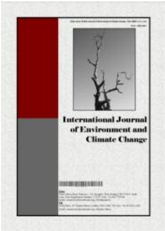

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# Impact of Long Term Application of Inorganic Fertilizers and Organic Manure on Soil Fertility and Crop Productivity under Soybean-Wheat Cropping System in a Vertisol

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The field experiments was conducted is an ongoing All India Co-ordinate Research Project on "Long term Fertilizer Experiment" during 2018-2019 with soybean-wheat cropping sequence at the Research Farm Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), India. The objective of the study was the Impact of long term application of inorganic fertilizers and organic manure on soil fertility and crop productivity under soybean-wheat cropping system in a Vertisol. The experiment consists of ten treatments *i.e.* $T_1$ 50% NPK, $T_2$ 100% NPK, $T_3$ 150% NPK, $T_4$ 100% NPK + Hand Weeding, $T_5$ 100% NPK + Zn, $T_6$ 100% NP, $T_7$ 100% N, $T_8$ 100% NPK+ Farm Yard Manure, $T_9$ 100% NPK–S and $T_{10}$ unfertilized plot (control) with four replications in a randomized block design. The findings of the present study indicated that the soil

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pH and EC were remaining unaltered even after continuous application of variable amounts of fertilizers either alone or in combination. A significant positive change in soil organic carbon, available N P K and S content was observed with continuous additions of balanced fertilizers and manures over the imbalanced or unfertilized treatments. The findings showed that the application of recommended dose of N, P and K (20:80:20 kg $ha^{-1}$ for soybean and 120:80:40 kg $ha^{-1}$ for wheat) with organic manure (FYM) @ 5 t $ha^{-1}$ resulted in 185.8% and 325.9% increase over control in soybean and wheat yields, respectively. Thus, the continuous use of balanced fertilization, either alone or in combination with organic manure is necessary for sustaining soil fertility and productivity of crops.

*Keywords: Long term fertilizer addition; nutrient availability; organic manure.*

## 1. INTRODUCTION

Soybean – wheat cropping sequence is one of the most prevalent cropping sequences followed in a substantial area of Madhya Pradesh, and in other part of the country. The profit motivated continuous application of imbalanced nutrients is the matter of great concern for sustainability. Use of inorganic fertilizer or organic manure alone cannot achieve and sustain the desired level of crop production under continuous cropping [1]. Therefore, integrated use of inorganic fertilizers with organic manure (FYM) is very essential as this practice not only sustains higher levels of productivity but also improves soil quality and hence the nutrient use efficiency [2]. 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 [3]. The present study was undertaken to find out the influence of continuous use of fertilizer and manure under an intensive cropping system in a Vertisol on soil fertility and crop productivity.

## 2. MATERIALS AND METHODS

A field experiment which was conducted during 2018-19 under AICRP- LTFE since 1972 at the Research Farm of the Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh – India. The experiment was located at $23^0$ 10’ N latitude, $79^0$ 57’ E longitudes and at elevation of 393.0 meter above mean sea level in the South-Eastern part of the Madhya Pradesh. The soil of experiment site represents a medium deep black soil, belonging to Kheri series and classified as very fine, fine *montmorillonite hyper thermic* family, Typic *Haplustert*. The textural class of soil is clay. The key soil properties (0-15 cm soil depth) are presented in Table 1.

**Table 1. Initial properties of the experimental soil (1972)**

| Soil Properties | Value |
|---|---|
| Soil pH (1:2.5) | 7.60 |
| Electrical conductivity (1:2.5) | 0.18 $dSm^{-1}$ |
| Organic carbon | 5.7 g $kg^{-1}$ |
| Available Nitrogen (N) | 193 kg $ha^{-1}$ |
| Available Phosphorous (P) | 7.6 kg $ha^{-1}$ |
| Available Potassium (K) | 370 kg $ha^{-1}$ |
| Available Sulphur (S) | 7.8 mg $kg^{-1}$ |

