International Journal of Recent Trends in Science And Technology, P-ISSN 2277-2812 E-ISSN 2249-8109
Special Issue, ACAEE: 2018 pp 181-194

Original Research Article

Comparative analysis of physico-chemical parameters and enzymatic activity of soil before sowing and after harvesting of wheat and soybean treated with different fertilizers

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Abstract

The study was conducted on black cotton soil under field conditions by using randomized block design with three replications in order to investigate the comparative analysis of physico-chemical properties and enzymatic activity of soil before sowing and after harvesting of wheat and soybean after treated with different fertilizers. Results of the research revealed that before sowing of soybean, nitrogen content of soil was found maximum (188.47 kg/ha) in 10% vermicompost + 100 gm urea treatment and minimum (95.62 kg/ha) in control, while after harvesting it was maximum (174.63 kg/ha) in the same treatment and minimum (85.46 kg/ha) in control. Before sowing the phosphorus content was recorded highest (36.21 Kg/ha) in 10% vermicompost + 100 gm NPK treatment and lowest (7.63 Kg/ha) in control, while after harvesting it was maximum (25.94 kg/ha) in 10% vermicompost + 100 gm urea and minimum (6.14 kg/ha) in control. Moreover before sowing of soybean the potassium content was maximum ((271.32 Kg/ha) in 10% vermicompost + 100 gm NPK and minimum (146.53 Kg/ha) in control. However in case of wheat before sowing the maximum (188.48 Kg/ha) nitrogen content was found in 10% vermicompost + 100 gm urea and minimum (95.64 Kg/ha) in the control, while as after harvesting it was observed maximum (165.52 kg/ha) in 10% VC + 100 gm urea and minimum (77.26 kg/ha) in control. Phosphorus was maximum (36.26 Kg/ha) in 10% vermicompost + 100 gm NPK treatment and minimum (7.62 kg/ha) in control before sowing while after harvesting it was maximum (25.72 kg/ha) in 10% vermicompost + 100 gm NPK and minimum (5.14 kg/ha) in control. Moreover before sowing of wheat potassium content was maximum (271.30 kg/ha) found in 10% vermicompost + 100 gm NPK and minimum (146.51 kg/ha) in control while after harvesting it was maximum (256.44 kg/ha) in 10% VC + 100 gm NPK and minimum (133.25 kg/ha) in control. The results revealed that there was a significant difference in nitrogen, phosphorus and potassium content of soil before sowing and after harvesting of soybean and wheat. Due to presence of root nodules the nitrogen uptake in soybean was less as compared to the wheat. Furthermore there was no significant difference in pH, electric conductivity, organic carbon zinc, copper, iron, manganese content and enzymatic (dehydrogenase, urease) activity before sowing and after harvesting of soybean and wheat. The organic carbon content, dehydrogenase and urease activity was enhanced by the application of organic manure (vermicompost, farmyard manure). The study concluded that integrated use of organic manure (vermicompost, farmyard manure) and chemical fertilizers (NPK, urea) is very helpful for enhancing the physico-chemical parameters and maintaining the soil fertility of soil. Among all the fertilizer combinations vermicompost along with NPK is the most effective fertilizer combination.

Key Words: Vermicompost, NPK, Dehydrogenase, Urease, Nitrogen, Phosphorus, Potassium.

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Access this article online

Quick Response Code:

Website: www.statperson.com

Accessed Date: 26 March 2018

Soil is a complex combination of minerals, water, air, organic matter, and a number of organisms that are the dead and decomposed remains of once-living things. It is formed by the weathering of rocks and the process of soil formation is known as paedogenesis, in which there is a conjoint result of physical, chemical and biological processes working on soil parent material. Fertilizers are organic or inorganic materials of natural or synthetic

origin that are added to soil to supply one or more nutrients essential for the growth of plants. Organic manure or organic fertilizers are fertilizers derived from animal or plant matter (e.g. compost, manure etc). Manure is any organic substance that is added to the soil to increase its fertility and for enhancing plant growth (Boller and Hani, 2004). The word manure came from Middle English "manuren" meaning "to cultivate land". Chemical fertilizers (inorganic or synthetic fertilizers) are defined as inorganic materials of synthetic origin that are added to soil to enhance plant growth. Fertilizers are prepared from a wide variety of natural and manufactured materials which are sold in different forms (solid, liquid and gaseous form). Our country possesses second rank after china for the major consumer of fertilizers and third rank in terms of highest producer of fertilizers in the world. The understanding of physico-chemical properties of soil is important because of their effect on nutrient availability to the plants. Many plants need all the essential nutrients for normal growth and completion of their life cycle. Fifteen of the essential nutrients for plants are supplied by the soil system. Of these, nitrogen (N), phosphorus (P) and potassium (K) are referred to as primary or macronutrients. This is because they are required by the plant in large amounts relative to other nutrients and they are the nutrients most likely to be found limiting plant growth and development in soil systems. Calcium (Ca), magnesium (Mg) and sulphur (S) are termed as secondary nutrients because they are less likely to be growth-limiting factors in soil systems. Zinc (Zn), chlorine (Cl), boron (B), molybdenum (Mo), copper (Cu), iron (Fe), manganese (Mn), cobalt (Co) and nickel (Ni) are termed as micronutrients because they are found in only very small amounts relative to other nutrients in the plant and they are least likely to be limiting plant growth and development in many soil systems. Organic manure (vermicompost, farmyard manure) is becoming an important component of environmentally sound agriculture. Nutrients contained in organic manure are released slowly and are stored for a longer time in the soil, thereby ensuring a longer residual effect and persistence of nutrient availability. Residual nature of organic sources makes them more value based for the whole system compared to individual crops (Arora and Maini., 2011). One of the fastest and effective ways to recycle the organic materials is vermicomposting, which is an eco-biotechnological process that transforms energy rich and complex organic substances into stabilized humus like end product (vermicompost) by the joint action of earthworms and microorganisms. Vermicompost is rich source of macro- and micro-nutrients, vitamins, enzymes, antibodies, growth hormones and immobilized microflora (Bhawalker, 1991). Carbon present in soil is in the form of organic matter. Organic matter concentrations have been proved to enhance the yield and yield components of crops as well as soil aeration, soil density and maximizing water holding capacity of soil for seed germination and plant root development (Zia *et.al.*, 1998). Soybean (*Glycine max* L.) is very important crop of Madhya Pradesh which is known as “Golden bean” or “Miracle crop” of 20th century as it is the richest source of protein and oil. The approximate biochemical composition of Soybean is 40% to 45 % of proteins, 18% to 20 % of edible oils, 24% to 26% of carbohydrates and good amount of vitamins (Kaul and Das, 1986). Wheat is the most important cereal crop and is highest in production of all the crops grown on more land area than any other commercial food crop in the world. The approximate biochemical composition of the crop is 66-71.6% carbohydrates, 13-16.7% proteins, 2.5-3.1% fats, 2.5-3% crude fibre (Khan, 1984). The study of physico-chemical properties and enzymatic activity is very essential because the quality (fertility) of soil can be determined by studying these properties. The agricultural production is greatly affected by the physico-chemical parameters and enzymatic activity of the soil used for it. The study of soil enzymatic activity indirectly represents the activity of soil micro-organisms and is reported to be the source of soil microbial activity (Burns *et al*., 2013). The soil fertility and functional diversity of micro-organisms can be explored by using the tool- soil enzyme activity (Nannipieri *et al*., 2002; Maurya *et al*., 2011). Furthermore various biochemical reactions which are necessary for the metabolism of microbes, decomposition of organic wastes, formation of organic matter and cycling of inorganic nutrients are catalyzed by the enzymatic activity of soil (Tabatabai, 1994). So taking the above facts under consideration the study was done to investigate the comparative physico-chemical parameters and enzymatic activity of soil before sowing and after harvesting of wheat and soybean using black cotton soil.

