cm)	39	39	39	39	39	39	39	39	39
Texture	22	22	22	22	22	22	22	22	22
Slope	52	52	52	52	52	52	52	52	52
OM (g/kg)	13	13	13	13	13	26	26	26	26
Av.-N (kg/ha)	12	24	36	36	36	36	36	36	36
Av.-P (kg/ha)	24	24	36	36	36	36	36	36	36
Av.-K (kg/ha)	44	44	44	44	44	44	44	44	44
pH	20	15	15	15	15	15	15	15	15
CEC (cmolp/kg)	40	40	40	40	40	40	40	40	40
SQI	266	273	297	297	297	310	310	310	310
SQIm	400	400	400	400	400	400	400	400	400
RSQI	66.5	68.25	74.25	74.25	74.25	77.5	77.5	77.5	77.5
ΔRSQI as compared to control	NA	1.75	7.75	7.75	7.75	11	11	11	11
Remark	NA	Slight	Moderate	Moderate	Moderate	Great	Great	Great	Great

Nutrient uptake by soybean:

The data [Table-5] revealed that the uptake of N, P, K and S by soybean seed and straw as well as and total uptake of these nutrients in relation to different treatments under consideration was higher in treatment FYM @ 6t per ha+ N20P13 as compared to any level of application of fertilizer source. Lowest uptake of all the nutrients was recorded in the control. The maximum uptake of N, P and K was also found in the treatment having FYM plus 100% NPK [25]. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelating of complex intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of different nutrients in different plant parts and the results are in agreement with the previous findings [26].

Table-5 *Nutrient uptake (kg/ha) by soybean seed and straw under different treatments*

Treatment	Seed				Straw				Total			
	N	P	K	S	N	P	K	S	N	P	K	S
Control	74.71	2.64	15.67	1.78	7.89	1.20	3.85	3.31	82.27	5.30	28.15	6.01
N20 P13	125.75	3.76	21.12	2.96	11.20	2.51	6.69	8.31	136.28	9.61	46.59	13.63
N30 P20	141.88	4.58	25.09	3.08	10.82	2.78	9.53	6.82	151.70	11.21	55.77	12.49
N40 P26	146.30	5.80	28.65	4.01	14.06	3.66	9.99	7.25	159.03	13.36	57.95	13.96
N60 P35	160.85	5.61	28.40	4.36	23.15	5.04	13.04	10.83	182.34	15.41	65.50	18.94
FYM @ 6 t/ha + N20 P13	170.16	5.97	32.19	5.11	21.23	5.79	13.65	10.25	189.39	16.50	71.44	19.59
Residues @ 5 t/ha + N20 P13	164.55	5.95	26.55	3.94	15.28	5.51	11.88	8.53	177.50	16.99	63.05	16.04
FYM @ 6 t/ha	163.07	6.32	27.26	3.92	21.09	5.57	15.20	7.13	181.49	17.20	65.41	14.21
Residues @ 5 t/ha	130.60	5.66	26.11	4.00	17.00	5.29	11.86	9.11	144.60	14.04	52.21	15.32
SEm (±)	9.15	0.3	1.4	0.4	1.0	0.2	0.6	0.4	4.6	0.3	1.5	0.6
CD (p = 0.05)	26.90	0.9	4.2	1.1	3.0	0.5	1.8	1.2	13.9	0.9	4.4	1.7

Conclusion

The highest soybean seed yield was recorded due to half of the recommended dose of N and P (N20P13) along with FYM @ 6 t per ha, which was associated with improvement of soil quality and plant physiological parameters. This treatment provided higher economic benefits as compared to other treatments. The status of this long-term manurial trial after 18 years establishes that for sustained economic production integrated approach of nutrient management is to be followed. Application of organic manures over years improved soil physical parameters and boost the production of soybean with higher sustainability index when coupled with half the level of recommended nutrients through fertilizers.

Conflict of Interest: None declared

References

[1] Virmani (1994) *Journal of Indian Society of Soil Science*, 42,516-24

[2] Karlen D.L., Mausbach M.J., Doran J.W., Cline R.G., Harris R.F. and Schuman G.E. (1997) *Soil Science Society of America Journal*, 61, 4-10.