The present experiment included 10 treatments viz., $T_1$ = 50% NPK, $T_2$ = 100% NPK, $T_3$ = 150% NPK, $T_4$ = 100% NPK + Hand Weeding (100% NPK+HW) , $T_5$ = 100% NPK + Zn (as 25 kg $ZnSO_4$ $ha^{-1}$), $T_6$ = 100% NP , $T_7$ = 100% N, $T_8$ = 100% NPK + 15 t $ha^{-1}$ Farm Yard Manure (100% NPK+FYM), $T_9$= 100% NPK–S and $T_{10}$ = Control (without any fertilizer application). The experiment was replicated four times in a randomized block design. The sources of N, P and K used were urea, single superphosphate and muriate of potash. In sulphur-free treatment, di-ammonium phosphate (DAP) was used instead of Single Super Phosphate (SSP) as source of P. Zinc application @ of 20 kg $ZnSO_4$ $ha^{-1}$ in alternate years to wheat crop was followed till 1987. Due to high build-up of Zn, its addition was discontinued till date. Farmyard manure @ 5 t $ha^{-1}$ $year^{-1}$ was applied only to soybean crop during *kharif* season since 1972. During rainy season, all the nutrients, viz. N, P and K were applied as basal before last harrowing, whereas in wheat half of the N was applied at the time of sowing and the remaining half was applied in two splits first half at 21–25 days after the first irrigation and the rest at 51-55 days after sowing. In 100% NPK + HW treatment weeding was done manually, whereas in other treatments chemical weed control (herbicide) was followed.

Soybean (Var. JS 20-29) was sown in the last week of June to first week of July as rainfed during *kharif*, 2018 and wheat (Var. GW-366) in the first week to second week of November as irrigated during *rabi, 2018*. Wheat was irrigated at critical phases of crop growth as and when needed. Insects and diseases were kept under check following suitable control measures. Soybean and wheat crops were harvested at maturity and yield data were recorded after threshing. The soil samples were collected from 0-15 cm soil depth after the harvest of wheat crop (2018-19) in the sequence of individual plot and were analysed for different parameters by following standard procedures for soil pH and EC (1 : 2.5 soil : water ratio) was determined by [4], organic carbon [5], available N [6] available P [7], available K [8] and available S [9]. to assess the pH value, electrical conductivity, organic carbon, available N, P, K and S. The grain yields of soybean and wheat were also recorded. All observations recorded on soybean-wheat yield and soil properties were analysed statistically as per method described by Panse and Sukhatme in simply MS Excel software of computer [10].

## 3. RESULTS AND DISCUSSION

### 3.1 Changes in Soil Fertility

#### 3.1.1 Soil pH and EC

Soil pH values did not change significantly even after 46 years of soybean and wheat cultivation and continuous use of chemical fertilizers and/or organic manure (Table-2). In accordance with the results obtained, the pH values of various treatments ranged between 7.31 to 7.65. This could be ascribed to the high buffering capacity of the soil and presence of appreciable amount of free calcium carbonate [11]. Use of chemical fertilizer like urea, though it possesses net residual acidity could not create significant alteration in the soil pH values. This effect appears to have been controlled by the presence of calcium carbonate. However, the electrical conductivity has been observed that no significant changes have occurred due to imposed treatments with values ranging from 0.16 to 0.19 dSm$^{-1}$ (Table-2). Similar, results on soil pH and EC has been earlier reported by Thakur et al., [1] and Panwar et al., [12].

### 3.2 Soil Organic Carbon

The soil organic carbon content varied from 4.20 to 8.58 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 a maximum value of 8.58 g kg$^{-1}$ in the treatment that has received 100% NPK along with FYM. This could be ascribed to the contribution from annual use of organic manure (5 t FYM ha$^{-1}$) during the period of experimentation. Increasing levels of fertilizer application has helped in increasing the organic carbon content, which is due to increased contribution from the biomass, as it is also observed that with increasing levels of fertilizer application, the crop yields had increased. Contribution from root stubble could also be expected to follow the same trend. Similar findings have been reported by Singh *et al.,* [13] and Patel *et al.,* [14]; who suggested similar reasons. 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 plays an important role in maintaining and improving soil health [2].

