

# 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 integrated nutrient management (INM) on soil fertility and of wheat cropping. The experiment comprised of 16 was comprising sixteen treatments viz. T1- control, T2- 100% RDF, T3- 100% RDF+S, T4- 100% RDF+S+Zn, T5- 100% R.D.F. + S + Zn + bio-fertilizer (Azotobactor+ P.S.B.), T6- 100% R.D.F. + 25% N through F.Y.M., T7- 100% R.D.F. + 25% N through F.Y.M. + S, T8- 100% R.D.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+ P.S.B.), T10-100% R.D.F. + 25% N through vermi compost, T11- 100% R.D.F. + 25% N through vermi compost + 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 vermi compost, 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 vermi compost + S + Zn + bio-fertilizer (Azotobactor+ P.S.B.). Integration of organic manures had showed slight increase in EC value while inorganic fertilizers had showed slight decrease in EC values when compared in comparison to the its initial value which was obviously due attributed to decomposition of organic matter in the soil. Similarly, Maximum increase in organic carbon content was obtained noted with the integration of organic and treatments followed by inorganic treatments. It may be due to decomposition and mineralization of organic matter by narrow C: N ratio. The status of N, P, K, S and Zn were slightly increased for in all the treatments in comparison to the its initial value, except for the control, for during both the years. However, Maximum increase in the soil available status of N, P, K, S and Zn were recorded with integration of when inorganic, organic and bio-fertilizers were integrated with 100% RDF. T<sub>11</sub> (100% R.D.F. + 25% N through vermicompost+S + Zn + bio-fertilizer (Azotobactor+P.S.B.) followed by T<sub>9</sub> (100% R.D.F. + 25% N through F.Y.M. + S + Zn+bio-fertilizer (Azotobactor+P.S.B.) and were minimum for the at control (T<sub>1</sub>) during both the years. Maximum microbial population was recorded with T<sub>11</sub> (100% R.D.F. + 25% N through

vermicompost+S + Zn + bio-fertilizers (*Azotobacter*+P.S.B.) followed by T<sub>9</sub> (100 % R.D.F. + 25 % N through F.Y.M. + S + Zn+bio-fertilizers (*Azotobacter*+P.S.B.) and minimum for the at control during both the years. What were the effects on Wheat crop and what was your conclusion and recommendation to farmers?

**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 people in the world. In India, wheat is cultivated on 29.6 million ha area with 93.5 million tonnes of produced and 31.5 q/ha (what is q/ha?) of average productivity (FAO, 2013). In Uttar Pradesh, it is grown on 9.73 million ha area with production 30.3 million tons and productivity of 31.14 q/ha? (Anonymous, 2013). The requirement of wheat was put at will be around 109 million tonnes to feed for feeding the 1.25 billion populations by in 2020 AD (Singh, 2010). Organic matter like FYM has been reported to be able to supply available nutrients to the plants, provided favourable soil environment and increase water holding capacity of the soils for longer time (authority?). 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<sup>-1</sup> significantly 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 @ at 10 and 20 t/ha increased the grain yield and the total N P and K uptake in wheat plants crop (Singh and Agrawal, 2005). Millions of farmers in developing countries need adequate resource for augmenting crop productivity and sustainability of soil. Therefore, to maintain fertility and productivity of soils at sustainable level for long duration, there is need to adopt the concept of integrated nutrient management. Organic manure such as farm yard manure, vermin-compost, crop residues, bio-fertilizers, green manures and chemical fertilizers are considered to be an integral component of integrated nutrient management and may help to recover soil health in cropping systems. 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 (Authority?) . Organic matter affects crop

growth and yields either directly by 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 increases the proportion of water available for plant growth and improves physical properties of soil (Sial et al., 2007). This study was therefore conducted to investigate the effect of integrating organic nutrient sources with inorganic fertilizer on the soil and wheat in Western Uttar Pradesh