MATERIAL AND METHODS

Experimental Details: The research work was carried out under field conditions at the “Botanical Garden” of Govt. Madhav Science PG College, Ujjain, M.P. using “Black cotton soil” which was not previously treated with any type of fertilizer or pesticide.

Size of Plot = $1m^2$

Organic manure used for the study: **(i)** Vermicompost (VC) - prepared from the cowdung, **(ii)** Farmyard manure (FYM).

Chemical fertilizers used for the study: (i) NPK, **(ii)** Urea

Treatment Details:

The nine treatments each of the size of $1m^2$ are;

T_1 = Control (no fertilizer) **T_2 =** 20% Farmyard manure (FYM)
T_3 = 20% Vermicompost (VC) **T_4 =** 200 gm NPK
T_5 = 10% FYM + 100gm NPK **T_6 =** 10% VC + 100 gm NPK
T_7 = 200 gm Urea **T_8 =** 10 % FYM + 100 gm Urea
T_9 = 10% VC + 100 gm Urea

Where,

20% of organic manure (VC or FYM) = amount of 20% of the $1m^2$ soil i.e. 20 cm^2 soil up to the depth of 20 cm.

10% of organic manure (VC or FYM) = amount of 10% of the $1m^2$ soil i.e. 10 cm^2 soil up to the depth of 20 cm.

Physico-chemical parameters: The various physico-chemical parameters studied in the present investigation are;

pH: It was performed according to the method proposed by Jackson (1967).

Electric conductivity (EC): (According to Jackson, 1967)

Organic carbon (OC): (According to Walkley and Black, 1934)

Nitrogen (N): (According to Saxena, 1989)

Phosphorus (P), Potassium (K), Zinc (Zn), Copper (Cu), Iron (Fe) and Manganese (Mn): These were performed according to the method proposed by APHA, AWWA, WPCA (1998) and Saxena (1989).

Soil enzymatic activity (Dehydrogenase and Urease activity): Dehydrogenase activity in soil was performed according to Casida *et al*. (1964).

Soil urease activity was measured according to the calorimetric method given by Douglas and Bremner (1970).

RESULTS AND DISCUSSION

Physico-chemical parameters of Experimental Soil, Vermicompost (VC) and Farmyard manure (FYM)

The various physico-chemical parameters studied were analyzed and given in Table 1.

Impact of different treatments on Physico-chemical properties (parameters) and enzymatic activity of soil before sowing (BS) and after harvesting (AH) of Soybean: In the present research the representative soil samples of each plot were collected from the surface soil layer at the depth of 0-20 cm. The results pertaining to the physico-chemical properties (parameters) of soil before sowing and after harvesting of soybean are shown in the tables of 2, 3 and 6. The physico-chemical parameters and enzymatic activity of soil studied are as under;

pH, Electric Conductivity (EC) and Organic Carbon (OC): The results revealed that before sowing of soybean it ranged between 7.51 to 7.61 while after harvesting the range of pH was 7.47 to 7.60. The electric conductivity (EC) ranged between 0.42 to 0.53 ds/m before sowing while after harvesting it was in the range between 0.42 and 0.54 ds/m. Moreover the results showed that organic carbon (OC) ranged between 5.64 to 13.17 g/kg before sowing while after harvesting it ranged between 5.64 to 14.25 ds/m. The OC was more in organic manure (VC and FYM) and combination of VC and NPK fertilizer. The study revealed that the application of organic manure and combination of organic manure (FYM, VC) and chemical fertilizers (NPK, urea) is more beneficial than the separate use of chemical fertilizers for increasing the organic carbon of the soil.