**Table 2. Effect of inorganic fertilizers and organic manure on nutrient status of soil after harvest of wheat (2018-19)**

| Treatments | pH | EC (dSm$^{-1}$) | OC (g kg$^{-1}$) | Available Nutrients (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|
| | | | | N | P | K | S |
| $T_1$ 50% NPK | 7.57 | 0.17 | 6.16 | 227 | 23.0 | 259 | 23.0 |
| $T_2$ 100% NPK | 7.44 | 0.18 | 7.45 | 292 | 35.5 | 305 | 32.1 |
| $T_3$ 150% NPK | 7.45 | 0.19 | 8.10 | 320 | 36.8 | 322 | 36.0 |
| $T_3$100%NPK + HW | 7.52 | 0.18 | 7.53 | 286 | 33.3 | 296 | 31.8 |
| $T_5$ 100% NPK + Zn | 7.53 | 0.18 | 7.61 | 292 | 33.5 | 292 | 31.7 |
| $T_6$ 100% NP | 7.48 | 0.17 | 6.78 | 252 | 28.8 | 248 | 30.7 |
| $T_7$ 100% N | 7.31 | 0.18 | 5.25 | 217 | 9.9 | 245 | 12.6 |
| $T_8$100%NPK+FYM | 7.37 | 0.16 | 8.58 | 330 | 38.0 | 338 | 38.6 |
| $T_9$ 100% NPK-S | 7.53 | 0.18 | 7.22 | 274 | 31.0 | 303 | 11.4 |
| $T_{10}$ Control | 7.65 | 0.17 | 4.20 | 188 | 9.8 | 242 | 11.3 |
| **CD (P=0.05)** | **NS** | **NS** | **0.40** | **30.1** | **3.09** | **32.6** | **1.27** |

### 3.3 Available Nitrogen

Continuous use of nitrogenous fertilizers for forty-six years tended to increase the available nitrogen status of soil (Table 2). Data indicate that the available nitrogen content ranged from 188 to 330 kg $ha^{-1}$ and that the highest value of available N was found associated with treatments ($T_8$) where recommended fertilizer with FYM @ 5 t $ha^{-1}$ had been applied. This showed an increase of 71% over initial value (193 N kg $ha^{-1}$). Sheeba and Chellamuthu [15] ascribed such an increase in available N to the mineralization of FYM. These results are in line with findings of Dwivedi and Dwivedi [11] who observed that available N content in soil increased significantly with the use of recommended fertilizer dose in combination with manure. Further, by increasing the application rate of nutrients, the amount of available nutrients also increased significantly ($T_8$ and $T_3$). With same level of nutrients application, the magnitude of soil available N was always higher with balanced nutrients application ($T_2$, $T_3$ or $T_8$). However, application of phosphorus along with nitrogen $T_6$ (100% NP) improved the available N status of the soil in comparison to the application of nitrogen alone under $T_7$ (100% N), and further the application of potassium with 100% NP i.e. 100% NPK had also improved N content (320 kg $ha^{-1}$) in soil. Khandagle *et al.,* [16] also reported an increase in available nitrogen contents due to graded application of NPK fertilizers.

### 3.4 Available Phosphorous

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 treatment resulted in highest value (38 kg $ha^{-1}$) of available P, followed by 150% NPK treatment (36.8 kg $ha^{-1}$) over initial value (7.6 kg $ha^{-1}$) after 46 years. The lowest values of available P in control and 100% N alone were due to continuous cropping without any additions of P in these treatments [17].

Similar results have been reported by Dwivedi *et al.,* [18]. 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 besides being a direct source of nutrients, might have also solubilized the insoluble phosphate in the soil through release of various organic acids [1].

### 3.5 Available Potassium

The data of available potassium (K) indicated a declining trend (242 to 338 kg $ha^{-1}$) from its initial level (370 kg $ha^{-1}$) of available K status which indicates considerable mining of available soil K after 46 years of intensive cropping (Table 2). The maximum decline was observed in case of control followed by 100% N alone; the magnitude of decline decreased with increasing levels of NPK application.

Among the inorganic fertilizers, continuous application of N or NP had depressive effect on available K content of the soil which may be due to nutrient imbalance in the soil. Continuous omission of K in crop nutrition caused mining of its native pools that caused reduction in the crop yields [11].

However, the highest available K status of soil was found associated with 100% NPK + FYM followed by 150% NPK treatments. The application of organic manure may have caused reduction in K fixation and consequentially increased K content due to interaction of organic matter with clay besides the direct addition of K to the soil [19]. The higher levels of K in 100% NPK treatment are due to higher rates of K application in this treatment. From these results, it can be concluded that the present K recommendations are not sufficient and need revision, otherwise an abrupt decline in production could be encountered in the near future.