## Materials and Methods

The present study was carried out by in Chandra Shekhar Azad University of Agriculture and Technology, Kanpur for two consecutive years from 2013-14 to 2014-15 cropping seasons to evaluate the different levels of INM on the soils, yield and economics of wheat production. The experiment was comprises of 16 sixteen treatments viz. T1- control, T2- 100%RDF,T3- 100% RDF+S, T4- 100%RDF+S+Zn, T5- 100% R.D.F. + S + Zn + bio-fertilizer (Azotobactor+ P.S.B.), T6- 100% R.D.F. + 25% N through F.Y.M., T7- 100% R.D.F. + 25% N through F.Y.M. + S, T8- 100% R.D.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+ P.S.B.), T10-100% R.D.F. + 25% N through vermicompost, T11- 100% R.D.F. + 25% N through vermi compost + 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 vermi compost, 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 vermi compost + S + Zn + bio-fertilizer (Azotobactor+ P.S.B.). The experiment consists of was a field study with plot size of 24.5m<sup>2</sup> and wheat variety PBW 550 as test crop in a randomized complete block design (RCBD) with three replications, Physio-chemical characteristics of soil of the experimental field of sand 56.80, silt 23.40%, clay 19.85,PH 8.30 and Organic Carbon (%) 0.420, plot size of the experiments was 24.5m<sup>2</sup> with wheat variety PBW 550.

**Soil Analysis :**The Site soil sample was taken before sowing and analyzed with the standard procedures as given below: Mechanical for the textural separates using International Pipette method as described by Piper (1966) was adopted for the analysis of soil separates. **The soil pH :**Determination of pH was read using done with the help of Elicodigital pH meter using in soil/water suspension in the ratio of 1 :2.5. **EC :** The soil EC was determined in 1:2.5

soil/water suspensions with the help of using conductivity meter (Jackson, 1967). **Organic Carbon:** The organic carbon content 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 by extracting the soil using by 0.5 M NaHCO<sub>3</sub> (pH 8.3) extractant as described given by Olsen et al. (1954). **Available Potassium:** Available Exchangeable potassium was first extracted by extraction using 1 N NH<sub>4</sub> OAC (pH 7.0) Morgan's solution and estimated by Flame photometer as described by (Jackson, 1967). **Available Sulphur :** Available The soil sulphur was determined by using 0.15 % CaCl<sub>2</sub> extractant (Williams and Steinbergs, 1959) and **S content** was determined by Turbidimetric procedure (Chesnin and Yien, 1951). **Available Zinc:** Available The soil zinc was extracted using made by 0.005 MDTPA (Diethylenetriaminepenta acetic acid) and adjusted pH 7.3 with dilute HCl and the Zn content was measured using with the help of an Atomic absorption spectro photometer according to r. The extraction was done by (Lindsay and Norvell (1978) procedure. **Microbial count :** The soil total bacteria, fungi and actinomycetes was counted in soil sample collected after crop harvest of crops by using dilution cultured plate count method. This was done by first of all putting 1.0 ml soil suspension of desired solution is poured in each sterilized petri-dishes and added after 20 ml of specific agar medium was added and dish contents both were thoroughly mixed by rotation and allowed to solidify and . Afterwards, it was incubated at particular temperature for definite period (be specific and give the temperature. Is it at room temperature or what? How long in hours or days?) depending upon the kind of micro-organisms. After incubation, the number of microbe colonies of microbes were appeared on each plates, were counted. The and population was calculated on using the basis of following equation: population/g of soil = Average numbers of colonies/plate x final working dilution of biological material (soil)

## Results and Discussion

Effect of integrated nutrient management on soil properties after at harvest of the crops