Nitrogen (N): The results revealed that there was a significant difference in nitrogen content before sowing and after harvesting of soybean among all the treatments. Before sowing of soybean the minimum nitrogen content (95.62 kg/ha) was in the control while maximum (188.47 kg/ha) was observed in 10% VC + 100 gm urea. After harvesting it was observed minimum (85.46 kg/ha) in control and maximum (174.63 kg/ha) in 10% VC + 100 gm urea. There was 10.16 kg/ha (10.62%) decrease of nitrogen in control and 13.84 kg/ha (7.34%) decrease in 10% VC + 100 gm urea.

The nitrogen content was increased by the application of organic manure and combination of organic manure and chemical fertilizers. Vermicompost along with NPK fertilizer is reported to contain maximum amount of nitrogen.

Phosphorus (P): Before sowing the phosphorus content was recorded maximum in 10% VC + 100 gm NPK (36.21 Kg/ha) and was recorded minimum in control (7.63 Kg/ha). After harvesting phosphorus content was observed maximum in 10% VC + 100 gm NPK (25.94 kg/ha) and minimum (6.14 kg/ha) was observed in control (figure). The study revealed that phosphorus content was increased by organic manure and the integrated application of organic manure and chemical fertilizer.

The results explored that there was a significant difference in phosphorus content before sowing and after harvesting of soybean in all the treatments. Before sowing the minimum phosphorus content (7.63 kg/ha) was in the control, while as maximum phosphorus (36.21 kg/ha) was observed in 10% VC + 100 gm NPK. After harvesting it was observed minimum (6.14 kg/ha) in control and maximum (25.94 kg/ha) in 10% VC + 100 gm urea. There was 1.49 kg/ha (19.52%) decrease of phosphorus in control and 10.27 kg/ha (28.36%) decrease in 10% VC + 100 gm NPK treatment.

Potassium (K): Before sowing of soybean it was observed highest in 10% VC + 100 gm NPK (271.32) and minimum in control (146.53). However after harvesting potassium content was recorded maximum in 10% VC +

100 gm NPK (257.51 kg/ha) and minimum in 200 gm urea (134.27) (figure 26). Moreover there was 11.67 kg/ha (7.96%) decrease of potassium in control and 13.81 kg/ha (5.08%) decrease in 10% VC + 100 gm NPK. The results revealed that potassium content was increased by organic manure and the integrated application of organic manure and chemical fertilizer.

Zinc (Zn), Copper (Cu), Iron (Fe) and Manganese (Mn): The results revealed that there was no significant difference in zinc, copper, iron and manganese content before sowing and after harvesting of soybean in all the treatments. Before sowing of soybean Zn ranged between 0.59 to 1.81 ppm while after harvesting it was in the range of 0.58 to 1.79 ppm. Copper (Cu) ranged between 3.88 to 5.73 ppm before sowing of soybean while after harvesting it was in the range of 3.87 to 5.72 ppm. Before sowing iron (Fe) content ranged between 2.87 to 4.37 ppm while after harvesting it was in the range of 2.86 to 4.36 ppm. Moreover manganese (Mn) ranged between 2.46 to 4.17 ppm before sowing of soybean while after harvesting it was in the range of 2.45 to 4.16 ppm (table 2,3 and 6). The study revealed that zinc, copper, iron and manganese content was found more in the organic manure (FYM, VC) treatments than the chemical fertilizers (Urea, NPK) and combination of organic manure and chemical fertilizer treatments.

Enzymatic activity of soil before sowing and after harvesting of soybean

Dehydrogenase activity: Results regarding the enzymatic activity (dehydrogenase and urease) of soil before sowing and after harvesting of soybean are given in table 8. There was no significant difference in urease activity before sowing and after harvesting of soybean. Before sowing it ranged between 0.74 to 0.87 µg TPF g^{-1} h^{-1} while after harvesting the range was 0.74 to 1.71 µg TPF g^{-1} h^{-1}.

Urease activity: There was no significant difference in urease activity before sowing and after harvesting of soybean. Before sowing it ranged between 1.15 to 1.86 µg g^{-1} min^{-1} while after harvesting the range was 1.27 to 2.96 µg g^{-1} min^{-1}.

Impact of different treatments on Physico-chemical properties (parameters) and enzymatic activity of soil before sowing (BS) and after harvesting (AH) of Wheat: In the present research the representative soil samples of each plot were collected from the surface soil layer at the depth of 0-20 cm. Results related with the physico-chemical properties of soil before sowing and after harvesting of wheat are given in tables 4, 5 and 7. The physico-chemical parameters and enzymatic activity of soil studied are as under;

pH, Electric Conductivity (EC), Organic Carbon (OC): The results revealed that there was no significant difference in pH, EC and OC before sowing and after harvesting of wheat in all the treatments. Before sowing pH ranged between 7.52 to 7.60 ppm while after harvesting it was in the range of 7.51 to 7.60 ppm. The results revealed that pH of soil are improved by the application of organic manure (VC, FYM). The EC ranged between 0.42 to 0.54 ds/m before sowing of wheat while after harvesting it was in the range of 0.42 to 0.55 ds/m. Moreover OC before sowing ranged between 5.66 to 13.42 g/kg while after harvesting it was in the range of 5.66 to 14.51 g/kg.

Nitrogen (N): There was a significant difference in the nitrogen content of soil before sowing and after harvesting of wheat in all the treatments. Before sowing of wheat the minimum nitrogen content (95.64 kg/ha) was observed in control while maximum (188.48 kg/ha) was in 10% VC + 100 gm urea treatment. After harvesting it was observed minimum (77.26 kg/ha) in control and maximum (165.52 kg/ha) in 10% VC + 100 gm urea. There was decline of 18.38 kg/ha (19.21%) nitrogen in control and 22.96 kg/ha (12.18%) decline in 10% VC + 100 gm urea treatment. The results revealed that there was less nitrogen uptake in soybean as compared to the wheat. The low nitrogen uptake in soybean is because of the presence of root nodules in which symbiotic biological nitrogen fixation occurs with the help of nitrogen fixing bacteria (*Rhizobium*). The results are in agreement with the findings of Stern (1993) and Li *et al*. (2001) who reported that during the cultivation of the non- leguminous crop (wheat) there is higher uptake of soil nitrogen as compared to the nitrogen uptake observed in leguminous crop (soybean).

