Effect of Integrated Nutrient Management on Soil Fertility and Soil Microbial Population after Cropping to Wheat Crop in Western Uttar Pradesh

Abstract

A field experiment was conducted during the rabi season of 2013-14 and 2014-15 at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur to evaluate the different levels of INM on soil fertility of wheat. The experiment was comprising sixteen treatments viz. T_1- control, T_2- 100% RDF,T_3- 100% RDF + S, T_4- 100% RDF + S + Zn, T_5- 100 % RDF + S + Zn + bio-fertilizer (Azotobactor + PSB), T_6- 100 % RDF + 25 % N through FYM, T_7- 100 % RDF + 25 % N through FYM + S, T_8- 100 % RDF + 25 % N through FYM + S + Zn, T_9-100 % RDF + 25 % N through FYM + S + Zn + bio-fertilizer Azotobactor + PSB, T_{10}-100 % RDF + 25 % N through vermicompost, T_{11}- 100 % RDF + 25 % N through vermicompost + S + Zn + bio-fertilizer Azotobactor + PSB, T_{12}- 75 % RDF, T_{13}-75 % RDF + 25 % N through FYM, T_{14}- 75 % R.D.F. + 25 % N through vermicompost, T_{15}-75 % RDF + 25 % N through FYM + S + Zn + bio-fertilizer Azotobactor + PSB and T_{16}- 75 % RDF + 25 % N through vermicompost + S + Zn + bio-fertilizer + PSB. Integration of organic manures showed slight increase in EC value while inorganic fertilizers showed slight decrease in EC values in comparison to its initial value which is obviously due to decomposition of organic matter in soil. Maximum increase in organic carbon content was noted with the integration of organic treatments followed by inorganic treatments. It may be due to decomposition and mineralization of organic matter by narrow C: N ratio. Status of N, P, K, S and Zn was slightly increased in all the treatments in comparison to its initial value except control during both the years. Maximum increase in available status of N, P, K, S and Zn was recorded with integration of inorganic, organic and bio-fertilizers with 100 % RDF.T_{11} (100 % R.D.F. + 25 % N through vermicompost + S + Zn + bio-fertilizer *Azotobactor* + PSB followed by T_9-100 % RDF + 25 % N through FYM + S + Zn + bio-fertilizer *Azotobactor* + PSB and minimum at control (T_1) during both the years. Maximum microbial population was recorded with T_{11} (100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers (*Azotobactor* +PSB) followed by T_9 (100 % R.D.F. + 25 % N through FYM + S + Zn +bio-fertilizers (*Azotobactor* + PSB) and minimum at control during both the years.

Keywords: Wheat crop, Organic and inorganic sources, RDF, microbial population

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world. Among the world's most important food grains, it ranks next to rice. It is eaten in various forms by more than one billion in the world. In India, wheat cultivated on 29.6 m ha area with 93.5 m tonnes of production and 31.5 q/ha of average productivity (FAO, 2013). In Uttar Pradesh, it is grown on 9.73 m ha area with production 30.3 m tons and productivity of 31.14 q/ ha (Anonymous, 2013). The requirement of wheat will be around 109 million tonnes for feeding the 1.25 billion populations by 2020 AD (Singh, 2010). Organic matter like FYM has supplied available nutrients to the plants provided favourable soil environment and increase water holding capacity of soil for longer time. Application of Farm yard Manure helps to increase the DMP, yield and nutrient uptake by wheat (Singh and Tomer, 1991).The soil incorporation of mustard/taramira + FYM and FYM at 10 t ha-1significantly increased grain yield of wheat across the years (Regar et al.,2005). (Prakash et al. 2002) also reported that soil density undergoes greater reduction with the use of FYM than chemical fertilizers. Application of FYM @ 10 and 20 tonnes / ha increased the grain yield and the total N P and K uptake in wheat crop (Singh and Agrawal, 2005).Millions of farmer in developing countries need adequate resource for augmenting crop productivity and sustainability of soil. Therefore to maintain fertility and productivity of soil at sustainable level for long duration, there is need to adopt the concept of integrated nutrient management. Organic manure such as farm yard manure, vermicompost, crop residues, Biofertilizer, green manure and chemical fertilizer are considered to be an integral component of integrated nutrient management and may help to recover soil health in cropping system. As they improve soil fertility and physical properties such as soil structure, aeration, porosity, infiltration rate and water holding capacity and decrease soil crusting, organic matter in soil improve physical condition of the soil for better performance of micro-organism and physical status of soil. Organic matter affects crop growth and yields either directly supplying nutrients or indirectly by modifying soil physical properties such as stability of aggregates, porosity and available water capacity that can improve the root environment and stimulate plant growth. Organic matter not only increases the water holding capacity of the soil but also proportion of water available for plant growth and improves physical properties of soil (Sial *et al*., 2007).