### 3.6 Available Sulphur

Data on available sulphur content clearly showed that available sulphur content in treatment devoid of applied sulphur ($T_9$) and control ($T_{10}$) were nearly the same over the initial value indicating that sulphur should be an important ingredient in fertilizer schedule else fair chances exists for the development of sulphur deficiency (Table-2). The application of NPK with FYM resulted in significantly higher available S content (38.6 kg $ha^{-1}$) than initial value (15.6 kg $ha^{-1}$) after 46 years of experimentation due to the application of single super phosphate and FYM, which contained sulphur. The continuous use of di-ammonium phosphate as P source has resulted in S deficiency in 100% NPK-S; causing reduction in crop yields [20].

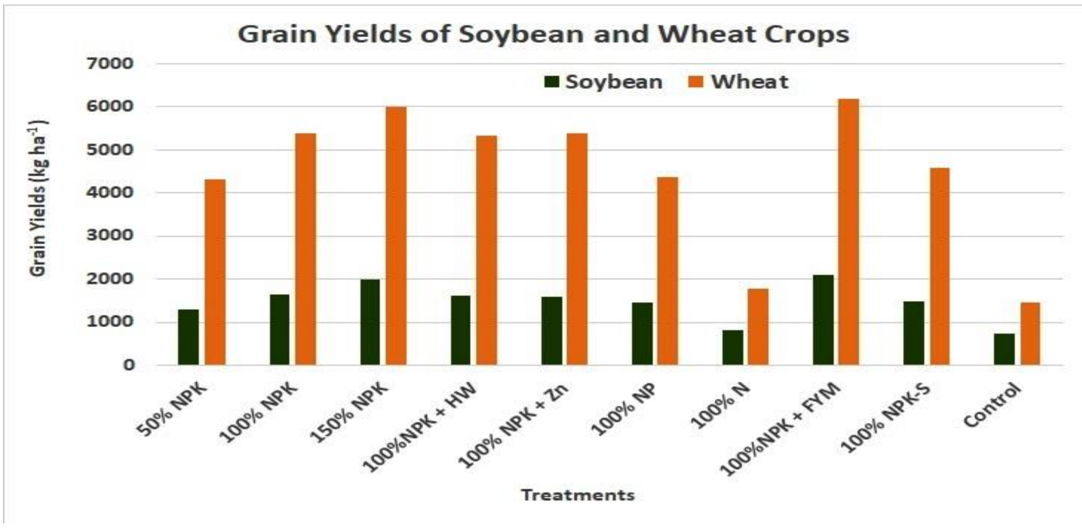


**Fig. 1. Soybean and wheat grain yields under long term fertilizer experiment (2018-19)**

## 3.7 Crop Productivity

The grain yields of soybean and wheat of 46 crop cycles (2018-19) are illustrated in Fig. 1. The lowest grain yields of soybean and wheat were recorded in control treatment. While, grain yield obtained in 100% NPK + FYM was significantly higher than 150% NPK treatment. 150% NPK treatment was found to be at par with the application of 100% NPK + FYM while, inclusion of K along with NP (100% NPK) caused an increase of around 13.4 and 22.9% over application of 100% NP alone in soybean and wheat, respectively. Instead of applying 150% NPK, it is better to use FYM with 100% NPK, since the yields obtained with 100% NPK+FYM are superior to 150% NPK application. The beneficial effect of FYM can be due to steady supply of all nutrients including the micronutrients and improvements in physical condition. Similar beneficial effects of FYM along with NPK have been reported by Sawarkar *et al.,* [21] and Dwivedi *et al.,* [22]. They observed that the continuous use of chemical fertilizers applied either singly or in combination with FYM had a marked effect on grain yields of soybean and wheat. Similar findings, have also been reported by Sharma *et al.,* [23] and Thakur *et al.,* [24].

## 4. CONCLUSIONS

From the present investigation, it could be concluded that the continuous cropping and fertilization influence the soil fertility and productivity of soybean and wheat over 46 years. Integrated use of organic manure along with 100% NPK not only sustained higher yield of both soybean and wheat, but also improved the soil fertility, which needs to be encouraged. The results indicated that balanced use of fertilizers alone or in combinations with organic manure resulted significant builds up of organic carbon content and in the available N, P, K and S. Further, imbalance use of inorganic fertilizers reduced crop yields and deteriorated soil fertility. Hence, it is recommended that balance application of fertilizers integrating with FYM is necessary to maintain soil fertility, productivity of soybean and wheat over a long period of time.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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