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Influence of organic & inorganic nutrient sources on soil productivity after wheat harvest under organic production system a success story and awareness

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Abstract
The field experiment was conducted during *Rabi* season 2015-16 and 2016-17 in Sultanpur diatrict, U.P. The treatments included System of Wheat Intensification (SWI) technique, Kera method and Furrow Irrigated Raised Bed (FIRB). The results revealed that soil pH and electrical conductivity remained within the normal range and were not significantly affected by the planting methods. However, SWI recorded comparatively lower EC and pH values closer to neutrality. Organic carbon content improved from the initial values (0.40 to 0.46%) and increased by about 9.30% under SWI and Kera method in pooled analysis. Similarly, improvement in soil nutrient status was observed after harvest. Under SWI, available nitrogen, phosphorus, and potassium increased by 8.03%, 16.16%, and 5.43%, respectively in pooled, over the initial soil status. Micronutrients also showed improvement, where sulfur, zinc, iron, manganese, copper, and boron increased by 2.52%, 4.60%, 3.21%, 3.57%, 10.87% and 4.84%, respectively in pooled. Application of different organic nutrient sources also influenced the soil chemical properties and nutrient availability after harvest of wheat. The treatments consisted of poultry manure (2.6 t/ ha), farmyard manure (16 t/ ha) and Bokashi manure (3.2 t/ ha). Soil pH and electrical conductivity remained within safe limits with all organic nutrient sources. Among the treatments, farmyard manure (16 t/ ha) recorded comparatively lower EC and pH values closer to neutral and significantly improved soil organic carbon, which increased by 9.30% in pooled over the initial soil organic carbon status. The availability of major nutrients such as nitrogen, phosphorus and potassium also increased with the application of farmyard manure by 9.31%, 18.69% and 5.68%, respectively in pooled, compared with the initial soil status. Similarly, micronutrient availability improved, where sulfur, zinc, iron, manganese, copper, and boron increased by 2.79%, 4.60%, 3.33%, 4.02%, 10.87%, and 4.84%, respectively in pooled.

Keywords: Organic wheat, planting methods, organic sources of nutrient, nutrient and chemical properties of soil.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important staple cereal crops in the world and plays a crucial role in ensuring global food security. It is cultivated extensively across diverse agro-ecological regions and contributes significantly to human nutrition as a major source of carbohydrates, proteins, vitamins and minerals. However, continuous cultivation of wheat with excessive use of chemical fertilizers has resulted in deterioration of soil health, decline in soil organic matter and imbalance in soil nutrient status, which ultimately affects crop productivity and agricultural sustainability.

In recent decades, increasing concerns regarding environmental degradation and soil fertility depletion have led to a growing interest in sustainable agricultural practices such as organic farming. Organic production systems rely primarily on organic sources of nutrients including farmyard manure, vermicompost, green manure, poultry manure and other biological inputs to maintain soil fertility and productivity. Organic amendments enhance soil physical, chemical and biological properties by increasing soil organic carbon, improving soil structure and stimulating microbial activity, thereby contributing to sustainable crop production.

Organic nutrient sources play an important role in maintaining soil productivity through gradual nutrient release and improvement of soil organic matter. Unlike synthetic fertilizers that supply nutrients rapidly but often lead to nutrient imbalance and soil degradation, organic inputs release nutrients slowly and improve nutrient availability over a longer period. Long-term studies have shown that the application of organic manures significantly increases soil organic carbon content, nutrient uptake and crop productivity in wheat-based cropping systems (Binjola *et al.*, 2017) [1].

The incorporation of organic manures also improves soil biological activity by promoting beneficial microorganisms involved in nutrient cycling and organic matter decomposition. Enhanced microbial activity leads to improved nutrient mineralization and better nutrient availability to crops. Moreover, organic amendments reduce soil bulk density, improve soil aggregation and increase water-holding capacity, which are essential for sustaining soil fertility and crop growth (Kumar *et al.*, 2015) [9].