Phosphorus (P): It was recorded maximum in 10% VC + 100 gm NPK (36.26 Kg/ha) and minimum in control (7.62 kg/ha) before sowing of wheat. The results revealed that after harvesting the phosphorus content was recorded maximum in 10% VC + 100 gm NPK (25.72 kg/ha). It was observed minimum in control (5.14 kg/ha). There was a significant difference in the phosphorus content before wheat and after harvesting of wheat in all the treatments. The minimum phosphorus content was observed in control (7.62 kg/ha) and maximum (36.26 kg/ha) in 10% VC + 100 gm NPK treatment before sowing of wheat, while after harvesting it was recorded minimum (5.16 kg/ha) in control and maximum (25.72 kg/ha) in 10% VC + 100 gm NPK. The decline of phosphorus content was 2.46 kg/ha (32.28%) in control while in 10% VC + 100 gm NPK there was 10.54 kg/ha (29.06%) decrease of phosphorus.

Potassium (K): There was a significant difference in the nitrogen content of soil before sowing and after harvesting of wheat in all the treatments. Before sowing of wheat the minimum potassium content (146.51 kg/ha)

was observed in control while maximum (271.30 kg/ha) was observed in 10% VC + 100 gm NPK treatment. After harvesting it was observed minimum (133.25 kg/ha) in control and maximum (256.44 kg/ha) in 10% VC + 100 gm NPK. The decrease of potassium content was 13.26 kg/ha (9.05%) in control while in 10% VC + 100 gm NPK there was 146.86 kg/ha (14.84%) decline of phosphorus.

Zinc (Zn), Copper (CU), Iron (Fe) and Manganese (Mn): There was no significant difference in the Zinc (Zn), Copper (CU), Iron (Fe) and Manganese (Mn content before sowing and after harvesting of soybean in all the treatments. Before sowing Zn ranged between 0.59 to 1.82 ppm while after harvesting it was in the range of 0.58 to 1.81 ppm. Before sowing of wheat Cu content ranged between 3.88 to 5.73 ppm while after harvesting it was in the range of 3.87 to 5.73 ppm. Before sowing Fe ranged between 2.86 to 4.35 ppm, while after harvesting it was in the range of 2.86 to 4.35 ppm. Before sowing it was Mn ranged between 2.46 to 4.16 ppm before sowing of wheat while after harvesting it was in the range of 2.46 to 4.15 ppm (table 4, 5 and 7).

Enzymatic activity of soil before sowing and after harvesting of Wheat

Dehydrogenase activity: The results pertaining to the dehydrogenase and urease activity of soil before sowing and after harvesting of wheat are shown in table 9. Before sowing it was observed highest in 20% VC (0.96 µg TPF g^{-1} h^{-1}) and lowest in control (0.74 µg TPF g^{-1} h^{-1}). After harvesting it was recorded highest in 20% VC (1.69 µg TPF g^{-1} h^{-1}) and was lowest in control (0.73 µg TPF g^{-1} h^{-1}) treatment.

Urease activity: Before sowing it was observed maximum in 10% VC + 100 gm urea (1.84 µg g^{-1} min^{-1}) and minimum urease activity was in control (1.14 µg g^{-1} min^{-1}). However after harvesting it was observed maximum in 10% VC + 100 gm urea (2.94 µg g^{-1} min^{-1}) and minimum was recorded in control (1.26 µg g^{-1} min^{-1}) treatment (table 31, figure 29). There was no significant difference in the dehydrogenase and urease activity before sowing and after harvesting of wheat. The results of the present study revealed that application of organic manure (FYM, VC) and integrated use of organic manure and chemical fertilizer (NPK, urea) improved the physico-chemical and biological (dehydrogenase, urease activity) properties of soil compared with the application of chemical fertilizers. The combination of organic manure and chemical fertilizer is the efficient way of proper nutrient management and maintenance of soil fertility. Vermicompost along with chemical fertilizer (NPK) is the most effective fertilizer combination which improves the physico-chemical properties and maintains the fertility and quality of soil. These results are in accordance with the findings of Chaudhary and Kumar (2013) who explored that physico-chemical parameters like pH, electric conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P) and potassium (K) of soil improved and was recorded more efficient by the application of vermicompost (VC) followed by farmyard manure (FYM), chemical fertilizer (NPK, urea) and control. It has been revealed that the physico-chemical parameters of soil were improved by using organic manure (FYM, VC) than by using chemical fertilizer (NPK, urea) (Kanwar *et al.*, 2002). Meena *et al.* (2015) reported that the application of VC and FYM significantly improved the physico-chemical properties and enzymatic activity (dehydrogenase and urease) of soil. Ramesh *et al.* (2009) explored that the availability of excess amount of organic carbon (OC) content in soil by the application of organic manure (VC, FYM) may be due to the biological immobilization and continuous mineralization of organic manure in the soil. The combined application of organic manure (VC, FYM) and chemical fertilizer (NPK, urea) significantly improved the physico-chemical parameters of soil compared to their separate use (Chettri *et al.*, 2004). Similar observations were also analysed by Yaduvanshi and Swarup (2006), Dwivedi *et al.* (2007) and Singh *at el.* (2012). The application of organic manure (VC, FYM) improves pH and electric conductivity of soil (Lund and Dass, 1980). The improvement of soil properties by the conjoint application is due to the retaining of nutrients in long time and making favourable conditions by providing organic matter in the soil (Singh *et al.*, 2002). Moreover, the increase in organic carbon (OC) and inorganic nitrogen (N) content by the integrated application is because of the presence of higher growth and activities of soil micro-organisms that are responsible for the conversion of the organic form of nitrogen into inorganic usable form (Panwar, 2008). Similar findings were also reported by Sing *et al.* (2006). Sharma and Bhushan (2001) and Efthimiadou *et al.* (2010) reported that macro and micro nutrient content of soil was improved by the conjoint application of organic manure (VC, FYM) and chemical fertilizer (NPK, urea). Similar results were also observed by Tadesse *et al.*, (2013) and Khang *et al.* (2011). The physico-chemical properties and N, P and K uptake has been reported to be significantly improved by the combined application of VC and chemical fertilizer (Vasanthi and Subramanian, 2004). Moreover due to fast release and higher concentration of nutrients from chemical fertilizers near the plant root zone is the reason of higher uptake of nutrients (Yaduvanshi and Swarup, 2006). The increase in the available nutrients (nitrogen) of soil by the integrated use of organic manure (VC, FYM) and chemical fertilizer (NPK, urea) is due to the