After harvest of the wheat test 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<sup>H</sup>:** Data with regard to soil pH values 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 across the treatments decreased in comparison compared to the control treatment. its initial value. Maximum The highest decreased in soil  $P^H$  was obtained recorded in under organic and bio-fertilizers treatments in comparison to inorganic treatments in both cropping seasons during both the years. Effect on soil EC (Table 1) showed a narrower and none significant variation within all between the treatments during both the years. It is interesting to report that Integration of organic and bio-fertilizers treatments showed resulted to slight increase in EC values in compared to the control while application of inorganic fertilizers application showed slight decrease in EC values during both the years. Effect of the treatments on soil organic carbon: Maximum organic carbon contents of 0.439 and 0.415% were recorded with T<sub>11</sub> (100 % R.D.F. + 25% N through vermicompost +S + Zn + bio-fertilizers (*Azotobactor*+ P.S.B.) followed by T<sub>9</sub> (100 R.D.F. + 25% N through F.Y.M. + S + Zn +bio-fertilizers (*Azotobactor*+ P.S.B.) and minimum 0.398 and 0.382% in control (T<sub>1</sub>) during 1<sup>st</sup> year and 2<sup>nd</sup> year of cropping. Integration of vermicompost showed higher increase in organic carbon % compared to FYM during both the years (Table 2). **Available status of nitrogen:** Maximum available status of Total nitrogen contents of 215.50 and 200.80 kg ha<sup>-1</sup> were recorded with T<sub>11</sub> (100% R.D.F. + 25% N through using vermi compost +S + Zn + bio-fertilizers (*Azotobactor*+ P.S.B.) and was followed by T<sub>9</sub> (100% R.D.F. + 25% N through F.Y.M. + S + Zn +bio-fertilizers (*Azotobactor*+ P.S.B.) and least with values of minimum 207.00 and 192.00 kg ha<sup>-1</sup> in control (T<sub>1</sub>) during 1<sup>st</sup> year and 2<sup>nd</sup> year of the wheat cropping respectively (Table 3). **Available status of phosphorus:** Available status of phosphorus within all the treatments varied from 12.20 - 11.50 and 11.50 - 13.25 kg ha<sup>-1</sup> during after the 1<sup>st</sup> year and 2<sup>nd</sup> cropping years, respectively. Integrated application of organic, inorganic and bio-fertilizers showed higher increased in the available status of phosphorus in comparison compared to inorganic fertilizers treatments during in both the years (Table-3). **Available status of potassium:** Maximum Increased in available status of the soil exchangeable potassium with values of 134.50 and 127.70 kg ha<sup>-1</sup> was recorded with T<sub>11</sub> (100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers(*Azotobactor*+ P.S.B.) which was followed by T<sub>9</sub> (100% R.D.F. + 25 % N through F.Y.M. + S + Zn +bio-fertilizers(*Azotobactor*+ P.S.B.) and least for the control (T<sub>1</sub>) with values of minimum 129.50 and 121.80 kg ha<sup>-1</sup> at control (T<sub>1</sub>) at both during 1<sup>st</sup> year and 2<sup>nd</sup> year of cropping respectively (Table-3).

**Available status of sulphur:** The data pertaining to the available status of soil sulphur contents given in (Table 4) showed that the values were none significantly influenced by the

application of the different fertilizer treatments except for the control during both the years. Like-wise nitrogen, phosphorus and potassium available status of sulphur also varied from minimum in control (T<sub>1</sub>) and maximum under (T<sub>11</sub>) (100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers (*Azotobacter*+ P.S.B.) during both the years. **Available status of zinc:** Integration nutrient management resulted to of zinc showed higher increase in available status of soil zinc when with 100% RDF and 75% RDF treatments were applied for during both the cropping years. Generally, It is also visualized from the data showed that all the treatments showed had slight increase in available status of soil zinc content compared to the except control during both the years. Integrated nutrient management showed It was also observed that 100% RDF showed had higher increase in available status of soil zinc in comparison compared to 75% RDF usage during both the years (Table-4).