Another important aspect of organic nutrient management is its residual effect on soil productivity after crop harvest. Organic manures not only supply nutrients to the current crop but also leave residual fertility in the soil, which benefits subsequent crops and enhances long-term soil productivity. Studies have demonstrated that residual effects of organic amendments such as FYM and green manure significantly improve soil nutrient status, plant growth and yield attributes of wheat in cropping systems (Singh *et al.*, 2023) [21].

In organic production systems, maintaining soil productivity is a major challenge due to the absence of synthetic fertilizers. Therefore, evaluation of different organic nutrient sources becomes essential to identify effective nutrient management strategies that can sustain soil fertility and crop productivity. Understanding the agronomic performance of different organic amendments on soil properties after crop harvest is particularly important for developing sustainable nutrient management practices in organic farming systems.

Therefore, the present study was undertaken to assess the effect of different organic nutrient sources on soil productivity parameters after wheat harvest and to identify suitable organic nutrient management practices for sustainable soil health and productivity in organic farming system.

Materials and Methods

The experiment was carried out during *Rabi* season 2015-16 and 2016-17 at Sultanpur at farmers fields. The soil of the experimental plots was sandy loam in texture, low in available nitrogen, medium in available phosphorus and high in available potash with 7.68 soil pH. The experiment was laid out in split plot design with three replications, having three planting methods, *viz.*, System of Wheat Intensification [SWI(t), 20 × 20 cm] technique, *Kera* method (22.5 × 10 cm) and Furrow Irrigated Raised Bed (FIRB, 22.5 × 10 cm); three organic sources of nutrient, *viz.*, Poultry manure (2.6 t/ ha), Farm yard manure (16 t/ ha) and *Bokashi* manure (3.2 t/ ha) were studied. Green manure *dhaincha* (*Sesbania aculeata* L.) was grown during *zaid* season and *Panchagavya* was sprayed in all the treatment; and the crop seeds were treated with *jeevamruth* organic formulation. There were total 9 treatment combinations in all. The net plot size was 5 × 4 m and net experimental area 540 m^2. The agronomic practices, *viz.*, weeding with cycle weeder in SWI technique, manual and hand weeding in *Kera* and FIRB methods were done and irrigation was given according to the schedules for all treatments. The wheat variety 'SHIATS W8' was sown. Data on pH value, EC (dS/ m), available nitrogen (kg/ ha), available phosphorus (kg/ ha), available potassium (kg/ ha), available organic carbon (%), available sulfur (ppm), available zinc (ppm), available iron (ppm), available manganese (ppm), available copper (ppm), available boron (ppm) were recorded. Data recorded on soil nutrient and chemical properties of soil were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976 [5].

Method of soil analysis

For testing of chemical properties of soil, *viz.*, pH, electrical conductivity, available nitrogen, available phosphorus, available potassium, organic carbon, available sulfur, available zinc, available iron, available manganese, available copper and available boron, the surface soil sample (0.15 cm depth) were collected randomly from each plot after crop harvest. The soil samples were analyzed using the following standard procedures.

1. Soil pH: It was determined with the help of glass electrode pH meter using 1:2.5 soil water suspensions as described by Jackson (1973) [7]. The pH is a measure of hydrogen or hydroxyl ion activity of the soil water system. It indicates whether the soil is acidic, neutral or alkaline in reaction. Since crop growth suffers much both under very low (strongly acidic) and very high pH (alkaline) conditions, appropriates reclamation measures become essential.

For determining the pH, 10 g of soil sample was taken in 50 ml beaker and added 20 ml of distilled water and stirred with the help of glass rod for about 5 minutes and kept for half an hour. Again the solution was stirred just before immersing the electrodes and pH reading on pH meter was recorded, having combined Glass electrode.

2. Electrical conductivity (EC): Metal ions, like metals, allow the electrical current to pass through them. Hence, the electrical conductivity of the soil-water system rises with increasing content of soluble salt in the soil. Electrical conductivity (EC) was determined by conductivity bridge meter using 1:2.5 soil water suspensions. In this method, 20 g of soil sample was taken in 100 ml beaker. Then 40 ml of distilled water was added to make a soil solution and shaken intermittently with the help of glass rod. Then it was allowed to stand until clear supernatant liquid is obtained. Calibrate the conductivity bridge with the help of standard KCl solution and determine the cell constant. After this the conductivity of the supernatant liquid was determined with the help of the conductivity bridge (Richards, 1954) [16].