Materials and Methods

The present study was carried out by Chandra Shekhar Azad University of Agriculture and Technology, Kanpur for two consecutive years from 2013-14 and 2014-15 to evaluate the different levels of INM on yield and economics of wheat. The experiment was comprising sixteen treatments viz. T1- control, T2- 100% RDF,T3-100% RDF +S, T_4-

100% RDF +S+Zn, T_5- 100 % R.D.F. + S + Zn + bio-fertilizer (Azotobacter + P.S.B.), T6- 100 % R.D.F. + 25 % N through F.Y.M., T_7- 100 % R.D.F. + 25 % N through F.Y.M. + S, T8- 100 % RD.F + 25 % N through F.Y.M. + S + Zn, T9-100 % R.D.F. + 25 % N through F.Y.M. + S + Zn + bio-fertilizer (Azotobactor + PSB), T10-100 % R.D.F. + 25 % N through vermicompost, T11- 100 % R.D.F. + 25 % N through vermicompost + S + Zn + bio-fertilizer (Azotobactor + P.S.B.), T12- 75 % R.D.F., T13- 75 % R.D.F. + 25 % N through F.Y.M., T14- 75 % R.D.F. + 25 % N through vermicompost, T15-75 % R.D.F. + 25 % N through F.Y.M. + S + Zn + bio-fertilizer (Azotobactor + P.S.B.) and T16- 75 % R.D.F. + 25 % N through vermicompost + S + Zn + bio-fertilizer (Azotobactor + P.S.B.). The experiment consists of Randomized Block Design with three replications. Physio-chemical characteristics of soil of the experimental field of sand 56.80, silt 23.40%, clay 19.85,P^H 8.30 and Organic Carbon (%) 0.420, plot size of the experiments was 24.5m^2 with wheat variety PBW 550.

Soil Analysis

The soil sample was taken before sowing and analyzed with the standard procedures as given below

Mechanical separates

International Pipette method as described by Piper (1966) was adopted for the analysis of soil

Separates pH

Determination of pH was done with the help of Elicodigital pH meter using soil water suspension in the ratio of 1 :2.5.

EC

EC was determined in 1:2.5 soil water suspensions with the help of conductivity meter (Jackson, 1967).

Organic Carbon

Organic carbon was determined by Walkley and Black's rapid titration method as described by Jackson (1967).

Available Nitrogen

Available nitrogen was estimated by Alkaline potassium permanganate method as described by Subbiah and Asija (1956).

Available Phosphorus

Available phosphorus was determined calorimetrically extracting by 0.5 M $NaHCO_3$ (pH 8.3) extractant as given by Olsen et al. (1954).

Available Potassium

Available potassium was first extracted by using **1 NNH_4 OAC** (pH 7.0) Morgan's solution and estimated by Flame photometer as described by (Jackson, 1967).

Available Sulphur

Available sulphur was determined by **0.15** % **$CaCl_2$ (**Williams and Steinbergs, 1959**)** and was determinedby Turbidimetric procedure (Chesnin and Yien, 1951).

Available Zinc

Available zinc was made by 0.005 MDTPA (Diethylenetriaminepenta acetic acid) and adjusted pH 7.3 with dilute HCl and Zn was measured with the help of an Atomic absorption spectro photometer. The extraction was done by (Lindsay and Norvell 1978) procedure.

Microbial count

The total bacteria, fungi and actinomycetes were counted in soil sample collected after harvest of crops by using dilution culture plate count method. First of all 1.0 ml suspension of desired solution is poured in sterilized petri-dishes and after 20 ml of specific agar medium was added and both were thoroughly mixed by rotation and allowed to solidify. Afterwards, it was incubated at particular temperature for definite period depending upon the kind of micro-organisms. After incubation, the number of colonies of microbes were appeared on each plates, were counted. The population was calculated on the basis of following equation. Population/g of soil = Average no. of colonies/plate x final working dilution of biological material (soil)

Results and Discussion

Effect of integrated nutrient management on soil properties at harvest of the crops. After harvest of the crop soil samples were collected in each treatments and analysis for physico-chemical properties of the soil. Soil microbial populations were also studied in same soil sample.

