

Original Research Article

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## Effect of Organic Manuring and Integrated Nutrient Management on Microbiological Properties in Sandy Soils under Wheat-Guar Cropping System

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### ABSTRACT

#### Keywords

Farm Yard Manure (FYM), Vermicompost (VC), Microbial biomass, Soil microbiological properties

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The long-term application of excessive chemical fertilizers has resulted in the degeneration of soil quality parameters such as soil microbial biomass and nutrient content, which in turn affects crop health, productivity, and soil sustainable productivity. Organic manuring and Integrated nutrient management system (INMS) gained importance in maintaining the soil health and fertility. The continuous application of vermicompost (VC) for ten years @ 15t/ha under wheat-guar cropping system at Bawal in sandy soils had beneficial effects on soil microbiological properties compared to conventional system using only chemical fertilizers. Organic C and total N increased from 0.163 to 0.270 and from 0.012 to 0.076%, respectively. The total P, available P and available N were 152, 8.0 and 29 mg/kg soil, respectively. The amount of total K varied from 1530 to 2019 and Zn from 126 to 175 mg/kg soil. The C mineralization rate and potentially mineralizable nitrogen were 6.8 and 41.5 mg/kg soil, respectively and were highest in treatment receiving VC @15t/ha. Microbial biomass C (MBC), microbial biomass N (MBN) and microbial biomass P (MBP) were 320, 40 and 12 mg/kg soil. The biomass C/N ratio ranged from 6.4 to 8.0 and C/P ratio from 20.0 to 26.6, and was highest treatment with VC @15t/ha.

### Introduction

Soil is a natural habitat that support plant growth. The long term use of chemical fertilizers damages the soil physical properties and causes environmental pollution (Sangshetty and Babalad, 2011). In many parts of Haryana, due to continuous use of chemical fertilizers, the level of soil organic matter has gone down. To build up or to maintain the level of soil organic matter in agricultural soil, use of organic amendments

or integrated use of chemical fertilizers along with organic amendments is being advocated and opted by many farmers in Haryana. The complementary use of chemical fertilizers, biofertilizers, organic manures and crop residues can ensure long-term nutrient supply and soil productivity (Anik *et al.*, 2017). Different management systems may result in changes in different nutrient release pattern and soil microbial community which may affect plant growth (Araujo *et al.*, 2008). The soil microbial biomass is a much more

labile component of soil organic matter than most of the other fractions (Sangshetty and Babalad, 2011). Low inputs of organic materials, excessive use of mineral fertilizers and more frequent tillage have contributed to a general reduction in soil organic matter (SOM) content, with a consequent decline in the quality of agricultural soils (Chang *et al.*, 2014). This negative effect of agricultural practices could be reversed by the correct utilization of manures and/or crop residues within cropping systems, either alone or in combination with mineral fertilizers (Mandal *et al.*, 2007). But any increase in SOM content due to organic matter addition may be slow. However, whilst the amount of C stored in soil is a good indicator of soil quality, it does not necessarily reflect the complexity of the organic compounds present and the influence that these may have on the microbiological processes controlling nutrient availability.

To overcome these limitations, different authors have proposed several soil indicators to study the effects of organic manure applications on soil C accumulation and C and N turnover (Gil-Sotres *et al.*, 2005). Some are based on soil physical and chemical properties but the majority focuses on biochemical properties that reflect the size and activity of microbial processes. This is because biologically mediated processes in soils play a key role in the mineralization of organic C and in nutrient cycling. Moreover, changes in the size and activity of the soil microbial biomass occur more rapidly in response to changes in environmental conditions, land use and management than most physical and chemical parameters (Frazao *et al.*, 2010).

The biochemical properties are more sensitive to environmental stress which play a major role in degradation, and provide rapid and accurate information on soil quality (García *et*

*al.*, 2000). While biochemical properties of the soil can be studied at various levels, the most relevant are those involved in transformation of organic matter (Leirós *et al.*, 2000). The biochemical parameters include variables directly related to microbial activity (microbial biomass C, soil respiration etc.) and the activities of extracellular hydrolytic enzymes involved in the C, N, S and P cycles in soil. These soil biochemical and microbiological parameters are considered as potential indicators of management impacts on soil quality (Gil-Sotres *et al.*, 2005; Mahmood *et al.*, 2017) especially under different agricultural management practices because soil microbial biomass and enzyme activities respond much more quickly to the changes in soil management practices as compared to total soil organic matter (Garcia-Ruiz *et al.*, 2008). The response of these soil biochemical and microbial variables to organic and conventional amendments is often studied in the long-term (Monaco *et al.*, 2008).