3. Available nitrogen: Available nitrogen content in soil sample was estimated by alkaline potassium permanganate method as described by Subbiah and Asija (1956) [17].

When available nitrogen in the soil is measured by organic carbon method, soil test nitrogen response equation developed based on alkaline potassium permanganate method cannot be directly used. Available nitrogen estimated by alkaline potassium permanganate method, has to be predicted from the easily oxidizable organic based on the regression equations developed between these two methods for different soils. For old alluvium grey-grayish yellow light textured soil is- $Y=103.3 + 321.0 X$

Where,

Y= N obtained by alkaline $KMnO_4$

X= % organic carbon

4. Available Phosphorus: Available phosphorus was extracted by 0.5 m $NaHCO_3$ as per procedure of Olsen's determined calorimetrically by molybdophosphoric blue colour method as described by Olsen *et al.* (1954) [15]. First, we made Olsen Extractant. Took 2.5 g soil + 0.5 g activated charcoal (phosphorus free) in a 250 ml flask and added 50 ml Olsen's extractant to it which was shaken for 30 minutes on a mechanical shaker and filtered it through Whatman filter paper No.1. A blank should also run side by side. Then, 10 ml of extract was taken in a 50 ml volumetric flask and 1-2 drops of 2,4 dinitrophenol indicator was added and adjusted the pH 3.5 by adding 5N NH_4OH. The end point was colourless. After adjustment of pH, added 8 ml of ascorbic acid solution to make up the volume 50 ml with distilled water. The intensity of colour was measured after 30 minutes and before 2 hours of colour development with the help of calorimeter using 660 mµ wavelength or red filter after adjusting the instrument at zero reading with blank. The amount of P was calculated in extrate by comparing the reading with standard curve for phosphorus. Available phosphorus in soil is calculated by following formula-

$$\text{Amount of P in soil (kg/ ha)} = \frac{2 \times V \times E \times G}{S \times F}$$

Where,
S = Soil taken (g)
E = Extracting solution taken (ml) to extract P from
F = Amount of soil extract (filtrate) taken to colour develop (ml)
V = Final volume made (ml)
R = Calorimetric reading
G = Corresponding ppm of P as per standard graph on R value

5. Available potassium: Available potassium in soil sample was determined by using neutral ammonium acetate solution as described by Toth and Prince (1949) [23]. The reading was taken on a flame photometer using potassium filter. 5 g soil was and 25 ml of neutral 1N ammonium acetate was taken in a shaking bottle and shaken on a horizontal shaker for 5 minutes. Then the solution was filtered through Whatman filter paper No. 1. The amount of K in extract was determined in the flame photometer after necessary setting and standardizing of instrument with 10, 20 and 30 ppm K solution.

$$\text{Amount of K in soil (kg/ha)} = R \times \frac{\text{Volume of the extract}}{\text{Weight of the soil}} \times \frac{224 \times 10^4}{10^6}$$

Where,
R = µg/ ml of K in the extract (obtained from the standard curve)

6. Available organic carbon: Organic carbon was determined by Walkley and Black's rapid titration method as described by Walkley and Black's (1934) [24]. In this method, 2 g of soil is taken in 500 ml conical flask and 10 ml of 1N $K_2Cr_2O_7$ solution and mix. Then add 20 ml of concentrated H_2SO_4 with swirling the flask during addition. Leave the flask as such as to cool the contents and allow the reaction to complete for 30 minutes. Then, 2 g of NaF powder was added to 200ml of distilled water and shaken vigorously. Then 10 drops of diphenylamine indicator was added, which will give violet colour to the suspension. After this, Titration of the contents of the flask with 0.5 N Ferrous Ammonium Sulphate solution was done. The end point is bright green. The volume of the 0.5 N Ferrous Ammonium Sulphate solution used was noted to calculate the results (as given below). Also run a blank titration in a similar way.

$$\text{Organic Carbon (\%)} = \frac{10(B-T)}{B} \times 0.003 \times \frac{100}{\text{Weight of soil}}$$

Where,
B= volume (in ml) of Ferrous Ammonium Sulphate solution required for blank titration
T= Ferrous Ammonium Sulphate solution needed for soil sample

7. Available sulfur: Sulfur was determined by turbidimetric method with the help of a spectrophotometer (Chesnin and Yien, 1950) [2]. In this method, 5 g soil was extracted with 25 ml of 0.15% $CaCl_2$ solution and shaken for 30 minutes. Turbidity was developed by using $BaCl_2$ and gum acacia solution and measured spectrophotometrically at 420 nm.

