

Effect of Long Term Fertilizer and FYM Application on Soil Fertility of a Vertisol under Soybean-Wheat Cropping System

Abstract

The present studies were conducted under All India Coordinated Research Project on Long Term Fertilizer Experiment, which was commenced since 1972. To assess the effect of 48 years (1972-73 to 2019-20) continuous application of inorganic fertilizers with or without organic manure i.e. FYM on soil fertility status of Vertisols under soybean-wheat cropping system. The results of the present study showed that the application of recommended dose of N, P and K (20:80:20 kg ha⁻¹ to soybean and 120:80:40 kg ha⁻¹ to wheat) with organic manure @ 5 t FYM ha⁻¹ improved the status of available N, P and S but decline in available K. Further, the integrated use of fertilizers with organic manure enhanced the soil organic carbon contents (9.5 g kg⁻¹) from its initial value (5.7 g ka⁻¹). Conjoint use of FYM with 100% NPK substantially improved contribution towards sustaining the soil fertility. A declining trend (228 to 335 kg ha⁻¹) from its initial value (370.0 kg ha⁻¹) of available K status was also observed as a result of continuous application of fertilizer and manure; this indicates considerable mining of available K from the soil. However, the decline of K was of lower magnitude with 100% NPK + FYM and 150% NPK treatments indicating the need to raise the dose of K fertilizer application to meet the demand of crops. Further, soil available nutrients to be adversely affected due to the imbalanced use of nutrients viz., 100% NP or 100% N alone treatments. Thus, the balance use of fertilizers continuously either alone or in combination with organic manure is necessary for sustaining soil fertility and crop productivity.

Keywords: Soybean-wheat cropping sequence, long-term fertilization, INM, physico-chemical properties, Vertisols

Introduction

To study the impact of continuous use of imbalance nutrient, balance nutrient combination with or without organic manures on soil fertility parameters and crop productivity under varied soil climatic situations of the country with special emphasis on the long-term sustainability of high production farming, ICAR had initiated the All India Coordinated Research Project (AICRP) on Long-term Fertilizer Experiments (LTFE) at 11 centres including Jabalpur centre for Vertisol in 1972. Describing the status nutrient in long term fertilizer and manure application under soybean–wheat cropping sequences mostly grown in subtropical region in Vertisol soil in area of Madhya Pradesh. The use of inorganic fertilizers or organic manure alone cannot achieve and sustain the desired level of crop production under continuous cropping (Keram *et al.*, 2014). Therefore, conjoint use of organic manures with inorganic fertilizers is very essential as this not only sustains higher levels of productivity but also improves soil quality and hence the nutrient use efficiency (Thakur *et al.* 2011). In view of declining productivity levels, increasingly greater emphasis is now being given to the integrated nutrient supply system which may play a significant role in sustaining soil quality (Sharma *et al.*, 2013; Dwivedi and Dwivedi, 2015). These experiments can be used for precise monitoring of changes in soil nutrient status of nutrient in Vertisol. In view of the above facts, the present study was conducted to find out the effect of continuous use of inorganic fertilizers with or without organic manure under soybean – wheat cropping system in a Vertisol on soil fertility.

Materials and methods

The present investigation was conducted in the ongoing All India Coordinated Research Project on Long-Term Fertilizer Experiment with soybean-wheat cropping sequence initiated during 1972 at the Research Farm, Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh (India). The experimental area is situated at 23°10' N latitude and 79° 57' E longitude and at elevation 393.0 meter above mean sea level in the South-Eastern part of the Madhya Pradesh. Jabalpur region has a peculiar semiarid and subtropical climate with a characteristics feature of dry summer and cold winter. In winter season (i.e. from November to February) the average temperature ranges from 4°C to 33°C and the relative humidity varies from 70% to 90%. Dry and warm weather usually persist during the months of March to June. During summer the temperature may attain a value as high as 45°C and drop down to below 5 or 10°C during winter. Monsoon season extends from mid-June to mid-September. The average annual rainfall of the region ranges between 1200 to 1500 mm.