### Effect of integrated nutrient management on total microbial population

**Total bacterial population:** The soil Total bacterial population given in (Table 5) showed variation values from  $13.5 \times 10^5$  -  $22.5 \times 10^5$  and  $13.1 \times 10^5$  -  $21.2 \times 10^5$  cfu g<sup>-1</sup> soil after during 1<sup>st</sup> year and 2<sup>nd</sup> year respectively. Integration of bio-fertilizer and organic manures showed favorable influence in soil bacterial population when compared in comparison to the inorganic fertilizers treatments during both the years. On the other hand, total fungal population (Table 5) showed a linear and significant increase influence due to in all the integrated nutrient management treatments in comparison compared to the control. The highest Maximum fungal population influenced of  $16.3 \times 10^3$  and  $15.9 \times 10^3$  cfu g<sup>-1</sup> soil was recorded with T<sub>11</sub> and (100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers(*Azotobacter*+ P.S.B.) followed by T<sub>9</sub> (100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +bio-fertilizers(*Azotobacter*, P.S.B.) and but least with value of minimum  $9.5 \times 10^3$  and  $9.2 \times 10^3$  cfu g<sup>-1</sup> soil in for the control (T<sub>1</sub>). Total actinomycetes population (Table 5) showed similar linear and significant increase trend as observed for the soil fungal population. in all the treatments in comparison to control during both the years. The total actinomycetes population ranged from  $10.5 \times 10^3$  to  $18.2 \times 10^3$  and  $10.1 \times 10^3$  to  $17.9 \times 10^3$  cfu g<sup>-1</sup> soil with minimum least value for the in control and maximum highest for in T<sub>11</sub> (100 % R.D.F. + 25 % N through vermicompost +S + Zn + bio-fertilizers(*Azotobacter*+ P.S.B.). It was also observed that integration of bio-fertilizers and organic manures showed favorable influence in improving the soil microorganisms population compared comparison to inorganic fertilizers for the two years of experimentation 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 in trend with reports by other authors when organic fertilizers were compared with inorganic fertilizers usage on soil microorganisms population counts 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 <sub>1</sub> . Control	8.29	8.20	0.20	0.18
T <sub>2</sub> .100 % R.D.F.	8.29	8.19	0.19	0.17
T <sub>3</sub> .100 % R.D.F. + S	8.28	8.19	0.19	0.17
T <sub>4</sub> .100 % R.D.F. + S + Zn	8.27	8.18	0.18	0.17
T <sub>5</sub> .100 % R.D.F. + S + Zn + Bio-fertilizers (Azotobactor+ P.S.B.)	8.27	8.17	0.18	0.16
T <sub>6</sub> .100 % R.D.F. + 25 % N through F.Y.M.	8.26	8.16	0.21	0.19
T <sub>7</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S	8.25	8.16	0.21	0.19
T <sub>8</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	8.25	8.15	0.21	0.19
T <sub>9</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers (Azotobactor+ P.S.B.)	8.24	8.15	0.22	0.20
T <sub>10</sub> .100 % R.D.F. + 25 % N through vermicompost	8.25	8.15	0.22	0.20
T <sub>11</sub> .100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize (Azotobactor+ P.S.B.)	8.24	8.14	0.22	0.21
T <sub>12</sub> .75 % R.D.F.	8.29	8.19	0.20	0.18
T <sub>13</sub> .75 % R.D.F. + 25 % N through F.Y.M.	8.28	8.18	0.21	0.18
T <sub>14</sub> .75 % R.D.F. + 25 % N through vermicompost	8.27	8.17	0.21	0.18
T <sub>15</sub> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (Azotobactor+ P.S.B.)	8.26	8.18	0.22	0.18
T <sub>16</sub> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(Azotobactor+ 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

Treatment	pH		EC	
	2013-2014	2014-2015	2013-2014	2014-2015
T <sub>1</sub> . Control	8.29	8.20	0.20	0.18
T <sub>2</sub> .100 % R.D.F.	8.29	8.19	0.19	0.17
T <sub>3</sub> .100 % R.D.F. + S	8.28	8.19	0.19	0.17