Therefore, understanding of soil biological processes that liberate plant nutrients is needed for soils receiving organic amendments or integrated use of chemicals fertilizers along with organic manures under tropical regions.

## **Materials and Methods**

### **Experimental design and treatments**

The field experiment on wheat-guar cropping system consisted of fifteen treatments along with a control in a randomized block design with four replications.

### **Soil sampling and its preparations**

Soil samples were collected from ten different locations with different treatments fertilized with organic manures and combination of

organic and inorganic nutrient sources from 0-15 cm layer in crop rotation systems from bawal.

Soil samples amended with organic and inorganic manures from last three to thirteen years were drawn from research farm. The soil samples were sieved through 2 mm sieve and stored at 4°C. For determination of microbial biomass and microbial activities, the soil was moistened to 60 per cent water holding capacity (WHC) and incubated at 30°C for 10 days to permit uniform rewetting and to allow microbial activity to equalibrate after the initial disturbances. Sub-samples of each soil were air-dried and ground for chemical analysis. Soil samples were analysed for chemical and biological properties.

### **Analytical methods**

#### **Soil chemical properties**

Five gram soil was mixed with 12.5 ml of distilled water. It was shaken for 30 min and pH of soil suspension was measured at room temperature with Systronics 331 pH meter and Electrical Conductivity (EC) was measured with Naina electrical conductivity meter, as per the procedure given by Jackson (1973). The organic C in soil samples was determined by method of Kalembassa and Jenkinson (1973). The alkaline potassium permanganate oxidizable soil N (KMnO<sub>4</sub>-N) as an index of available N was determined as per the procedure given by Subbiah and Asija (1956). Olsen-P was extracted with 0.5 M sodium bicarbonate (pH 8.5) as outlined by (Olsen *et al.*, 1954) and the P content in the extract was determined by a spectrophotometer. Available K was determined in the neutral normal ammonium acetate extract of soil with the help of flame photometer (Jackson, 1973). Available Zn was determined by method of Lindsay and

Norvell (1978) using atomic absorption spectrophotometer.

#### **Ammoniacal nitrate - nitrogen and carbon mineralization**

Ammoniacal and Nitrate - Nitrogen were estimated by steam distillation method of Keeney and Bremner (1965). Carbon Mineralization was determined by measuring CO<sub>2</sub> evolution from soil for 4 weeks by method of Pramer and Schmidt (1964) with slight modification. Soil basal respiration (respiration rate) was estimated by placing 100 g of oven-dried equivalent of field-moist soil in a tube and incubating the sample in the dark in a 500-mL airtight Duran bottle along with 10 mL of sodium hydroxide (NaOH) to absorb carbon dioxide (CO<sub>2</sub>). The carbon dioxide carbon (CO<sub>2</sub>-C) was determined by titration.

#### **Microbial biomass C, N and P**

Soil microbial biomass C, N and P were measured by standard estimation procedures. Microbial biomass carbon, biomass nitrogen and phosphorus, was estimated by method described by Vance *et al.* (1987), Pruden *et al.* (1985) and Brookes *et al.* (1982). Soil microbial carbon (MBC) and soil microbial nitrogen (MBN) were determined by 24 h chloroform fumigation followed by extraction with 0.5 M potassium sulfate (K<sub>2</sub>SO<sub>4</sub>). The amount of CO<sub>2</sub> evolved was determined by subtracting the fumigated soil from that of unfumigated one. For microbial biomass P analysis, 5 g of field-moist soil was weighed into a crucible and fumigated in a desiccator with 50 ml of alcohol-free chloroform for 5 days. Hundred millilitres of sodium bicarbonate extracting solution was used to shake both fumigated and unfumigated soil samples for 30 minutes. Soil samples not fumigated were equilibrated simultaneously with a series of P containing standard

solutions as correction for adsorption of P during fumigation. The amount of chloroform released P was determined according to the relationship between P added (from standard solutions or microbial lysis) and P extracted.