The soil of the experimental field is medium black belonging to Kheri series of fine montmorillonitic hyperthermic family of Typic Haplustert. At the time of initiation of study in the year 1972, the physico-chemical properties are presented in Table 1. The experiment included 10 treatments viz., T₁ - 50% NPK, T₂ - 100% NPK, T₃ - 150% NPK, T₄ - 100% NPK + Hand Weeding, T₅ - 100% NPK + Zn, T₆ - 100% NP, T₇ - 100% N, T₈ - 100% NPK + 5 t FYM ha⁻¹, T₉ - 100% NPK – S (Sulphur-free) and T₁₀ - control, each replicated four times in a randomized block design. The recommended N, P and K dose, based on initial soil test, was 20 kg N, 80 kg P₂O₅ and 20 kg K₂O ha⁻¹ for soybean crop and 120 kg N, 80 kg P₂O₅ and 40 kg K₂O ha⁻¹ for wheat. The sources of N, P and K used were urea, single superphosphate and muriate of potash. In sulphur-free treatment (T₉), diammonium phosphate (DAP) was used instead of SSP as source of P. The zinc application @ of 20 kg ZnSO₄ ha⁻¹ in alternate years to wheat crop was followed till 1987. Due to high buildup of Zn, its addition is discontinued till date. Farmyard manure was applied @ 5 t ha⁻¹ year⁻¹ only to soybean crop during kharif season. In 100% NPK + HW treatment, weeding was done manually, whereas in other treatments chemical weed control (herbicide) was followed. All packages of practices were followed to raise soybean and wheat crops as per recommendations.

Table 1: Physico-chemical properties of soil (0–20 cm depth) at initiation of the Long-Term Fertilizer Experiment (1972)

S. No.	Soil Properties	Value
1.	pH (1:2.5), soil : water	7.6
2.	Electrical conductivity (1:2.5)	0.18 dS m ⁻¹
3.	Organic carbon	5.7 g kg ⁻¹
4.	Calcium Carbonate	46.0 g kg ⁻¹
5.	Available nitrogen	193.0 kg ha ⁻¹
6.	Available phosphorus	7.60 kg ha ⁻¹
7.	Available potassium	370.0 kg ha ⁻¹
8.	Available sulphur	15.6 kg ha ⁻¹

Source: AICRP on Long-Term Fertilizer Experiment, JNKVV Jabalpur.

The soil samples were collected after harvest of wheat crop from 0-20 cm depths in the 48th cropping year (2019-20) and were analyzed for the soil physico-chemical properties namely pH, EC were determined by 1:2 soil : water suspension (Jackson, 1973), organic carbon (Walkley and Black, 1934), available N (Subbiah and Asija, 1956), available P (Olsen *et al.*, 1954), available K ((Muhr *et al.*, 1965), and available S (Chesnin and Yien, 1951). The data generated on soil analysis was statistically analyzed to draw suitable inference as per standard method described by Panse and Sukhatme (1970).

Results and Discussion

Soil pH and EC

The data of soil pH and EC presented in table 2 clearly indicated that the soil pH values did not change significantly even after 48 years of continuous application of inorganic fertilizers with or without organic manure under soybean - wheat cropping system in a Vertisol. In accordance with the findings obtained, the soil pH values of various treatments ranged between 7.38 to 7.60. This could be ascribed to the high buffering capacity of the soil and presence of appreciable amount of free calcium carbonate (Thakur *et al.*, 2009b). Use of chemical fertilizer like urea, though it possesses net residual acidity could not create significant alteration in the pH values of the soil. This effect appears to have been controlled by the presence of calcium carbonate. However, the soil electrical conductivity has been observed that no significant changes have occurred due to imposed treatments on the EC values ranged from 0.15 to 0.19 dSm⁻¹ (Table-2). Similar, findings have also been earlier reported by Sawarkar *et al.*, (2010); Nagwanshi *et al.*, (2018) and Dubey *et al.*, (2016).