T <sub>4</sub> .100 % R.D.F. + S + Zn	8.27	8.18	0.18	0.17
T <sub>5</sub> .100 % R.D.F. + S + Zn + Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	8.27	8.17	0.18	0.16
T <sub>6</sub> .100 % R.D.F. + 25 % N through F.Y.M.	8.26	8.16	0.21	0.19
T <sub>7</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S	8.25	8.16	0.21	0.19
T <sub>8</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	8.25	8.15	0.21	0.19
T <sub>9</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers ( <i>Azotobactor</i> + P.S.B.)	8.24	8.15	0.22	0.20
T <sub>10</sub> .100 % R.D.F. + 25 % N through vermicompost	8.25	8.15	0.22	0.20
T <sub>11</sub> .100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize ( <i>Azotobactor</i> + P.S.B.)	8.24	8.14	0.22	0.21
T <sub>12</sub> .75 % R.D.F.	8.29	8.19	0.20	0.18
T <sub>13</sub> .75 % R.D.F. + 25 % N through F.Y.M.	8.28	8.18	0.21	0.18
T <sub>14</sub> .75 % R.D.F. + 25 % N through vermicompost	8.27	8.17	0.21	0.18
T <sub>15</sub> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	8.26	8.18	0.22	0.18
T <sub>16</sub> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers( <i>Azotobactor</i> + 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 (OC &N)

Treatment	Organic Carbon (%)		Available Nitrogen kg ha <sup>-1</sup>	
	2013-2014	2014-2015	2013-2014	2014-2015
T <sub>1</sub> . Control	0.398	0.382	0.398	0.382
T <sub>2</sub> .100 % R.D.F.	0.422	0.392	0.422	0.392
T <sub>3</sub> .100 % R.D.F. + S	0.424	0.394	0.424	0.394
T <sub>4</sub> .100 % R.D.F. + S + Zn	0.426	0.396	0.426	0.396
T <sub>5</sub> .100 % R.D.F. + S + Zn + Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	0.428	0.398	0.428	0.398
T <sub>6</sub> .100 % R.D.F. + 25 % N through F.Y.M.	0.432	0.402	0.432	0.402
T <sub>7</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S	0.434	0.405	0.434	0.405
T <sub>8</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	0.435	0.408	0.435	0.408
T <sub>9</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers ( <i>Azotobactor</i> + P.S.B.)	0.436	0.410	0.436	0.410
T <sub>10</sub> .100 % R.D.F. + 25 % N through vermicompost	0.435	0.404	0.435	0.404
T <sub>11</sub> .100 % R.D.F. + 25 % N through	0.439	0.415	0.439	0.415

vermicompost +S + Zn + Bio Fertilize  
(Azotobactor+ P.S.B.)

<b>T<sub>12</sub></b> 75 % R.D.F.	0.415	0.386	0.415	0.386
<b>T<sub>13</sub></b> .75 % R.D.F. + 25 % N through F.Y.M.	0.423	0.388	0.423	0.388
<b>T<sub>14</sub></b> .75 % R.D.F. + 25 % N through vermicompost	0.427	0.390	0.427	0.390
<b>T<sub>15</sub></b> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (Azotobactor+ P.S.B.)	0.426	0.393	0.426	0.393
<b>T<sub>16</sub></b> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(Azotobactor+ P.S.B.)	0.431	0.396	0.431	0.396
<b>S.E. ±</b>	0.010	0.009	0.010	0.009
<b>C.D. (at 5 %)</b>	NS	NS	NS	NS

Treatment	Organic Carbon (%)		Available Nitrogen kg ha <sup>-1</sup>	
	2013-2014	2014-2015	2013-2014	2014-2015
<b>T<sub>1</sub></b> . Control	0.398	0.382	0.398	0.382
<b>T<sub>2</sub></b> .100 % R.D.F.	0.422	0.392	0.422	0.392
<b>T<sub>3</sub></b> .100 % R.D.F. + S	0.424	0.394	0.424	0.394
<b>T<sub>4</sub></b> .100 % R.D.F. + S + Zn	0.426	0.396	0.426	0.396
<b>T<sub>5</sub></b> .100 % R.D.F. + S + Zn + Bio-fertilizers (Azotobactor+ P.S.B.)	0.428	0.398	0.428	0.398
<b>T<sub>6</sub></b> .100 % R.D.F. + 25 % N through F.Y.M.	0.432	0.402	0.432	0.402
<b>T<sub>7</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S	0.434	0.405	0.434	0.405
<b>T<sub>8</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	0.435	0.408	0.435	0.408
<b>T<sub>9</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers (Azotobactor+ P.S.B.)	0.436	0.410	0.436	0.410
<b>T<sub>10</sub></b> .100 % R.D.F. + 25 % N through vermicompost	0.435	0.404	0.435	0.404
<b>T<sub>11</sub></b> .100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize (Azotobactor+ P.S.B.)	0.439	0.415	0.439	0.415
<b>T<sub>12</sub></b> 75 % R.D.F.	0.415	0.386	0.415	0.386
<b>T<sub>13</sub></b> .75 % R.D.F. + 25 % N through F.Y.M.	0.423	0.388	0.423	0.388
<b>T<sub>14</sub></b> .75 % R.D.F. + 25 % N through vermicompost	0.427	0.390	0.427	0.390
<b>T<sub>15</sub></b> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers (Azotobactor+ P.S.B.)	0.426	0.393	0.426	0.393
<b>T<sub>16</sub></b> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers(Azotobactor+ P.S.B.)	0.431	0.396	0.431	0.396
<b>S.E. ±</b>	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 P & K Contents