8. Available zinc, iron, manganese, copper and boron: Diethylenetriaminepentaacetic acid (DTPA) was used for extraction of elements, *viz*., Zn, Cu, Fe, Mn and B. This extractant was advanced by Lindsay and Norvell (1978) [11]. The estimation of elements in the extract is done with the help of Atomic Absorption Spectrophotometer (AAS). DTPA 0.005 M, 0.01 M $CaCl_2.2H_2O$ and 0.1 M Triethanolamine (TEA) extractant: Added 1.967 g DTPA and 13.3 ml TEA in 400 ml distilled water in a 500 ml flask. Taken 1.47 g $CaCl_2.2H_2O$ in a separate 1000 ml flask. Added 500 ml distilled water and shaken to dissolve. Added DTPA+TEA mixture in $CaCl_2$ solution and made the volume to 1 litre. The pH was adjusted to 7.3 by using 1 M HCl before making the volume.

Results

Chemical properties of soil after harvesting

The record regarding the effect of different planting methods and organic source of nutrient on chemical status of soil in wheat field is given in the table 1, 2, 3, 4, 5 and 6.

Electrical conductivity (dS/ m)

Highest electrical conductivity (0.88, 0.86 and 0.87 dS/ m respectively) was registered with exactly same values in the treatment M_2 (*Kera* method) and M_3 (Furrow Irrigated Raised Bed) during both the years and in pooled, though it was found no significance difference.
Data pertaining to organic sources of nutrient showed statistical variation in electrical conductivity (EC). The highest EC (0.89, 87 and 0.89 dS/ m respectively) was registered by S_3 (*Bokashi* manure, 3.2 t/ ha) during both the years and pooled, though it was recorded non significant.
Appraisal of the data on EC remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

pH value

Highest soil pH (7.63 and 7.55) was registered in the treatment M_2 (*Kera* method) in 2015-16 and pooled; and pH (7.48) by M_3 (Furrow Irrigated Raised Bed) in 2016-17, though it was found no significance difference. The results showed that treatment M_1 (System of Wheat Intensification technique) is more suitable for the better crop performance.
Data pertaining to organic sources of nutrient showed statistical variation in soil pH. It further registered that highest soil pH (7.64 and 7.48) by S_3 (*Bokashi manure*, 3.2 t/ ha) during both the years of experiment and pooled, though it was recorded non significant; where also, it was registered with exactly same values by S_1 (Poultry manure, 2.6 t/ ha) with S_3 (*Bokashi manure*, 3.2 t/ ha) in 2016-17. The results showed that treatment S_2 (Farm yard manure, 16 t/ ha) is more suitable for the better crop performance.
Appraisal of the data on soil pH remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available organic carbon (%)

Highest organic carbon was registered with exactly same values in the treatment M_1 (System of Wheat Intensification technique) and M_2 (*Kera* method) during both the years and pooled; and it was also recorded with exactly same values by M_3 (Furrow Irrigated Raised Bed) in both the years, though it was found no significance difference.

Data pertaining to organic sources of nutrient showed significant difference in organic carbon. It further registered that higher organic carbon (0.44% and 0.50%) by S_2 (Farm yard manure, 16 t/ ha) during both the years and pooled. The mean data also recorded with exactly same values by S_1 (Poultry manure, 2.6 t/ ha) with S_2 (Farm yard manure, 16 t/ ha) in 2015-16. However, S_1 (Poultry manure, 2.6 t/ ha) was observed statistically at par with S_2 (Farm yard manure, 16 t/ ha) in 2016-17.