Soil Organic Carbon

The organic carbon content of soil ranged between 5.6 to 9.5 g kg⁻¹ (Table 2). Organic carbon content of soil with an initial value of 5.7 g kg⁻¹ (1972) had increased significantly and attained the highest value of 9.5 g kg⁻¹ in 100% NPK + FYM treatment. Further, increasing levels of fertilizer application result in increasing the organic carbon content, which is due to increased contribution from the biomass. The organic carbon contents improved significantly with proportionate increment in fertilizer addition at 50% NPK (6.9 g kg⁻¹) and 100% NPK (7.9 g kg⁻¹) and 150% NPK (9.1 g kg⁻¹) doses. Contribution from root stubble could also be expected to follow the same trend (Dwivedi and Rawat, 2013; Meshram *et al.*, 2018). Further, applying organic manure along with NPK fertilizer was beneficial because it supplemented NPK and added some secondary and micronutrients and also improved the physical and biological characteristics of the soil. These findings indicate that organic carbon content plays an important role in maintaining and improving soil health (Bairwa *et al.* 2021).

Available Nitrogen

Long term use of nitrogenous fertilizers for forty-eight years tended to increase the available nitrogen status of soil (Table 2). Data indicated that the available nitrogen content was varied from 200 to 328 kg ha⁻¹ and that the highest value of available N was found under recommended dose of NPK fertilizer with FYM @ 5 t ha⁻¹ treatments. Bairwa *et al.*, (2021) ascribed such an increase in available N to the mineralization of FYM could be resulted due

to better biological activities in presence of FYM. Further, by increasing the application rate of nutrients i.e. 50% NPK, 100% NPK and 150% NPK, the amount of available nutrients also increased significantly (219, 276 and 307 kg ha⁻¹) respectively. However, the application of phosphorus along with nitrogen i.e. 100% NP improved the available nitrogen status of the soil in comparison to the application of 100% N alone treatment, and further the application of potassium with 100% NP i.e. 100% NPK had also improved N content (276 kg ha⁻¹) in soil. These results are in line with findings of Nagwanshi *et al.*, (2018) who observed that available nitrogen content in soil increased significantly with the use of recommended dose of fertilizers and manure. Similar trend on available N status of soil have also been reported by Panwar *et al.*, (2017) and Patel *et al.*, (2018).

Available Phosphorus

Available phosphorous showed a substantial build up with continuous addition of phosphatic fertilizers in comparison to initial content (Table-2). Application of 100% NPK + FYM resulted in highest value (40.5 kg ha⁻¹) of available P, followed by (38.9 kg ha⁻¹) in 150% NPK treatment over initial value (7.6 kg ha⁻¹) after 48 years. The lowest values of available P in control (11.1 kg ha⁻¹) and 100% N alone (12.3 kg ha⁻¹) were due to continuous cropping without any additions of P in these treatments (Dubey *et al.*, 2016). Similar results have been reported by Thakur *et al.* (2011). The increase in available P due to FYM may be due to the inactivation of iron and aluminium and hydroxyl aluminium ions, which reduced fixation of P. The concentration of P in available pool further increased due to the P addition from FYM. The FYM also being a direct source of nutrients, might have also solubilized the insoluble phosphate in the soil through release of various organic acids (Dwivedi and Dwivedi, 2015).

Available Potassium

The perusal of data indicated a declining trend (228 to 335 kg ha⁻¹) from its initial level of available K (370 kg ha⁻¹) which indicates considerable mining of available soil K after forty-eight years of intensive cropping (Table 2). The decline was of the same magnitude in 150 % NPK and 100% NPK + FYM treatment as compared to initial value and was relatively lower as compared to other treatment. It was indicated that the recommended fertilizer schedule failed to meet the requirement of the crop and hence maximum decline was observed in control and 100% N alone treatment. The magnitude of K decreased with increasing level of NPK application. Among the inorganic fertilizers, continuous application of N or NP had a depressive effect on the available K content of the soil, which might be due to nutrient imbalance in soil. Continuous omission of K in crop nutrition caused mining of its

native pools that caused reduction in the crop yields. The depletion of available K, even in treatments receiving K fertilization under continuous cropping, were also reported by Pathariya *et al.* (2022) and Sawarkar *et al.* (2013). Higher levels of K due to FYM application might be ascribed to reduction of K fixation that increased K content due to interaction of organic matter with clay, besides the direct K addition in the available pool of the soil (Pathariya *et al.*, 2022). The higher levels of K in 150% NPK treatment were due to higher dose of K in this treatment.