## Results and Discussion

### Soil chemical properties

The chemical properties of soil such as pH, organic C, total N, available N, total P, available P, total K, total Zn are influenced by various short and long term crop management practices such as crop rotations, organic manuring and chemical fertilizers.

Soil chemical properties of wheat-guar rotation system at research farm Bawal after ten years of application of organic amendments are presented in Table 1. The soil pH ranged from 7.05 to 7.62. The pH of soil receiving vermicompost (VC) was higher as compared to other treatments. The electrical conductivity (EC) of soils ranged from 0.12 to 0.29 dS/m. No significant difference in pH and EC was observed in soils receiving different organic amendments. Soil organic C was higher in treatments receiving organic amendments and a combination of organic manures and inorganic fertilizers as compared to soils receiving inorganic fertilizers alone. Organic C increased from 0.163 to 0.270%. The highest amount of organic C was observed in soils which received VC @ 15t /ha and least organic C was observed in unfertilized (control) soils. Organic C was 3.1 % higher in soil receiving VC than the soil receiving (Farm Yard Manure) FYM @15t /ha. Appireddy *et al.* (2008) monitored the comparative performance of five varieties of bell pepper (*Capsicum annuum* L.) and observed changes in soil properties under organic and integrated nutrient management (INM) systems. They reported higher soil pH and organic carbon in

the plots treated with organic manures alone as compared to INM.

There was a significant difference in total N content of soils receiving different organic amendments. The total N increased from 0.012 to 0.076% and was 4.1% more in treatment which received VC @15t /ha than VC@10t/ha+100% RF (Recommended Fertilizer). Gharib *et al.* (2008) studied the effect of compost and biofertilizers on the growth, yield and oil constituents of marjoram (*Majorana hortensis* L.). The soil pH was found to be 7.10. Organic carbon and total nitrogen were 0.29 and 0.01%, respectively.

The available N increased from 11 to 29 mg/kg and was highest in treatment with VC@15t /ha. Application of fertilizers and manures resulted in significant improvement in the buildup of the available N content of subsurface soil. So, it is clear that application of organic manures in conjunction with chemical fertilizers increased the available N in soil is attributed to the increase in total SOC that might have been partially due to a slow release of N from straw and manure as suggested by Gami *et al.*, (2001) and Bhandari *et al.*, (2002). Total P and available P were significantly higher in soils receiving VC, FYM, combination of FYM and inorganic fertilizers. The total P and available P were 152 and 8.0 mg/kg soil, respectively. Amount of total K varied from 1530 to 2019 and total Zn from 126 to 175 mg/kg soil. Available P and K also have been shown to increase in soils under organic management systems (Clark *et al.*, 1998). Sangshetty and Babalad (2011) studied the effect of different sources of organic manures on soil chemical properties under organic cotton production system on the nutrient uptake, nutrient status of the soil after the harvest of cotton genotypes and reported that soil available N, P and K were significantly higher with RDF + FYM (360.50, 60.50 and 495.33 kg NPK/ha,

respectively). Mahmood *et al.* (2017) studied the effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties

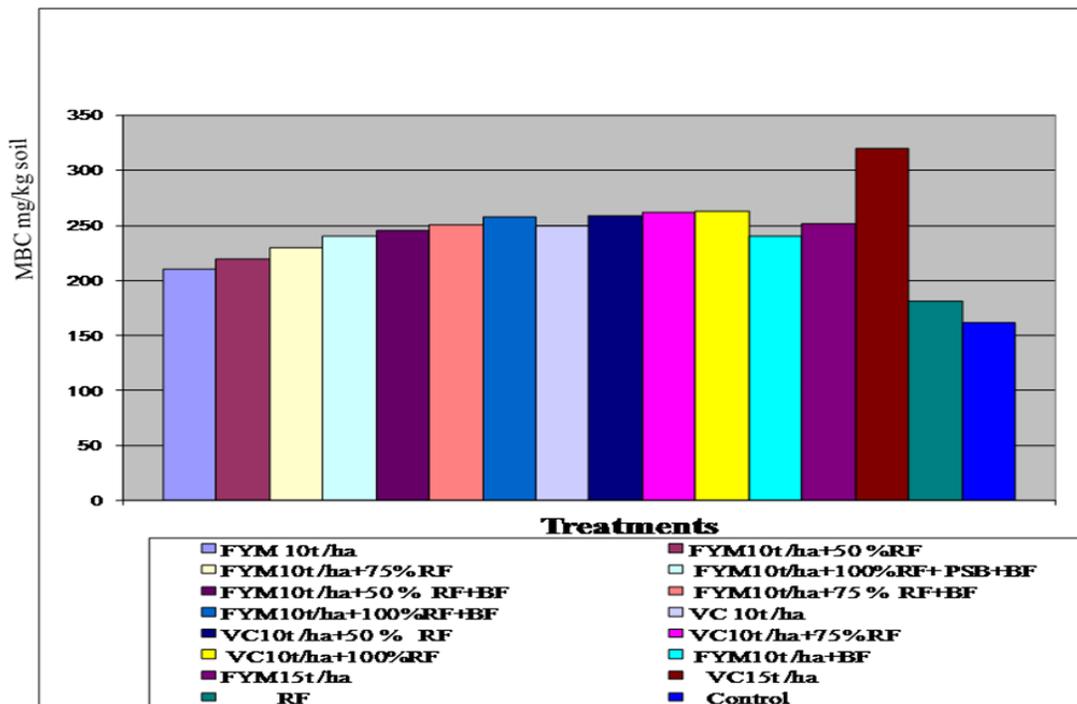
**Carbon mineralization rate**

The evolution of CO<sub>2</sub> from soil is a total sum of respiration and carbon mineralization by soil biota and is a sensitive indicator of soil organic matter turnover.

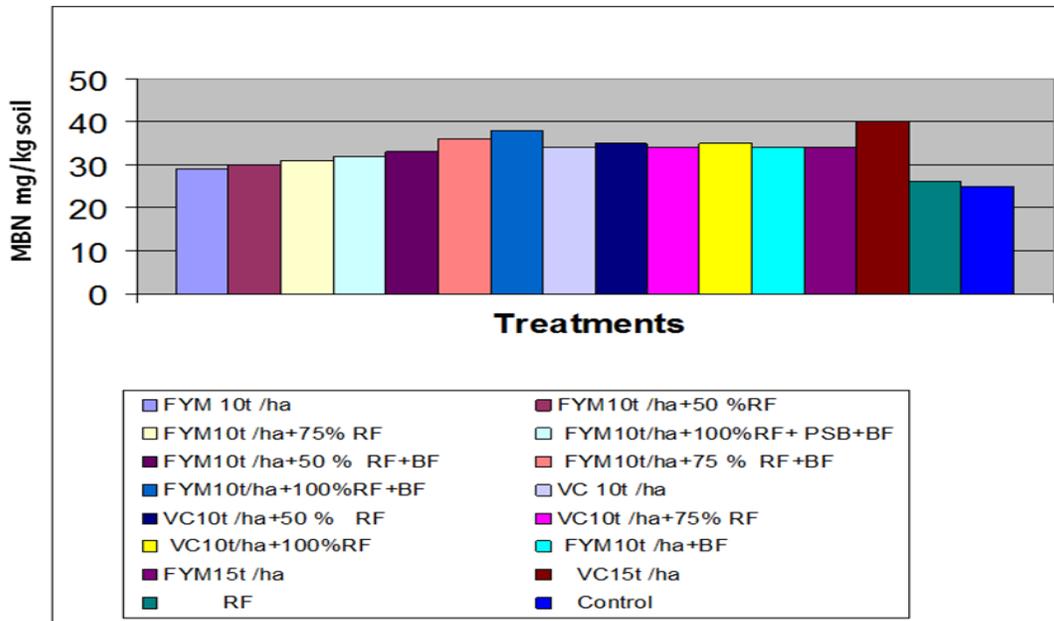
Carbon mineralization rate as affected by different organic amendments in wheat-guar rotation system at Bawal has been compiled in Table 2. The amount of CO<sub>2</sub> evolution was higher in all the treatments during first week of incubation and it decreased with further incubation with least amount of CO<sub>2</sub> evolved in fourth week of incubation. The rate of