Effect on soil P^H

Data with regard to soil P^H are given in table 1 showed narrower variation within all the treatments during both the years. It is also visualized from the data that P^H value in all the treatments decreased in comparison to its initial value. Maximum decreased in soil P^H was recorded in organic and bio-fertilizers treatments in comparison to inorganic treatments during both the years.

Effect on soil EC

Table 1 showed narrower and none significant variation within all the treatments during both the years. It is interesting to report that integration of organic and bio-fertilizers treatments showed slight increase in EC values in comparison to control while application of inorganic fertilizers showed slight decrease in EC values during both the years.

Effect on soil organic carbon

Maximum organic carbon content 0.439 and 0.415 % was recorded with T_{11}(100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers (*Azotobacter* + P.S.B.) followed by T_9 (100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +bio-fertilizers (*Azotobacter* + P.S.B.) and minimum 0.398 and 0.382 % in control (T_1) during 1st year and 2nd year. Integration of vermicompost showed higher increase in organic carbon % in comparison to FYM during both the years (Table 2).

Available status of nitrogen

Maximum available status of nitrogen 215.50 and 200.80 kg ha $^{-1}$ was recorded with T_{11}(100 % R.D.F. + 25 % N through vermi compost +S + Zn + bio-fertilizers(*Azotobacter* + P.S.B.)followed by T_9(100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +bio-fertilizers (*Azotobacter* + P.S.B.) and minimum 207.00 and 192.00 kg ha^{-1} in control (T_1) during 1st year and 2nd year, respectively (Table 3).

Available status of phosphorus

Available status of phosphorus within all the treatments varied from 12.20 to 11.50 and 11.50 to 13.25 kg ha^{-1} during 1st year and 2nd year, respectively. Integrated application of organic, inorganic and bio-fertilizers showed higher increase in the available status of phosphorus in comparison to inorganic fertilizers treatments during both the years (Table-3).

Available status of potassium

Maximum increase in available status of potassium 134.50 and 127.70 kg ha^{-1} was recorded with T_{11}(100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers (*Azotobacter* + P.S.B.) Followed by T_9(100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +bio-fertilizers(*Azotobacter*+ P.S.B.) and minimum 129.50 and 121.80 kg ha^{-1} at control (T_1) during 1st year and 2nd year, respectively (Table-3).

Available status of sulphur

The data pertaining to the available status of sulphur given in table 4 showed none significantly influenced by application of different treatments except control during both the years. Like-wise nitrogen, phosphorus and potassium available status of sulphur also varied from minimum in control (T_1) and maximum under (T_{11}) (100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers (*Azotobactor*+ P.S.B.) during both the years.

Available status of zinc

Integration of zinc showed higher increase in available status of zinc with 100 % RDF and 75 % RDF treatments during both the years.It is also visualized from the data that all the treatments showed slight increase in available status of zinc except control during both the years. It was also observed that 100 % RDF showed higher increase in available status of zinc in comparison to 75 % RDF during both the years (Table-4).

Effect of integrated nutrient management on total microbial population

Total bacterial population

Total bacterial population given in table 5 showed variation from 13.5 x 10^5 to 22.5 x 10^5 and 13.1 x 10^5 to 21.2 x 10^5cfu g^{-1}soil during 1st year and 2nd year respectively. Integration of bio-fertilizer and organic manures showed favorable influence in soil bacterial population in comparison to inorganic fertilizers treatments during both the years.

Total fungal population

Table 5 showed linear and significant influence in all the treatments in comparison to control. Maximum fungal population influenced 16.3 x 10^3 and 15.9 x 10^3 cfu g^{-1} soil was recorded with T_{11}(100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers (*Azotobactor* + P.S.B.)Followed by T_9 (100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +bio-fertilizers (*Azotobacter*, P.S.B.) and minimum 9.5 x 10^3 and 9.2 x 10^3cfu g^{-1} soil in control (T_1).