Appraisal of the data on organic carbon remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available N (kg/ ha)

Highest available nitrogen (99.25 and 111.25 kg/ ha) was registered in the treatment M_1 (System of Wheat Intensification technique) during both the years and pooled, though it was found no significance difference. The mean data also recorded with exactly same values by M_2 (*Kera* method) with M_1 (System of Wheat Intensification technique) in 2015-16.

Data pertaining to organic sources of nutrient showed significant difference in available nitrogen. It further registered that highest available nitrogen (100.00 and 113.00 kg/ ha) by S_2 (Farm yard manure, 16 t/ ha) in both the years and pooled. However, S_1 (Poultry manure, 2.6 t/ ha) was found to be statistically at par with S_2 (Farm yard manure, 16 t/ ha) in both the years. Further, statistically lowest value was registered by S_3 (*Bokashi manure,* 3.2 t/ ha) in both the years and pooled.

Appraisal of the data on available nitrogen remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available P_2O_5 (kg/ ha)

Highest available phosphorus (20.50 and 25.50 kg/ ha) was registered in the treatment M_1 (System of Wheat Intensification technique) in both the years and pooled, though it was found no significance difference. Further, it was registered with exactly same values by M_3 (Furrow Irrigated Raised Bed) in 2015-16.

Data pertaining to organic sources of nutrient showed statistical variation in available phosphorus. It further registered that highest available phosphorus (21.00 and 26.00 kg/ ha) by S_2 (Farm yard manure, 16 t/ ha) in both the years and pooled and found non significant.

Appraisal of the data on available phosphorus remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available K_2O (kg/ ha)

Highest available potassium (257.60 kg/ ha and 273.78 kg/ ha) was registered in the treatment M_1 (System of Wheat Intensification technique) in both the years, though it was found no significance difference; as per result the significance difference was observed in pooled. However, M_2 (*Kera* method) was found to be statistically at par with M_1 (System of Wheat Intensification) in pooled. Further, statistically lowest value was registered by M_3 (Furrow Irrigated Raised Bed) in both the years and pooled.

Data pertaining to organic sources of nutrient showed statistical variation in available potassium. It further registered that highest available potassium (257.60 and 275.02 kg/ ha) by S_2 (Farm yard manure, 16 t/ ha) in both the years and pooled and found non significant.

Appraisal of the data on available potassium remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available sulfur (ppm)

Highest available sulfur (11.68 and 12.07 ppm) was registered in the treatment M_1 (System of Wheat Intensification technique) in both the years and pooled, though it was found no significance difference.

Data pertaining to organic sources of nutrient showed statistical variation in available sulfur. It further registered that highest available sulfur (11.71 and 11.90 ppm) by S_2 (Farm yard manure, 16 t/ ha) in both the years and pooled and observed non significant.

Appraisal of the data on available sulfur remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available zinc (ppm)

Highest available zinc (0.88 and 0.93 ppm) was registered in the treatment M_1 (System of Wheat Intensification technique) in both the years and pooled; where, it was registered with exactly same values by M_2 (*Kera* method) and M_3 (Furrow Irrigated Raised Bed) in 2016-17, though it was found no significance difference.

Data pertaining to organic sources of nutrient showed statistical variation in available zinc. It further registered that highest available zinc (0.88 and 0.94 ppm) by S_2 (Farm yard manure, 16 t/ ha) has the in both the years and observed non significant. However, in pooled it was observed significantly higher available zinc by S_2 (Farm yard manure, 16 t/ ha) and S_1 (Poultry manure (2.6 t/ ha) was found to be statistically at par. Further, statistically lowest value was registered by S_3 (*Bokashi manure,* 3.2 t/ ha) in both the years and pooled.

Appraisal of the data on available zinc remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available iron (ppm)

Highest available iron (8.48 and 8.89 ppm) was registered in the treatment M_1 (System of Wheat Intensification technique) in both the years and pooled, though it was found no significance difference.

Data pertaining to organic sources of nutrient showed statistical variation in available iron. It further registered that highest available iron (8.49 and 8.89ppm) by S_2 (Farm yard manure, 16 t/ ha) in both the years and pooled and found non significant.