Available Sulphur

The data presented in table 2 pertaining to the available sulphur content indicated that the lowest value of available sulphur in soil was observed in control (15.0 kg ha⁻¹), followed by 100% N alone (18.2 kg ha⁻¹) treatment. While, the highest value was recorded in 100% NPK + FYM (39.8 kg ha⁻¹), followed by 150% NPK treatments (35.0 kg ha⁻¹). The content of available sulphur was found significantly higher in 100 % NPK (35.0 kg ha⁻¹) as compared to 100% NPK-S (18.3 kg ha⁻¹). The application of NPK with FYM resulted in significantly higher available S content (39.8 kg ha⁻¹) than initial value (15.6 kg ha⁻¹) after 48 years of experimentation due to the application of single super phosphate and FYM, which contained sulphur (Thakur *et al.*, 2009a; Thakur *et al.*, 2011). The continuous use of diammonium phosphate as P source has resulted in S deficiency in 100% NPK-S plots causing reduction in crop yields (Dwivedi and Dwivedi, 2015). The similar results were reported by the Dwivedi *et al.*, (2016) and Sawarkar *et al.* (2015).

Table 2: Effect of long term nutrient management on soil physico-chemical properties.

Treatments	pH	EC	OC	N	P	K	S
		dS m ⁻¹	g kg ⁻¹				
T ₁ = 50% NPK	7.55	0.18	6.9	219	21.7	253	22.3
T ₂ = 100% NPK	7.50	0.18	7.9	276	36.0	284	31.6
T ₃ = 150% NPK	7.48	0.19	9.1	307	38.9	326	35.0
T ₄ = 100% NPK+ HW	7.55	0.17	8.1	281	35.0	291	32.5
T ₅ = 100% NPK + Zn	7.58	0.16	7.6	287	33.7	297	32.9
T ₆ = 100% NP	7.53	0.17	7.0	249	29.8	250	30.5
T ₇ = 100% N	7.55	0.17	6.3	231	12.3	242	18.2
T ₈ = 100% NPK + FYM	7.60	0.15	9.5	328	40.5	335	39.8
T ₉ = 100% NPK (- S)	7.53	0.18	7.7	271	35.0	288	18.3

T ₁₀ = Control	7.38	0.15	5.6	200	11.1	228	15.0
CD (P=0.05)	NS	NS	0.25	0.21	1.38	6.11	1.06

Conclusions

It is concluded that the continuous application of inorganic fertilizers with or without organic manure under soybean-wheat cropping sequence over forty-eight years significantly improved the soil organic carbon and available nutrients. A declining trend of available K from its initial status was noticed in soil. Incorporation of manure (FYM) in Vertisol soils improved the nutrient buildup. Thus, findings clearly indicated that the recommended dose of NPK with organic manure are essential for sustainable crop production and soil fertility.

References

- Bairwa J, Dwivedi BS, Rawat A, Thakur RK, Mahawar N. Long-term effect of nutrient management on soil microbial properties and nitrogen fixation in a vertisol under soybean-wheat cropping sequence. *Journal of the Indian Society of Soil Science*. 2021; 69(2):171-8.
- Chesnin L, Yien CH. Turbidimetric determination of available sulfates. *Soil Science Society of America Journal*. 1951; 15(C):149-51.
- Dubey L, Dwivedi BS, Dwivedi AK, Thakur RK. Effect of long term application of fertilizers and manure on profile distribution of various phosphorus fractions in Vertisol. *Green Farming*. 2016; 7(2):365-70.
- Dwivedi BS, Rawat AK. Nutrient management technology for niger *Guizotia abyssinica* LF) crop in tribal areas. *Plant Archives*. 2013; 13(2):809-13.
- Dwivedi AK, Dwivedi BS. Impact of long term fertilizer management for sustainable soil health and crop productivity: Issues and challenges. *Volume: 49 Research Journal*. 2015; 49(3):374.
- Dwivedi BS, Rawat AK, Dixit BK, Thakur RK. Effect of inputs integration on yield, uptake and economics of Kodo Millet (*Paspalum scrobiculatum* L.). *Economic Affairs*. 2016 Sep 1; 61(3):519.
- Jackson ML. *Soil chemical analysis*, pentice hall of India Pvt. Ltd., New Delhi, India. 1973; 498:151-4.
- Keram KS, Sharma BL, Sharma GD, Thakur RK. Impact of zinc application on its translocation into various plant parts of wheat in a vertisol. *The Bioscan*. 2014;

9(2):491-5.