Total actinomycetes population

Table 5 showed linear and significant increase in all the treatments in comparison to control during both the years. The total actinomycetes population ranged from 10.5 x 10^3 to 18.2 x 10^3 and 10.1 x 10^3 to 17.9 x 10^3cfu g^{-1} soil with minimum in control and maximum in T_{11}(100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers (*Azotobactor* + P.S.B.) **.**It was also observed that integration of bio-fertilizers and organic manures showed favorable influence in comparison to inorganic fertilizers during both the years, this may be due to that added organic matter acts as a source of the nutrients and also as a substrate for decomposition and mineralization of nutrients, thereby creating a favorable condition for the proliferation of microbes in the soil. These findings are related to the findings of (Mahajan *et al.* 2007, Walia *et al.* 2010 and Gill *et al.* 2016).

Table No -1**:** Effect of Integrated Nutrient Management on Soil Properties (pH & EC).

Treatment	**pH**		**EC**	
	2013-2014	**2014-2015**	**2013-2014**	**2014-2015**
T_{1}- Control	8.29	8.20	0.20	0.18
T_{2}-100 % R.D.F.	8.29	8.19	0.19	0.17
T_{3}-100 % R.D.F. + S	8.28	8.19	0.19	0.17
T_{4}-100 % R.D.F. + S + Zn	8.27	8.18	0.18	0.17
T_{5}-100 % R.D.F. + S + Zn + Bio-fertilizers (*Azotobacter* + P.S.B.)	8.27	8.17	0.18	0.16
T_{6}-100 % R.D.F. + 25 % N through F.Y.M.	8.26	8.16	0.21	0.19
T_{7}-100 % R.D.F. + 25 % N through F.Y.M. + S	8.25	8.16	0.21	0.19
T_{8}-100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	8.25	8.15	0.21	0.19
T_{9}-100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers (*Azotobacter* + P.S.B.)	8.24	8.15	0.22	0.20
T_{10}-100 % R.D.F. + 25 % N through vermicompost	8.25	8.15	0.22	0.20
T_{11}-100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize (*Azotobacter*+ P.S.B.)	8.24	8.14	0.22	0.21
T_{12}75 % R.D.F.	8.29	8.19	0.20	0.18
T_{13}-75 % R.D.F. + 25 % N through F.Y.M.	8.28	8.18	0.21	0.18
T_{14}-75 % R.D.F. + 25 % N through vermicompost	8.27	8.17	0.21	0.18
T_{15}- 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (*Azotobacter*+ P.S.B.)	8.26	8.18	0.22	0.18
T_{16}- 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(*Azotobacter*+ P.S.B.)	8.26	8.17	0.22	0.19
S.E. ±	0.028	0.023	0.022	0.021
C.D. (at 5 %)	NS	NS	NS	NS

Table No.-2: Effect of Integrated Nutrient Management on Soil Properties (O C & N).

Treatment	**Organic Carbon (%)**		**Available Nitrogen kg ha^{-1}**	
	2013-2014	**2014-2015**	**2013-2014**	**2014-2015**
T_{1}- Control	0.398	0.382	0.398	0.382
T_{2}-100 % R.D.F.	0.422	0.392	0.422	0.392
T_{3}-100 % R.D.F. + S	0.424	0.394	0.424	0.394
T_{4}-100 % R.D.F. + S + Zn	0.426	0.396	0.426	0.396
T_{5}-100 % R.D.F. + S + Zn + Bio-fertilizers (*Azotobacter*+ P.S.B.)	0.428	0.398	0.428	0.398

T $_{6-}$100 % R.D.F. + 25 % N through F.Y.M.	0.432	0.402	0.432	0.402
T $_{7-}$100 % R.D.F. + 25 % N through F.Y.M. + S	0.434	0.405	0.434	0.405
T $_{8-}$100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	0.435	0.408	0.435	0.408
T $_{9-}$100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers (*Azotobacter*+ P.S.B.)	0.436	0.410	0.436	0.410
T $_{10-}$100 % R.D.F. + 25 % N through vermicompost	0.435	0.404	0.435	0.404
T $_{11-}$100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize (*Azotobacter*+ P.S.B.)	0.439	0.415	0.439	0.415
T $_{12}$75 % R.D.F.	0.415	0.386	0.415	0.386
T $_{13-}$75 % R.D.F. + 25 % N through F.Y.M.	0.423	0.388	0.423	0.388
T $_{14-}$75 % R.D.F. + 25 % N through vermicompost	0.427	0.390	0.427	0.390
T $_{15-}$ 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (*Azotobacter*+ P.S.B.)	0.426	0.393	0.426	0.393
T $_{16-}$ 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(*Azotobacter*+ P.S.B.)	0.431	0.396	0.431	0.396
S.E. ±	0.010	0.009	0.010	0.009
C.D. (at 5 %)	NS	NS	NS	NS

Table No.-3: Effect of Integrated Nutrient Management on Soil Properties (P &K).