Treatment	Available P ( Kg ha <sup>-1</sup> )		Exchanrable K (Kg ha <sup>-1</sup> )	
	2013-2014	2014-2015	2013-2014	2014-2015
T <sub>1</sub> . Control	12.20	11.50	12.20	11.50
T <sub>2</sub> .100 % R.D.F.	13.80	12.55	13.80	12.55
T <sub>3</sub> .100 % R.D.F. + S	13.88	12.62	13.88	12.62
T <sub>4</sub> .100 % R.D.F. + S + Zn	13.95	12.70	13.95	12.70
T <sub>5</sub> .100 % R.D.F. + S + Zn + Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	14.05	12.78	14.05	12.78
T <sub>6</sub> .100 % R.D.F. + 25 % N through F.Y.M.	14.15	12.82	14.15	12.82
T <sub>7</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S	14.22	12.90	14.22	12.90
T <sub>8</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	14.28	12.98	14.28	12.98
T <sub>9</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers ( <i>Azotobactor</i> +P.S.B.)	14.35	13.02	14.35	13.02
T <sub>10</sub> .100 % R.D.F. + 25 % N through vermicompost	14.20	12.85	14.20	12.85
T <sub>11</sub> .100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize ( <i>Azotobactor</i> + P.S.B.)	14.50	13.25	14.50	13.25
T <sub>12</sub> .75 % R.D.F.	12.75	11.90	12.75	11.90
T <sub>13</sub> .75 % R.D.F. + 25 % N through F.Y.M.	13.55	12.25	13.55	12.25
T <sub>14</sub> .75 % R.D.F. + 25 % N through vermicompost	13.60	12.40	13.60	12.40
T <sub>15</sub> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	13.72	12.50	13.72	12.50
T <sub>16</sub> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers( <i>Azotobactor</i> + 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

Treatment	Available P. (Phosphorus) Kg ha <sup>-1</sup>		Available K. (Potassium) Kg ha <sup>-1</sup>	
	2013-2014	2014-2015	2013-2014	2014-2015
T <sub>1</sub> . Control	12.20	11.50	12.20	11.50
T <sub>2</sub> .100 % R.D.F.	13.80	12.55	13.80	12.55
T <sub>3</sub> .100 % R.D.F. + S	13.88	12.62	13.88	12.62
T <sub>4</sub> .100 % R.D.F. + S + Zn	13.95	12.70	13.95	12.70
T <sub>5</sub> .100 % R.D.F. + S + Zn + Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	14.05	12.78	14.05	12.78
T <sub>6</sub> .100 % R.D.F. + 25 % N through F.Y.M.	14.15	12.82	14.15	12.82
T <sub>7</sub> .100 % R.D.F. + 25 % N through	14.22	12.90	14.22	12.90