slow release of nutrients (minerals) by organic manure and sufficient supply of nutrients (nitrogen) by the chemical fertilizers. Moreover due to the presence of diverse micro-organisms, the organic forms of nitrogen get converted into inorganic (usable) form of nitrogen resulting in the excess availability of nitrogen to the plant (Bharadwaj and Omanwar, 1994). The maximum availability of inorganic phosphorus by the combined use of organic manure and chemical fertilizer is because of the presence of organic acids during microbial decomposition of organic matter which can play an important role for the solubilisation of available phosphates resulting in the increment of available phosphorus reserve of the soil (Khan *et al.*, 1984; Reddy *et al.*, 1990). Similar results were also observed by (Laxminarayana, 2006). Moreover the increase in available potassium of soil by the integrated application of organic manure (VC, FYM) and chemical fertilizer (NPK) might be because of the advantage of slow release of nutrients, fast mineralization and development of microflora (Laxminarayan and Patiram, 2006). However because of the maximum utilization of available nutrients (minerals) by the plants supplied from the application of chemical fertilizers could be the cause for the low concentration of available nutrients (N, P, K) in the soil (Uma, 1999). The organic carbon content of soil was increased by the application of fertilizers and was found maximum by the integrated use of organic manure and chemical fertilizer. The results are in agreement with Santhy *et al.* (2001) and Tomar (2003) who explored that because of the process of decomposition of the residues of plant roots and shoot in the soil is the reason for the increase in soil organic carbon content. Similar findings were also reported by Swarup and Yaduvanshi (2000) and Verma *et al.* (2005). Because of the buffering capacity and presence of calcium carbonate in the soil is the cause for do not showing any residual effect (toxicity) on the pH and electric conductivity of soil on the application of chemical fertilizers (Tembhare *et al.*, 1998; Swarup and Yaduvanshi 2000). Dehydrogenase is an important enzyme present in all living cells of microbes and can be utilized to function as a tool for the respiration of micro-organisms and an indication of soil microbial activity (Tejada *et al.*, 2011). Urease is also an essential type of enzyme which plays an important role in the process of hydrolysis of urea to convert it into ammonia and carbon dioxide (Byrnes and Amberger, 1989). The enzymatic activity (dehydrogenase and urease) of soil showed improvement in the organic manure (VC, FYM) and integrated use of organic manure and chemical fertilizer (NPK, urea) treatments. The application of VC and FYM significantly enhance the enzymatic activity or biological properties (dehydrogenase and urease activity) of soil (Meena *et al.*, 2015). Similarly Datt *et al.* (2013) explored that the dehydrogenase and urease activity of soil was improved by the application of organic manure and integrated application of organic manure (VC, FYM) and chemical fertilizer (NPK, urea). Similar results were also observed by Verma and Mathur (2009). The presence of organic carbon in soil supplied through organic manure (VC, FYM) provide energy to the micro-organisms, improve soil structure which results in the enhancement of soil enzyme (dehydrogenase and urease) activity (Marinari *et al.*, 2000). Deforest *et al.* (2012) revealed that organic manure enhances microbial growth and activity which in turn results in the improvement of the enzymatic activity (dehydrogenase and urease) of soil. Similar results were also reported by Pancholy and Rice (1973). The urease enzyme plays an important role to consistently converge the organic form of nutrients into inorganic (usable) forms which results in the significant improvement of soil urease activity and in the process of conversion urease enzymes act on C-N bond (Jaun *et al.*, 2008).

CONCLUSION

The present study concluded that organic manure (vermicompost, farmyard manure) is rich in both macro and micro nutrients and contains more enzymatic activity than the soil. The application of organic manure (vermicompost, farmyard manure) and combination of organic manure and chemical fertilizers (NPK, urea) is more helpful for improving the physico-chemical properties, enzymatic activity of soil than the separate application of chemical fertilizers. Vermicompost along with NPK is the best fertilizer combination for the sustainable agriculture and for maintaining the fertility and quality of the soil. Moreover due to the presence of root nodules, the nitrogen uptake in soybean is comparatively less than the nitrogen uptake in wheat.