Treatment	**Available P. (Phosphorus) Kg ha $^{-1}$**		**Available K. (Potassium) Kg ha $^{-1}$**	
	2013-2014	**2014-2015**	**2013-2014**	**2014-2015**
T $_{1-}$ Control	12.20	11.50	12.20	11.50
T $_{2-}$100 % R.D.F.	13.80	12.55	13.80	12.55
T $_{3-}$100 % R.D.F. + S	13.88	12.62	13.88	12.62
T $_{4-}$100 % R.D.F. + S + Zn	13.95	12.70	13.95	12.70
T $_{5-}$100 % R.D.F. + S + Zn + Bio-fertilizers (*Azotobacter*+ P.S.B.)	14.05	12.78	14.05	12.78
T $_{6-}$100 % R.D.F. + 25 % N through F.Y.M.	14.15	12.82	14.15	12.82
T $_{7-}$100 % R.D.F. + 25 % N through F.Y.M. + S	14.22	12.90	14.22	12.90
T $_{8-}$100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	14.28	12.98	14.28	12.98
T $_{9-}$100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers (*Azotobacter*+ P.S.B.)	14.35	13.02	14.35	13.02
T $_{10-}$100 % R.D.F. + 25 % N through vermicompost	14.20	12.85	14.20	12.85
T $_{11-}$100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize	14.50	13.25	14.50	13.25

(*Azotobacter*+ P.S.B.)				
T 12 75 % R.D.F.	12.75	11.90	12.75	11.90
T 13- 75 % R.D.F. + 25 % N through F.Y.M.	13.55	12.25	13.55	12.25
T 14- 75 % R.D.F. + 25 % N through vermicompost	13.60	12.40	13.60	12.40
T 15- 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (*Azotobacter*+ P.S.B.)	13.72	12.50	13.72	12.50
T 16- 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(*Azotobacter*+ P.S.B.)	13.90	12.70	13.90	12.70
S.E. ±	0.573	0.405	0.573	0.405
C.D. (at 5 %)	NS	NS	NS	NS

Table No.-4: Effect of Integrated Nutrient Management on Soil Properties (S &Zn).

Treatment	**Available S. kg ha^{-1}**		**Available Zn.g ha^{-1}**	
	2013-2014	**2014-2015**	**2013-2014**	**2014-2015**
T 1- Control	15.85	14.50	15.85	14.50
T 2- 100 % R.D.F.	16.60	15.35	16.60	15.35
T 3- 100 % R.D.F. + S	16.95	15.80	16.95	15.80
T 4- 100 % R.D.F. + S + Zn	17.10	15.95	17.10	15.95
T 5- 100 % R.D.F. + S + Zn + Bio-fertilizers (*Azotobacter*+ P.S.B.)	17.25	16.10	17.25	16.10
T 6- 100 % R.D.F. + 25 % N through F.Y.M.	16.75	15.40	16.75	15.40
T 7- 100 % R.D.F. + 25 % N through F.Y.M. + S	17.30	16.15	17.30	16.15
T 8- 100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	17.60	16.40	17.60	16.40
T 9- 100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers (*Azotobacter*+ P.S.B.)	17.85	16.65	17.85	16.65
T 10- 100 % R.D.F. + 25 % N through vermicompost	16.85	15.50	16.85	15.50
T 11- 100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize (*Azotobacter*+ P.S.B.)	18.10	16.85	18.10	16.85
T 12 75 % R.D.F.	16.10	14.90	16.10	14.90
T 13- 75 % R.D.F. + 25 % N through F.Y.M.	16.35	15.30	16.35	15.30
T 14- 75 % R.D.F. + 25 % N through vermicompost	16.25	15.40	16.25	15.40
T 15- 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (*Azotobacter*+ P.S.B.)	16.70	15.60	16.70	15.60
T 16- 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(*Azotobacter*+ P.S.B.)	16.85	15.70	16.85	15.70
S.E. ±	0.325	0.272	0.325	0.272
C.D. (at 5 %)	NS	NS	NS	NS

Table No.-5: Effect of Integrated Nutrient Management on microbial population.