F.Y.M. + S				
T <sub>8</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	14.28	12.98	14.28	12.98
T <sub>9</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers ( <i>Azotobactor</i> + P.S.B.)	14.35	13.02	14.35	13.02
T <sub>10</sub> .100 % R.D.F. + 25 % N through vermicompost	14.20	12.85	14.20	12.85
T <sub>11</sub> .100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize ( <i>Azotobactor</i> + P.S.B.)	14.50	13.25	14.50	13.25
T <sub>12</sub> 75 % R.D.F.	12.75	11.90	12.75	11.90
T <sub>13</sub> .75 % R.D.F. + 25 % N through F.Y.M.	13.55	12.25	13.55	12.25
T <sub>14</sub> .75 % R.D.F. + 25 % N through vermicompost	13.60	12.40	13.60	12.40
T <sub>15</sub> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	13.72	12.50	13.72	12.50
T <sub>16</sub> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers( <i>Azotobactor</i> + 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 S & Zn Contents

Treatment	Available S (kg ha <sup>-1</sup> )		Available Zn (g ha <sup>-1</sup> )	
	2013-2014	2014-2015	2013-2014	2014-2015
T <sub>1</sub> . Control	15.85	14.50	15.85	14.50
T <sub>2</sub> .100 % R.D.F.	16.60	15.35	16.60	15.35
T <sub>3</sub> .100 % R.D.F. + S	16.95	15.80	16.95	15.80
T <sub>4</sub> .100 % R.D.F. + S + Zn	17.10	15.95	17.10	15.95
T <sub>5</sub> .100 % R.D.F. + S + Zn + Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	17.25	16.10	17.25	16.10
T <sub>6</sub> .100 % R.D.F. + 25 % N through F.Y.M.	16.75	15.40	16.75	15.40
T <sub>7</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S	17.30	16.15	17.30	16.15
T <sub>8</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	17.60	16.40	17.60	16.40
T <sub>9</sub> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers ( <i>Azotobactor</i> + P.S.B.)	17.85	16.65	17.85	16.65
T <sub>10</sub> .100 % R.D.F. + 25 % N through vermicompost	16.85	15.50	16.85	15.50
T <sub>11</sub> .100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize ( <i>Azotobactor</i> + P.S.B.)	18.10	16.85	18.10	16.85
T <sub>12</sub> 75 % R.D.F.	16.10	14.90	16.10	14.90
T <sub>13</sub> .75 % R.D.F. + 25 % N through F.Y.M.	16.35	15.30	16.35	15.30
T <sub>14</sub> .75 % R.D.F. + 25 % N through vermicompost	16.25	15.40	16.25	15.40

<b>T<sub>15</sub></b> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	16.70	15.60	16.70	15.60
<b>T<sub>16</sub></b> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers( <i>Azotobactor</i> + P.S.B.)	16.85	15.70	16.85	15.70
<b>S.E. ±</b>	0.325	0.272	0.325	0.272
<b>C.D. (at 5 %)</b>	NS	NS	NS	NS

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

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

Treatment	Bacteria (× 10 <sup>5</sup> cfu g <sup>-1</sup> )		Fungi (× 10 <sup>3</sup> cfu g <sup>-1</sup> )		Actinomycetis (× 10 <sup>3</sup> cfu g <sup>-1</sup> )	
	2013-14	2014-15	2013-14	2014-15	2013-2014	2014-15
<b>T<sub>1</sub></b> . Control	13.5	13.1	9.5	13.5	13.1	9.5
<b>T<sub>2</sub></b> .100 % R.D.F.	17.5	17.1	12.6	17.5	17.1	12.6