Table 1: Physico-chemical (quality) parameters of Soil, Farmyard manure and Vermicompost before starting the experiments

Type of Material	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Soil	7.60 ±0.19	0.42 ±0.02	5.63 ±0.34	95.62 ±1.67	7.63 ±0.94	146.53 ±2.45	0.59 ±0.06	3.88 ±0.21	2.87 ±0.13	2.46 ±0.16
Farmyard manure	7.43 ±0.16	1.63 ±0.04	196.46 ±1.13	233.46 ±1.16	50.16 ±1.10	396.37 ±2.64	291.52 ±1.47	273.52 ±1.52	212.34 ±1.44	214.15 ±1.62
Vermicompost	7.14 ±0.12	1.84 ±0.02	198.53 ±0.92	246.57 ±0.85	55.24 ±0.91	438.52 ±2.04	320.13 ±1.16	289.34 ±1.41	239.24 ±1.51	248.37 ±1.24

EC = Electric conductivity, OC = Organic carbon. Value given in each cell of the table is mean value; ± sign denotes standard deviation (SD)

Table 2: Physico-chemical parameters of soil before sowing of Soybean

Treatment	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm/ha)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Control (T_1)	7.61 ±0.19	0.42 ±0.02	5.64 ±0.36	95.62 ±1.67	7.63 ±0.94	146.53 ±2.45	0.59 ± 0.06	3.88 ±0.21	2.87 ±0.13	2.46 ±0.16
20% FYM (T_2)	7.54 ±0.17	0.49 ±0.06	11.73 ±0.43	172.43 ±1.82	30.13 ±1.06	251.27 ±2.52	1.25 ±0.15	4.61 ±0.25	3.85 ±0.24	3.59 ±0.26
20% VC (T3)	7.51 ±0.15	0.53 ±0.05	12.31 ±0.48	178.47 ±1.68	34.44 ±1.13	266.41 ±2.43	1.81 ±0.13	5.73 ±0.22	4.37 ±0.23	4.17 ±0.28
200 gm NPK (T_4)	7.53 ±0.21	0.43 ±0.08	5.64 ±0.39	132.52 ±2.14	22.59 ±0.98	214.62 ±2.84	0.59 ±0.07	3.88 ±0.23	2.88 ±0.19	2.46 ±0.25
10% FYM+100gm NPK (T_5)	7.55 ±0.15	0.45 ±0.04	9.81 ±0.42	177.35 ±1.73	32.96 ±1.15	255.47 ±2.44	0.74 ±0.13	4.19 ±0.21	3.23 ±0.21	2.97 ±0.27
10% VC+100gm NPK (T_6)	7.54 ±0.17	0.47 ±0.07	11.52 ±0.46	184.26 ±1.64	36.21 ±1.18	271.32 ±2.26	1.06 ±0.14	4.91 ±0.22	3.71 ±0.23	3.78 ±0.29
200gm Urea(T_7)	7.52 ±0.22	0.46 ±0.10	5.64 ±0.40	161.83 ±1.97	8.13 ±0.92	147.24 ±2.76	0.58 ±0.09	3.87 ±0.20	2.87 ±0.20	2.46 ±0.27
10% FYM+100gm Urea (T_8)	7.56 ±0.18	0.47 ±0.05	9.59 ±0.41	180.37 ±2.14	23.72 ±1.03	235.53 ±2.61	0.71 ±0.08	4.27 ±0.24	3.19 ±0.22	2.93 ±0.26
10% VC+100gm Urea (T_9)	7.54 ±0.21	0.55 ±0.06	11.51 ±0.45	188.47 ±2.23	28.52 ±1.08	248.47 ±2.53	0.95 ±1.03	4.86 ±0.23	3.91 ±0.20	3.73 ±0.28

Value given in each cell of the table is mean value; value along with ± sign denotes standard deviation (SD)

Table 3: Physico-chemical parameters of soil after harvesting of Soybean

Treatment	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Control (T_1)	7.60 ±0.22	0.42 ±0.03	5.64 ±0.71	86.46 ±1.22	6.14 ±0.96	134.86 ±2.13	0.58 ±0.04	3.88 ±0.21	2.87 ±0.17	2.46 ±0.21
20% FYM (T_2)	7.51 ±0.17	0.50 ±0.06	12.31 ±0.43	161.85 ±1.82	21.87 ±1.06	242.75 ±2.52	1.24 ±0.15	4.60 ±0.25	3.85 ±0.24	3.59 ±0.26
20% VC (T3)	7.47 ±0.15	0.54 ±0.05	14.25 ±0.48	166.92 ±1.68	24.61 ±1.13	255.16 ±2.43	1.79 ±0.13	5.72 ±0.22	4.36 ±0.23	4.16 ±0.28
200 gm NPK (T_4)	7.52 ±0.21	0.43 ±0.08	5.69 ±0.39	114.52 ±2.14	15.13	193.83	0.59 ±0.07	3.87 ±0.23	2.88 ±0.19	2.45 ±0.25

					±0.98	±2.84				
10% FYM+100gm NPK (T_5)	7.54 ±0.15	0.46 ±0.04	10.63 ±0.42	164.26 ±1.73	23.27 ±1.15	239.25 ±2.44	0.73 ±0.13	4.19 ±0.21	3.22 ±0.21	2.97 ±0.27
10% VC+100gm NPK (T_6)	7.51 ±0.17	0.48 ±0.07	12.64 ±0.46	171.41 ±1.64	25.94 ±1.18	257.51 ±2.26	1.04 ±0.14	4.90 ±0.22	3.71 ±0.23	3.78 ±0.29
200gm Urea(T_7)	7.50 ±0.22	0.43 ±0.10	5.68 ±0.40	142.35 ±1.97	6.25 ±0.92	134.27 ±2.76	0.58 ±0.09	3.87 ±0.20	2.86 ±0.20	2.46 ±0.27
10% FYM+100gm Urea (T_8)	7.55 ±0.18	0.46 ±0.05	9.94 ±0.41	167.41 ±2.14	9.38 ±1.03	219.82 ±2.61	0.70 ±0.08	4.26 (±0.24)	3.19 ±0.22	2.93 ±0.26
10% VC+100gm Urea (T_9)	7.52 ±0.21	0.48 ±0.06	12.25 ±0.45	174.63 ±2.23	13.44 ±1.08	235.21 ±2.53	0.94 ±1.03	4.86 ±0.23	3.90 ±0.20	3.73 ±0.28

Value given in each cell of the table is mean value; value along with ± sign denotes standard deviation (SD)