Treatment	**Bacteria (× 10^5 cfu g^{-1})**		**Fungi (× 10^3cfu g^{-1})**		**Actinomycetis (× 10^3 cfu g^{-1})**	
	2013-14	**2014-15**	**2013-14**	**2014-15**	**2013-2014**	**2014-15**
T_{1}- Control	13.5	13.1	9.5	13.5	13.1	9.5
T_{2}-100 % R.D.F.	17.5	17.1	12.6	17.5	17.1	12.6
T_{3}-100 % R.D.F. + S	17.8	17.2	12.9	17.8	17.2	12.9
T_{4}-100 % R.D.F. + S + Zn	18.1	17.9	13.2	18.1	17.9	13.2
T_{5}-100 % R.D.F. + S + Zn + Bio-fertilizers (*Azotobacter*+ P.S.B.)	20.6	20.3	14.2	20.6	20.3	14.2
T_{6}-100 % R.D.F. + 25 % N through F.Y.M.	19.2	18.8	14.9	19.2	18.8	14.9
T_{7}-100 % R.D.F. + 25 % N through F.Y.M. + S	19.6	19.2	15.1	19.6	19.2	15.1
T_{8}-100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	20.0	19.7	15.3	20.0	19.7	15.3
T_{9}-100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers (*Azotobacter*+ P.S.B.)	22.1	21.9	15.8	22.1	21.9	15.8
T_{10}-100 % R.D.F. + 25 % N through vermicompost	19.8	19.5	15.2	19.8	19.5	15.2
T_{11}-100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize (*Azotobacter*+ P.S.B.)	22.5	21.2	16.3	22.5	21.2	16.3
T_{12}75 % R.D.F.	15.2	14.9	11.8	15.2	14.9	11.8
T_{13}-75 % R.D.F. + 25 % N through F.Y.M.	16.8	16.5	13.8	16.8	16.5	13.8
T_{14}-75 % R.D.F. + 25 % N through vermicompost	17.4	17.1	14.5	17.4	17.1	14.5
T_{15}- 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (*Azotobacter*+ P.S.B.)	18.3	17.9	14.1	18.3	17.9	14.1
T_{16}- 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(*Azotobacter*+ P.S.B.)	18.7	18.4	14.7	18.7	18.4	14.7
S.E. ±	1.645	1.413	1.159	1.645	1.413	1.159
C.D. (at 5 %)	3.377	2.900	2.378	3.377	2.900	2.378

Conclusion

Organic matter affects crop growth and yields either directly supplying nutrients or indirectly by modifying soil physical properties such as stability of aggregates, porosity and available water capacity that can improve the root environment and stimulate plant growth.

References

1. Sial, R.A., Chuadhary, E.H. Hussain, S. and Naveed, M. 2007. Effect of organic

manures and chemical fertilizer on grain yield of wheat. Soil and Environment. 26(2): 130-133.

2. Singh, V and Tomer, J.S. (1991) Effect of K and FYM levels on yield and uptake of nutrients by wheat. Journal of Potassium research 7 (4): 309-313.
3. Singh,R and Agrawal, S.K. (2005) Effect of levels of farm yard manure and nitrogen fertilizer on grain yield and use efficiency of nutrients on wheat(Triticum aestivum). Indian Journal of Agricultural Science 75(7): 408-413.
4. Chesnin, L. and Yien, C.H. (1951).Turbidimetric determination of available sulphur.*Proc. Soil Sci. Soc. America*,14 : 149- 151.
5. Jackson , M.L. (1967) soil chemical analysis, prentice hall of India Pvt. Ltd., New Delhi.
6. Lindsay, W.L. and Norvell, W.A. (1978).zinc in soil and plant nutrient *Adv. Pergamum press, oxford.*
7. Olsen, S.R; Cole, C.V; Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate.*Circ.US Dept. of Agric. Washington D.C. 939.*
8. Piper, C.S. (1996) soil and plant analysis, university of Adelaide, Australia. Subbiah and Asija, G.S. (1956) a rapid procedure for the estimation of available nitrogen in soil.*Current Sci.*25: 259-260.
9. Mahajan, S., Kanwar, S. S., Kumari, P. and Sharma, S. P. 2007. Long-term effect of mineral fertilizers and amendments on microbial dynamics in an alfi sol of Western Himalayas.*Indian J. microbiology*., 47:86-89.