carbon mineralized ranged from 3.3 to 6.8 mg/kg soil/28 day. The C mineralization rate was lower in inorganically fertilized soils compared to soils receiving organic manures and a combination of organic manures and inorganic fertilizers. The highest C mineralization rate was observed in soils receiving VC @ 15t /ha and lowest in soils receiving recommended dose of fertilizers. Sharma *et al.* (2011) found that there was a significant increase in carbon mineralization, soil microbial biomass carbon and soil dehydrogenase activity with the organic amendment. The maximum increase in soil microbial activities were found when sole organic source (farm yard manure (50%) + biofertilizer (25%) + green manure (25%)) has been used in combination with the conservation tillage and the optimum water supply.

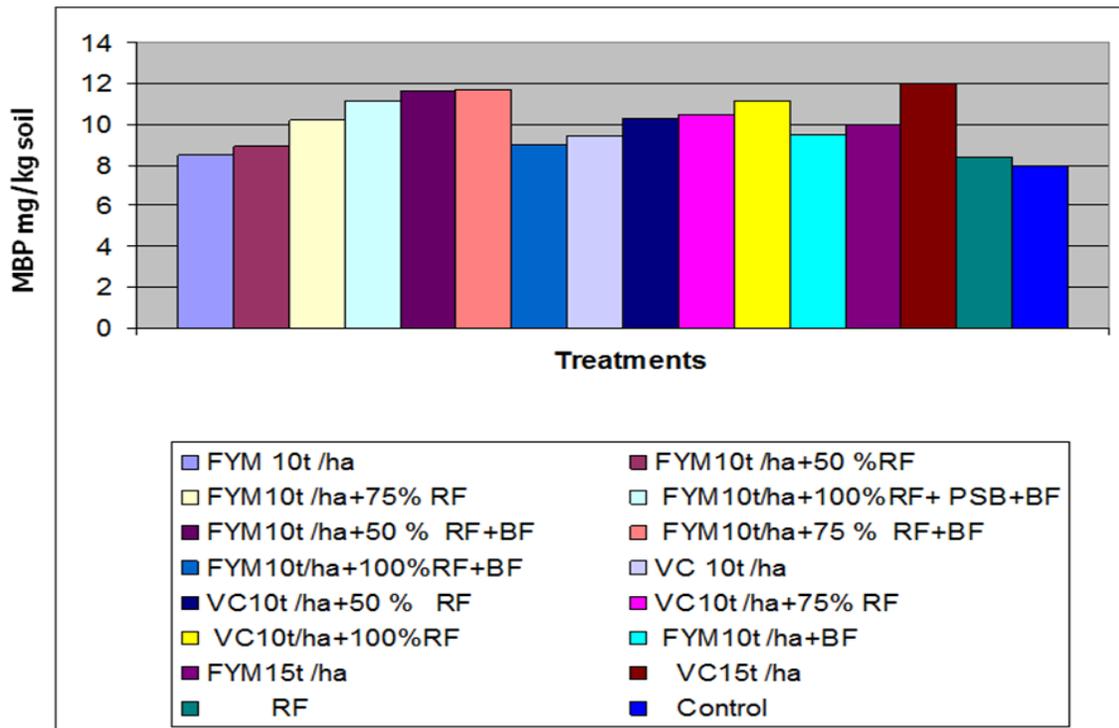
**Figure.1** Microbial biomass C as affected by different organic and inorganic amendments in wheat-guar rotation system at research farm Bawal



**Figure.2** Microbial biomass N as affected by different organic and inorganic amendments in wheat-guar rotation system at research farm Bawal



**Figure.3** Microbial biomass P as affected by different organic and inorganic amendments in wheat-guar rotation system at research farm Bawal



**Table.1** Effect of different organic and inorganic amendments on soil chemical properties in wheat-guar rotation system at research farm Bawal