Table 4: Physico-chemical parameters of soil before sowing of Wheat

Treatment	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Control	7.60 ±0.16	0.42 ±0.02	5.66 ±0.38	95.64 ±1.64	7.62 ±0.96	146.51 ±2.45	0.5 ±0.06	3.88 ±0.21	2.86 ±0.13	2.47 ±0.16
20% FYM	7.55 ±0.19	0.48 ±0.05	11.79 ±1.32	172.4 ±1.80	30.13 ±1.04	251.22 ±2.52	1.26 ±0.15	4.62 ±0.25	3.90 ±0.24	3.75 ±0.26
20% VC	7.52 ±0.15	0.54 ±0.07	13.42 ±1.43	178.49 ±1.65	34.44 ±1.15	266.38 ±2.43	1.82 ±0.13	5.73 ±0.22	4.35 ±0.23	4.16 ±0.28
200 gm NPK	7.53 ±0.21	0.43 ±0.06	5.67 ±0.57	132.55 ±2.12	22.59 ±0.96	214.60 ±2.84	0.59 ±0.07	3.88 ±0.23	2.86 ±0.19	2.46 ±0.25
10% FYM+100gm NPK	7.54 ±0.15	0.45 ±0.05	9.87 ±1.15	177.38 ±1.70	32.96 ±1.17	255.42 ±2.44	0.74 ±0.13	4.17 ±0.21	3.22 ±0.21	2.99 ±0.27
10% VC+100gm NPK	7.55 ±0.17	0.48 ±0.08	11.56 ±1.42	187.30 ±1.66	36.26 ±1.15	271.30 ±2.26	1.07 ±0.14	4.93 ±0.22	3.82 ±0.23	3.79 ±0.29
200gm Urea	7.53 ±0.22	0.43 ±0.11	5.66 ±0.39	161.86 ±1.96	7.92 ±0.92	147.21 ±2.76	0.58 ±0.09	3.88 ±0.20	2.86 ±0.20	2.46 ±0.27
10% FYM+100gm Urea	7.57 ±0.18	0.45 ±0.07	9.54 ±1.25	180.39 ±2.15	23.75 ±1.05	235.49 ±2.61	0.71 ±0.08	4.28 ±0.24	3.18 ±0.22	2.94 ±0.26
10% VC+100gm Urea	7.54 ±0.21	0.47 ±0.04	11.53 ±1.25	188.48 ±2.24	28.58 ±1.06	248.45 ±2.53	0.96 ±1.03	4.88 ±0.23	3.86 ±0.20	3.72 ±0.28

Value given in each cell of the table is mean value; value along with ± sign denotes standard deviation (SD)

Table 5: Physico-chemical parameters of soil after harvesting of Wheat

Treatment	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Control (T_1)	7.60 ±0.20	0.42 ±0.03	5.66 ±0.35	77.26 ±1.26	5.14 ±0.98	133.25 ±2.18	0.59 ±0.05	3.87 ±0.19	2.86 ±0.15	2.47 ±0.18
20% FYM (T_2)	7.51 ±0.21	0.49 ±0.07	12.29 ±0.44	150.54 ±1.94	20.46 ±1.07	240.84 ±2.56	1.24 (±0.14	4.61 ±0.27	3.89 (±0.22	3.74 ±0.25
20% VC (T3)	7.48 ±0.23	0.55 ±0.06	14.51 ±0.42	157.62 ±1.76	24.58 ±0.12	254.62 ±2.44	1.81 ±0.16	5.73 ±0.24	4.35 ±0.25	4.15 ±0.26
200 gm NPK (T_4)	7.51 ±0.26	0.43 ±0.09	6.02 ±0.47	101.61 ±1.82	14.16 ±0.96	191.43 ±2.84	0.58 ±0.05	3.87 ±0.21	2.86 ±0.18	2.46 ±0.21
10% FYM+100gm NPK (T_5)	7.53 ±0.24	0.45 ±0.07	10.55 ±0.45	156.54 ±1.46	22.25 ±1.17	238.72 ±2.24	0.74 ±0.14	4.16 ±0.22	3.22 ±0.23	2.98 ±0.24
10% VC+100gm NPK (T_6)	7.53 ±0.24	0.49 ±0.05	12.27 ±0.41	164.26 ±1.51	25.72 ±0.19	255.44 ±2.13	1.05 ±0.16	4.92 ±0.23	3.81 ±0.24	3.78 ±0.27
200gm Urea(T_7)	7.52 ±0.27	0.43 ±0.12	5.97 ±0.43	130.25 ±1.73	5.16 ±0.87	135.62 ±2.09	0.58 ±0.07	3.88 ±0.20	2.86 ±0.20	2.46 ±0.19
10% FYM+100gm Urea (T_8)	7.56 ±0.25	0.45 ±0.06	10.21 ±0.44	157.82 ±1.68	8.45 ±1.04	218.45 ±2.68	0.70 ±0.10	4.28 ±0.23	3.17 ±0.23	2.93 ±0.24
10% VC+100gm Urea (T_9)	7.51 ±0.24)	0.48 ±0.04	11.98 ±0.48	165.52 ±1.71	12.37 ±1.07	233.53 ±2.52	0.95 ±0.13	4.88 ±0.25	3.85 ±0.25	3.71 ±0.26

Value given in each cell of the table is mean value; value along with ± sign denotes standard deviation (SD)

Table 6: Analysis of Physico-chemical parameters of Soil before sowing (BS) and after harvesting (AH) of Soybean