[3] Jackson M.L. (1973) Soil Chemical Analysis, Constable and Co. Ltd. Prentice Hall of India Pvt. Ltd. New Delhi. pp. 10-114

[4] Walkley A and Black I.A. (1934) Soil *Science*, 47,29-38.

[5] Subbiah B.V. and Asiija E.C. (1956) *Current Science*, 25 (8), 259-260.

[6] Olsen S.R., Cole C.V., Watanabe F.S. and Dean L.A. (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U. S. Department of Agriculture Circular, pp. 939.

[7] Black C.A. (1965) Methods of soil analysis Part I Am. Soc. Agron. Inc. Publi. Madison Wisconsin USA.

[8] Chesnin L. and Yein C.H. (1951) *Soil Science Society of America Journal*, 15,149-151.

[9] Chaturvedi S. and Chandel A.S. (2005) *Indian Journal of Agronomy,* 50, 311-313.

[10] Bharadwaj V. and Omanwar P.K. (1994*) Journal of Indian society of Soil Science,* 42, 387-392.

[11] Sharma R.A. and Sharma S.K. (2005) International Conference on Sustainable Crop Production in Stress Environment: Management and Future Policy Options, February 10–12, 2005, JNKVV, Jabalpur, pp 199.

[12] Banger A.R and Jatgar H.S. (1995) Proceedings of state level seminar on "Integrated Nutrient Management for Sustainable Agriculture", October 7-8, 1995, Mahatma Phule Krishi Vidyapeeth, Rahuri, pp 10.

[13] Keram K.S, Sharma B.L, Sharma G.D and Thakur R.K. (2014) *The Bioscan*, 9 (2),491-495.

[14] Sharma G.D, Thakur Risikesh, Som Raj, Kauraw D.L and Kulhare P.S. (2013) *The Bioscan*, 8 (4), 1159-1164.

[15] Haynes R. and Naidu R. (1998) *Nutrient Cycling in Agro ecosystems*, 51, 123–137.

[16] El-Shakweer M., El-Sayad E. and Ewees M. (1998) *Soil and Tillage Research*, 29, 2067–2088.

[17] Rasool R., Kukal S. and Hira G. (2007) *Soil and Tillage Research*, 96, 64–72.

[18] Zhang S., Yang X., Wiss M., Grip H. and Lovdahl L. (2006*) Geoderma*, 136, 579–587

[19] Anderson S.H., Gantzer C.J. and Brown J.R. (1990) *Journal of Soil and Water Conservation*, 45, 117–121.

[20] Barzegar A.R., Nelson P.N., Oades J.M. and Rengasamy P. (1997) *Soil Science Society of America Journal*, 61, 1131–1137.

[21] Bolton H., Elliott L.F., Ppendick R.I. and Bezdicek D.F. (1985) *Soil Biology and Biochemistry*, 17, 297-302.

[22] Haines P.J. and N.C. Ureen, (1990) *Australian Journal of Soil Research*, 30, 365-371.

[23] Larson W.E. and Pierce F.J. (1994) The dynamics of soil quality as a measure of sustainable management. In: Defining Soil Quality for a Sustainable Environment. J W Doran et al. (Eds). SSSA. Special Publication 35, SSSA and ASA, Madison, WI, pp 37-51.

[24] Pierce F.J. and Larson W.E. (1993) Developing criteria to evaluate sustainable land management. In: Utilization of Soil Survey Information for Sustainable Land Use, Kimble (Ed), Proceeding of the eighth international soil management workshop: Oregon, California, and Nevada. May 1993. USDA, Soil Conservation Service, National Soil Survey Center, Licoin, NE, pp 7-14

[25] Babbu Singh Brar, Jagdeep Singh, Gurbir Singh and Gurpreet Kaur (2015) *Agronomy*, 5, 220-238.

[26] Mitra S., Roy A., Saha A. R., Maitra D. N., Sinha M. K., Mahapatra B. S. and Saha S. (2010) *Indian Journal of Agricultural Sciences*, 80(9), 801-804.