- Meshram MK, Dwivedi BS, Naik KR, Risikesh T, Keram KS. Impact of organic and inorganic sources of nutrients on yield, nutrient uptake, soil fertility and economic performance of rice in a Typic haplustert. *Journal of Soils and Crops*. 2018;28(1):31-6.
- Muhr, G.R., Datta, N.P., Shankar, Subaramoney, H., Leley, V.K. and Donahue, R.L.) *Soil Testing in India*. U.S. Agency for International Development. 1965; New Delhi, 120 p.
- Nagwanshi, A., Dwivedi, A.K., Dwivedi, B.S. and Anupama, K. Effect of long term application of fertilizer and manure on soil properties of a Vertisol in soybean-wheat cropping sequence. *International Journal of Chemical Studies*. 2018; 6(3), 2946-2949.
- Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *United States Department of Agriculture Circular*. 1954; 939.
- Panse, V.G. and S.V. Sukhatme. *Statistical methods for Agril. Workers*. 1970. ICAR Publication.
- Panwar S, Dwivedi AK, Dwivedi BS, Nagwanshi A. Distribution of zinc pools as influenced by long term application of fertilizers and manure in a Vertisol. *International Journal of Chemical Studies*. 2017; 5(6):1931-4.
- Patel G, Dwivedi BS, Dwivedi AK, Thakur R, Singh M. Long-term effect of nutrient management on soil biochemical properties in a Vertisol under soybean-wheat cropping sequence. *Journal of the Indian Society of Soil Science*. 2018; 66(2):215-21.
- Pathariya P, Dwivedi BS, Dwivedi AK, Thakur RK, Singh M, Sarvade S. Potassium Balance under Soybean–wheat Cropping System in a 44 Year Old Long Term Fertilizer Experiment on a Vertisol. *Communications in Soil Science and Plant Analysis*. 2022 Jan 19; 53(2):214-26.
- Sawarkar SD, Khamparia NK, Thakur R, Dewda MS, Singh M. Effect of long-term application of inorganic fertilizers and organic manure on yield, potassium uptake and profile distribution of potassium fractions in Vertisol under soybean-wheat cropping system. *Journal of the Indian Society of Soil Science*. 2013; 61(2):94-8.
- Sawarkar SD, Risikesh T, Khamparia RS. Impact of long term continuous use of inorganic and organic nutrients on micronutrients uptake by soybean in vertisol. *Journal of*

- Soils and Crops. 2010; 20(2):207-10.
- Sawarkar S D, Singh Muneshwar, Khamparia N K, Wanjari R H and Thakur Risikesh. *Research Bulletin* on Long Term Impact of Fertilizer and Manure on Soil Quality, Crop Productivity and Sustainability under Soybean-Wheat System in Vertisol. AICRP on LTFE, ICAR – Indian Institute of Soil Science. 2015; Bhopal, pp 1 – 63.
- Sharma YM, Jatav RC, Sharma GD, Thakur R. Status of micronutrients in mixed red and black soils of Rewa district of Madhya Pradesh, India. *Asian Journal of Chemistry*. 2013 Apr 11; 25(6):3109.
- Subbiah, B.V. and Asija, G.L. A rapid procedure for the determination of available N in soils. *Current Science*. 1956; 25, 259-265.
- Risikesh T, Sawarkar SD. Influence of long term continuous application of nutrients and spatial distribution of sulphur on soybean-wheat cropping sequence. *Journal of Soils and Crops*. 2009; 19(2):225-8.
- Risikesh T, Kauraw DL, Muneshwar S. Effect of continuous applications of nutrient inputs on spatial changes of soil physicochemical properties of a medium black soil. *Journal of Soils and Crops*. 2009; 19(1):14-20.
- Thakur R, Sawarkar SD, Vaishya UK, Singh M. Impact of continuous use of inorganic fertilizers and organic manure on soil properties and productivity under soybean-wheat intensive cropping of a Vertisol. *Journal of the Indian Society of Soil Science*. 2011; 59(1):74-81.
- Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*. 1934 Jan 1; 37(1):29-38.