Appraisal of the data on available iron remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available manganese (ppm)

Highest available manganese (4.22 and 4.48 ppm) was registered in the treatment M_1 (System of Wheat

Intensification technique) in both the years and pooled, though it was found no significance difference.

Data pertaining to organic sources of nutrient showed statistical variation in available manganese. It further registered that highest available manganese (4.24 and 4.49 ppm) by S_2 (Farm yard manure, 16 t/ ha) in both the years and pooled and found non significant.

Appraisal of the data on available manganese remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available copper (ppm)

The highest available copper (0.47, 0.54 and 0.51 ppm) was registered in the treatment M_1 (System of Wheat Intensification technique) during both the years and pooled, though it was found non significant. Further, M_2 (*Kera* method) and M_3 (Furrow Irrigated Raised Bed) was recorded with exactly same values with M_1 (System of Wheat Intensification technique) in 2016-17.

Data pertaining to organic sources of nutrient showed statistical variation in available copper. It further registered that highest available copper (0.46 and 0.55 ppm) by S_2 (Farm yard manure, 16 t/ ha) in both the years of experiment and pooled, though it was found to be non significant; however, it was registered significant in pooled. The mean data also registered with exactly same values by S_1 (Poultry manure, 2.6 t/ ha) with S_2 (Farm yard manure, 16 t/ ha) in 2015-16.

Appraisal of the data on available copper remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Available boron (ppm)

Highest available boron (0.63 and 0.66 ppm) was registered in the treatment M_1 (System of Wheat Intensification technique) in both the years and pooled; it was observed with exactly same values by M_3 (Furrow Irrigated Raised Bed) in both the years and by M_2 (*Kera* method) with M_1 (System of Wheat Intensification) in 2015-16, though it was found to be non significant.

Data pertaining to organic sources of nutrient showed statistical variation in available boron. It further registered that highest available boron (0.64 and 0.66 ppm) by S_1 (Poultry manure, 2.6 t/ ha) in both the years and pooled, though it was found to be non significant. Further, S_2 (Farm yard manure, 16 t/ ha) was registered with exactly same values with S_1 (Poultry manure, 2.6 t/ ha) in 2016-17 and pooled.

Appraisal of the data on available boron remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Discussion

D1. Effect of planting methods on physico-chemical properties of the soil after harvest of wheat

Laboratory analysis of soil samples collected both at pre-planting and post-harvest indicate that all soils are in slightly alkaline range, but the lowest and nearer to neutral soil pH (7.54) was registered with exactly same values by System of Wheat Intensification technique and Furrow Irrigated Raised Bed in pooled analysis, though it was found non significant.

The highest EC was recorded with exactly same values under *Kera* method and Furrow Irrigated Raised Bed in pooled analysis, though it was found non significant. Total EC content of the soil before the experiment (0.90 and 0.88 dS/ m) during both the years and after the experiment there was decreased in EC of the soil due to different planting methods during both the years and in pooled analysis. Further, the lowest EC was registered in System of Wheat Intensification technique in pooled analysis.

Further, the organic carbon content of the soil under System of Wheat Intensification technique and *Kera* method tended to showed increased organic carbon content equally, while the Furrow Irrigated Raised Bed was recorded a lowest content of organic carbon. Total organic carbon content of the soil before the experiment (0.40 and 0.46%) during both the years and after the experiment revealed that there was improvement in organic carbon status of the soil due to different planting methods during both the years and pooled analysis. In this respect in System of Wheat Intensification technique and *Kera* method enhanced the OC in the soil by about 9.30% from the initial status of organic carbon content in the soil in pooled analysis (Table 1 and 2).

D2. Effect of planting methods on nutrient status of the soil after harvest of wheat

D2.1. Soil available macronutrients

In order to find out the competitive ability of different planting methods, the macronutrients status of the soil from wheat crop field were measured.