<b>T<sub>3</sub></b> .100 % R.D.F. + S	17.8	17.2	12.9	17.8	17.2	12.9
<b>T<sub>4</sub></b> .100 % R.D.F. + S + Zn	18.1	17.9	13.2	18.1	17.9	13.2
<b>T<sub>5</sub></b> .100 % R.D.F. + S + Zn + Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	20.6	20.3	14.2	20.6	20.3	14.2
<b>T<sub>6</sub></b> .100 % R.D.F. + 25 % N through F.Y.M.	19.2	18.8	14.9	19.2	18.8	14.9
<b>T<sub>7</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S	19.6	19.2	15.1	19.6	19.2	15.1
<b>T<sub>8</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	20.0	19.7	15.3	20.0	19.7	15.3
<b>T<sub>9</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers ( <i>Azotobactor</i> + P.S.B.)	22.1	21.9	15.8	22.1	21.9	15.8
<b>T<sub>10</sub></b> .100 % R.D.F. + 25 % N through vermicompost	19.8	19.5	15.2	19.8	19.5	15.2
<b>T<sub>11</sub></b> .100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize ( <i>Azotobactor</i> + P.S.B.)	22.5	21.2	16.3	22.5	21.2	16.3
<b>T<sub>12</sub></b> .75 % R.D.F.	15.2	14.9	11.8	15.2	14.9	11.8
<b>T<sub>13</sub></b> .75 % R.D.F. + 25 % N through F.Y.M.	16.8	16.5	13.8	16.8	16.5	13.8
<b>T<sub>14</sub></b> .75 % R.D.F. + 25 % N through vermicompost	17.4	17.1	14.5	17.4	17.1	14.5
<b>T<sub>15</sub></b> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	18.3	17.9	14.1	18.3	17.9	14.1
<b>T<sub>16</sub></b> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers( <i>Azotobactor</i> + P.S.B.)	18.7	18.4	14.7	18.7	18.4	14.7
<b>S.E. ±</b>	1.645	1.413	1.159	1.645	1.413	1.159
<b>C.D. (at 5 %)</b>	3.377	2.900	2.378	3.377	2.900	2.378

Treatment	Bacteria ( $\times 10^5$ cfu g <sup>-1</sup> )		Fungi ( $\times 10^3$ cfu g <sup>-1</sup> )		Actinomycetis ( $\times 10^3$ cfu g <sup>-1</sup> )	
	2013-14	2014-15	2013-14	2014-15	2013-2014	2014-15
<b>T<sub>1</sub></b> . Control	13.5	13.1	9.5	13.5	13.1	9.5
<b>T<sub>2</sub></b> .100 % R.D.F.	17.5	17.1	12.6	17.5	17.1	12.6
<b>T<sub>3</sub></b> .100 % R.D.F. + S	17.8	17.2	12.9	17.8	17.2	12.9
<b>T<sub>4</sub></b> .100 % R.D.F. + S + Zn	18.1	17.9	13.2	18.1	17.9	13.2
<b>T<sub>5</sub></b> .100 % R.D.F. + S + Zn + Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	20.6	20.3	14.2	20.6	20.3	14.2
<b>T<sub>6</sub></b> .100 % R.D.F. + 25 % N through F.Y.M.	19.2	18.8	14.9	19.2	18.8	14.9
<b>T<sub>7</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S	19.6	19.2	15.1	19.6	19.2	15.1
<b>T<sub>8</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn	20.0	19.7	15.3	20.0	19.7	15.3
<b>T<sub>9</sub></b> .100 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio -fertilizers ( <i>Azotobactor</i> + P.S.B.)	22.1	21.9	15.8	22.1	21.9	15.8
<b>T<sub>10</sub></b> .100 % R.D.F. + 25 % N through vermicompost	19.8	19.5	15.2	19.8	19.5	15.2

T <sub>11</sub> -100 % R.D.F. + 25 % N through vermicompost +S + Zn + Bio Fertilize ( <i>Azotobactor</i> + P.S.B.)	22.5	21.2	16.3	22.5	21.2	16.3
T <sub>12</sub> 75 % R.D.F.	15.2	14.9	11.8	15.2	14.9	11.8
T <sub>13</sub> .75 % R.D.F. + 25 % N through F.Y.M.	16.8	16.5	13.8	16.8	16.5	13.8
T <sub>14</sub> .75 % R.D.F. + 25 % N through vermicompost	17.4	17.1	14.5	17.4	17.1	14.5
T <sub>15</sub> . 75 % R.D.F. + 25 % N through F.Y.M. + S + Zn +Bio-fertilizers ( <i>Azotobactor</i> + P.S.B.)	18.3	17.9	14.1	18.3	17.9	14.1
T <sub>16</sub> . 75 % R.D.F. + 25 % N through vermicompost + S + Zn + Bio-fertilizers( <i>Azotobactor</i> + 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

## 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.

UNDER PEER REVIEW