Treatment	Stages for Analysis	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
T_1	BS	7.61	0.42	5.64	95.62	7.63	146.53	0.59	3.88	2.87	2.46
	AH	7.60	0.42	5.64	86.46	6.14	134.86	0.58	3.88	2.87	2.46
T_2	BS	7.54	0.49	11.73	172.43	30.26	251.27	1.25	4.61	3.85	3.59
	AH	7.51	0.50	12.31	161.85	21.87	242.75	1.24	4.60	3.85	3.59
T_3	BS	7.51	0.53	13.17	178.47	35.41	266.41	1.81	5.73	4.37	4.17
	AH	7.47	0.54	14.25	166.92	24.61	255.16	1.79	5.72	4.36	4.16
T_4	BS	7.53	0.43	5.64	132.52	22.51	214.62	0.59	3.88	2.88	2.46
	AH	7.52	0.43	5.69	114.52	15.13	193.83	0.59	3.87	2.88	2.45
T_5	BS	7.55	0.45	9.81	177.35	32.92	255.47	0.74	4.19	3.23	2.97
	AH	7.54	0.46	10.63	164.26	23.27	239.25	0.73	4.19	3.22	2.97
T_6	BS	7.54	0.47	11.52	184.26	36.21	271.32	1.06	4.91	3.71	3.78
	AH	7.51	0.48	12.64	171.41	25.94	257.51	1.04	4.90	3.71	3.78
T_7	BS	7.52	0.43	5.64	161.83	8.13	147.24	0.58	3.87	2.87	2.46
	AH	7.50	0.43	5.68	142.35	6.25	134.27	0.58	3.87	2.86	2.46
T_8	BS	7.56	0.46	9.59	180.37	23.72	235.53	0.71	4.27	3.19	2.93
	AH	7.55	0.46	9.94	167.41	9.38	219.82	0.70	4.26	3.19	2.93
T_9	BS	7.54	0.47	11.51	188.47	28.52	248.46	0.95	4.86	3.91	3.73
	AH	7.52	0.48	12.25	174.63	13.44	235.21	0.94	4.86	3.90	3.73

Table 7: Analysis of Physico-chemical parameters of soil before sowing (BS) and after Harvesting (AH) of Wheat

Treatment	Stages of Analysis	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
T_1	BS	7.60	0.42	5.66	95.64	7.62	146.51	0.59	3.88	2.86	2.47
	AH	7.60	0.42	5.66	77.26	5.14	133.25	0.59	3.87	2.86	2.47
T_2	BS	7.55	0.48	11.79	172.43	30.13	251.22	1.26	4.62	3.90	3.75
	AH	7.51	0.49	12.29	150.54	20.46	240.84	1.24	4.61	3.89	3.74
T_3	BS	7.52	0.54	13.42	178.49	34.44	266.38	1.82	5.73	4.35	4.16
	AH	7.48	0.55	14.51	157.62	24.58	254.62	1.81	5.73	4.35	4.15
T_4	BS	7.53	0.43	5.67	132.55	22.59	214.60	0.59	3.88	2.86	2.46
	AH	7.51	0.43	6.02	101.61	14.16	191.43	0.58	3.87	2.86	2.46
T_5	BS	7.54	0.45	9.87	177.38	32.96	255.42	0.74	4.17	3.22	2.99
	AH	7.53	0.45	10.55	156.54	22.25	238.72	0.74	4.16	3.22	2.98
T_6	BS	7.55	0.48	11.56	187.30	36.26	271.30	1.07	4.93	3.82	3.79
	AH	7.53	0.49	12.27	164.26	25.72	255.44	1.05	4.92	3.81	3.78
T_7	BS	7.53	0.43	5.66	161.86	7.92	147.21	0.58	3.88	2.86	2.46
	AH	7.52	0.43	5.97	130.25	5.16	135.62	0.58	3.88	2.86	2.46
T_8	BS	7.57	0.45	9.54	180.39	23.75	235.49	0.71	4.28	3.18	2.94
	AH	7.56	0.45	10.21	157.82	8.45	218.45	0.70	4.28	3.17	2.93
T_9	BS	7.54	0.47	11.53	188.48	28.58	248.45	0.96	4.88	3.86	3.72
	AH	7.51	0.48	11.98	165.52	12.37	233.53	0.95	4.88	3.85	3.71

Table 8: Enzymatic activity of soil before sowing (BS) and after harvesting (AH) of Soybean

Treatment	Dehydrogenase activity (µg TPF g^{-1} h^{-1})		Urease (µgg^{-1} min^{-1}) (µgg^{-1} min^{-1})	
	Before sowing	After harvesting	Before sowing	After harvesting
Control (T1)	0.74	0.74	1.15	1.27
20% FYM (T2)	0.91	1.48	1.57	2.59
20% VC (T3)	0.97	1.71	1.64	2.83
200 gm NPK (T4)	0.76	0.88	1.16	1.83
10% FYM+100gm NPK (T5)	0.87	1.41	1.49	2.46
10% VC+100gm NPK (T6)	0.94	1.64	1.51	2.78
200gm Urea(T7)	0.75	0.82	1.35	1.94
10% FYM+100gm Urea (T8)	0.84	1.35	1.56	2.77
10% VC+100gm Urea (T9)	0.93	1.55	1.86	2.96

Table 9: Enzymatic activity of soil before sowing (BS) and after harvesting (AH) of Wheat

Treatment	Dehydrogenase activity (µg TPF g^{-1} h^{-1})	Urease (µgg^{-1} min^{-1}) (µgg^{-1} min^{-1})

	Before sowing	After harvesting	Before sowing	After harvesting
Control (T1)	0.74	0.73	1.14	1.14
20% FYM (T2)	0.91	1.61	1.65	2.76
20% VC (T3)	0.96	1.69	1.72	2.78
200 gm NPK (T4)	0.75	0.86	1.15	1.84
10% FYM+100gm NPK (T5)	0.86	1.43	1.57	2.43
10% VC+100gm NPK (T6)	0.93	1.52	1.63	2.57
200gm Urea(T7)	0.74	0.84	1.37	1.92
10% FYM+100gm Urea (T8)	0.82	1.33	1.66	2.81
10% VC+100gm Urea (T9)	0.89	1.47	1.84	2.94

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Source of Support: None Declared
Conflict of Interest: None Declared