Among the planting methods the soil total available nitrogen and phosphorus were not affected by the crops. This could be due to relatively slow turnover times for soil organic matter (SOM), making the incorporation of residual into total soil nitrogen small. With regard to the effect on the available K content in the soil, the significant difference was observed under System of Wheat Intensification technique in pooled analysis, though it was found non significant in both the years. Total nitrogen, phosphorus and potassium content of the soil before the experiment (90.90 and 103.95 kg/ ha), (17.10 and 22.50 kg/ ha) and (241.92 and 262.08 kg/ ha) during both the years and after the experiment revealed that there was improvement in nitrogen, phosphorus and potassium status of the soil due to different planting methods during both the years and pooled analysis. In this respect in System of Wheat Intensification technique enhanced the N, P and K in the soil by about 8.03%, 16.16% and 5.43% from the initial status of nitrogen, phosphorus and potassium content respectively in the soil in pooled analysis (Table 1 and 3).

D2.2 Soil available micronutrients

In order to find out the competitive ability of different planting methods, the micronutrients status of the soil from wheat crop field were measured.

The essential micronutrients content in the soil were statistically analyzed during both the years and in pooled analysis. The highest values of the sulfur, zinc, iron, manganese, copper and boron were recorded in System of Wheat Intensification technique during both the years and in pooled, though it was found non significant. Total sulfur, zinc, iron, manganese, copper and boron content of the soil before the experiment (11.24 and 11.74 ppm), (0.83 and 0.90 ppm), (8.20 and 8.62 ppm), (4.08 and 4.32 ppm), (0.42 and 0.50 ppm) and (0.60 and 0.64 ppm) during both the years and after the experiment revealed that there was improvement up to some extent in sulfur, zinc, iron, manganese, copper and boron status of the soil. In this regard System of Wheat Intensification technique enhanced the sulfur, zinc, iron, manganese, copper and boron content in the soil by about 2.52%, 4.60, 3.21%, 3.57%, 10.87% and 4.84% from the initial status of the soil in pooled analysis respectively (Table 4,5 and 6).

D3. Effect of organic sources of nutrient on physico-chemical properties of the soil after harvest of wheat

Laboratory analysis of the soil samples collected from wheat crop field at post harvest showed that the lowest and closer to neutral soil pH (7.60, 7.44 and 7.52) due to application of Farm yard manure at the rate of 16 t/ ha during both the years and in pooled analysis, though there was found no significance difference.

The soil samples analysis at post harvest showed that the lowest EC (0.87, 0.85 and 0.86) due to application of farm yard manure (16 t/ ha) during both the years of investigation and in pooled analysis, though there was no significance difference. The EC was found normal with all the organic sources of nutrient as the limits suggested by Muhr *et al.* (1965) [12] for judging salt problem of soil (EC< 1.0 dS/ m). The normal electrical conductivity with organic sources of nutrient might have ascribed to leaching of salts to lower horizons. This lines are in support by Singh and Mishra (2012) [20].

Further, the available status of nutrients such as organic carbon was enhanced due to application of different forms of organic manures. Total organic carbon content of the soil before the experiment (0.40 and 0.46%) during both the years and after the experiment revealed that there was improvement in organic carbon status of the soil due to different organic sources of nutrient during the both the years and pooled analysis. In this respect among the different organic sources of nutrient farm yard manure (16 t/ ha) recorded significantly higher value and enhanced the OC in the soil by about 8.70% from the initial status of organic carbon content in the soil in pooled analysis (Table.1 and 2). The decrease in pH probably may be due to an increase of organic carbon (OC) concentration and improved biological activity after application of organic sources of nutrient (Shaaban *et al.*, 2013) [18]. Decomposition of soil organic matter produces carbonic acid via carbon dioxide (CO_2) dissolution in water, which could decrease the pH towards neutral point (Niazi *et al.*, 2001). Kumar *et al.* (2007) and Yaduvanshi (2003) [8, 14, 26] also reported that improvement in soil organic carbon content and decrease in soil pH due to addition of organic manures. Further, significantly higher organic carbon with farm yard manure which might have attributed to higher addition of humus to the soil and thus, mass per unit volume decreased resulting in increased soil organic carbon content (Naik and Yakadri, 2004) [13]. Another reason, enhancement of the soil organic carbon content with farm yard manure might be due to the constant addition of organic matter influencing the physical, chemical and biological properties of the soil. Similar findings collaborate with Sharma and Kumar (1989) [22].

D4. Effect of organic nutrient sources on soil available nutrient status after harvest of wheat

D4.1. Soil available macronutrients

At wheat crop field the available status of major nutrients such as nitrogen, phosphorus and potassium were enhanced due to application of different forms of organic manures. Total nitrogen, phosphorus and potassium content of the soil before the experiment (90.90 and 103.95 kg/ ha), (17.10 and 22.50 kg/ ha) and (241.92 and 262.08 kg/ ha) during both the years and after the experiment revealed that there was improvement in nitrogen, phosphorus and potassium status of the soil with all the manurial application during the both the years and pooled analysis. With regard to the effect on the available nitrogen content in the soil, the significant difference was observed under organic source with farm yard manure during both the years and in pooled analysis. In this respect among the different organic sources of nutrient recorded highest value in treatment S_2 (Farm yard manure 16 t/ ha) enhanced the N, P and K in the soil by about 9.31%, 18.69% and 5.68% from the initial status of nitrogen, phosphorus and potassium content respectively in the soil in pooled analysis (Table 1 and 3). The organic sources of nutrients can accelerate soil nutrients activation, improve soil nutrients content, maintain available nutrients balance, and then improve soil fertility (Garcia-Gil *et al.* 2004; Huang *et al.* 2010) [4, 6]. Organic sources of nutrients can also increase the activity of microorganisms and enzymes with regard to nutrient transformation, hence increasing soil available nutrients (Lazcano *et al.* 2013). Diacono and Montemurro (2010) [3, 10] also reported that long-term application of organic amendments enhances soil available potassium, extractable phosphorus and available nitrogen availability. Similarly, our study found that being continued as organic farming for the 10th year consecutively (till May 2018) gave the promising results in terms of soil fertility and productivity, which could be the reason of increment in soil macronutrients. Further, significantly higher available nitrogen with the application of farm yard manure which might be due to the higher organic carbon content as well as direct addition of nitrogen (N) through decomposition of the FYM added to the soil.

D4.2. Soil available micronutrients

At wheat crop field the available soil micronutrients status such as sulfur, zinc, iron, manganese, copper and boron were increased due to application of different forms of organic manures during both the years and pooled analysis. It was observed significant in available zinc and copper due to application of farm yard manure (16 t/ ha) in pooled analysis, though it was found non significant in both the years; where sulfur, iron, manganese and boron were registered as non significant with all the application of organic sources of nutrient in both the years and pooled. Total sulfur, zinc, iron, manganese, copper and boron content of the soil before the experiment (11.24 and 11.74 ppm), (0.83 and 0.90 ppm), (8.20 and 8.62 ppm), (4.08 and 4.32 ppm), (0.42 and 0.50 ppm) and (0.60 and 0.64 ppm) during both the years and after the experiments revealed that there was improvement up to some extent in sulfur, zinc, iron, manganese, copper and boron status of the soil. In this regard among the different organic sources of nutrient recorded highest value in treatment S_2 (Farm yard manure, 16 t/ ha) enhanced the sulfur, zinc, iron, manganese, copper and boron content in the soil by about 2.79%, 4.60%, 3.33%, 4.02%, 10.87% and 4.84% from the initial status of the soil in pooled analysis respectively (Table 4, 5 and 6). It was observed that increased in micronutrients content in the soil with all organic sources of nutrient application may be due to increased in organic carbon content (Sidhu and Sharma, 2010) [19]. Further, the soil was maintained organically for many years, which could have ascribed in increasing the availability of micronutrients. This line corroborate with Wang *et al.* (2008) [25].

Conclusion

The present study clearly demonstrated that different organic nutrient sources and planting methods influenced soil fertility status after harvest of organic wheat. Although planting methods did not show significant differences in most soil chemical parameters, the System of Wheat Intensification technique showed comparatively better improvement in soil nutrient status. Among the organic nutrient sources, application of farmyard manure at 16 t/ ha proved to be the most effective in improving soil organic carbon, available nitrogen, phosphorus, potassium and micronutrient status of the soil. Therefore, the application of farmyard manure in organic wheat cultivation can be recommended as an effective nutrient management strategy for sustaining soil health and improving long-term soil productivity under organic production systems.

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