Treatments	pH (1:2.5) ratio	EC (dS/m)	Organic C (%)	Available P (mg/kg soil)	Total P (mg/kg soil)	Total N (%)	Available N (mg/kg soil)	Total K (mg/kg soil)	Total Zn (mg/kg soil)
FYM 10t /ha	7.14	0.21	0.208	4.2	80.2	0.040	13	1900	129
FYM 10t /ha+50 %RF	7.19	0.23	0.225	4.7	92.8	0.042	15	1940	133
FYM 10t /ha+75% RF	7.25	0.22	0.231	4.8	99	0.044	14	1960	136
FYM10t/ha+100%RF+PSB+BF	7.31	0.26	0.235	5.0	109	0.047	17	1970	140
FYM 10t /ha+50 % RF+BF	7.32	0.25	0.238	5.2	119	0.056	17	1975	143
FYM 10t/ha+75 % RF+BF	7.35	0.26	0.239	5.5	125	0.059	20	1982	147
FYM 10t/ha+100%RF+BF	7.39	0.22	0.242	5.7	129	0.063	22	1990	151
VC 10t /ha	7.42	0.24	0.246	5.9	131	0.062	24	1992	156
VC 10t /ha+50 % RF	7.62	0.27	0.249	6.2	133	0.067	25	1996	161
VC 10t /ha+75% RF	7.56	0.29	0.251	6.6	139	0.069	26	1998	163
VC 10t/ha+100%RF	7.42	0.25	0.255	6.8	141	0.073	28	2001	166
FYM 10t /ha+BF	7.16	0.27	0.258	7.2	146	0.070	25	2010	169
FYM 15t /ha	7.23	0.23	0.262	7.9	150	0.072	27	2015	170
VC 15t /ha	7.54	0.20	0.270	8.0	152	0.076	29	2019	175
RF	7.09	0.19	0.200	6.0	141	0.018	12	1640	160
Control	7.05	0.12	0.163	3.8	70	0.012	11	1530	126
C.D.	N.S	N.S	0.014	0.03	6	0.002	1.6	105	16

**Table.2** Carbon mineralization rate as affected by different organic amendments in wheat-guar rotation system at research farm Bawal

Cumulative CO <sub>2</sub> -C evolved (mg/kg soil)					
Treatments	1 week	2 week	3 week	4 week	Mineralization rate C (mg/kg/28 days)
<b>FYM 10t /ha</b>	61.0	48.0	30.0	9.0	5.2
<b>FYM 10t /ha+50 %RF</b>	62.0	50.0	33.0	10.0	5.5
<b>FYM 10t /ha+75% RF</b>	63.5	52.0	34.0	12.0	5.7
<b>FYM 10t/ha+100%RF+PSB+BF</b>	63.8	54.6	35.0	13.0	5.9
<b>FYM 10t /ha+50 % RF+BF</b>	64.0	52.0	34.0	16.0	5.9
<b>FYM 10t/ha+75 % RF+BF</b>	64.0	54.0	37.0	15.0	6.0
<b>FYM 10t/ha+100%RF+BF</b>	63.0	49.0	43.0	19.0	6.1
<b>VC 10t /ha</b>	65.0	55.0	36.0	18.0	6.2
<b>VC 10t /ha+50 % RF</b>	64.3	55.0	40.0	18.0	6.3
<b>VC 10t /ha+75% RF</b>	62.0	51.0	34.0	32.0	6.3
<b>VC 10t/ha+100%RF</b>	65.0	56.0	39.0	20.0	6.4
<b>FYM 10t /ha+BF</b>	64.0	54.0	33.0	31.0	6.5
<b>FYM 15t /ha</b>	70.0	53.0	35.0	29.0	6.6
<b>VC 15t /ha</b>	80.0	51.0	34.0	27.0	6.8
<b>RF</b>	42.0	28.0	18.0	11.0	3.5
<b>Control</b>	42.0	27.0	16.0	10.0	3.3
<b>C.D.</b>					0.4

**Table.3** Potentially mineralizable nitrogen after 30 days of incubation as affected by different organic amendments in wheat-guar rotation system at Bawal

Treatments	Days of incubation						Mineralized N mg/kg/30 days
	0			30			
	NH <sub>4</sub> <sup>+</sup> -N	NO <sub>3</sub> <sup>-</sup> -N	Total Mineral N	NH <sub>4</sub> <sup>+</sup> -N	NO <sub>3</sub> <sup>-</sup> -N	Total Mineral N	
<b>FYM 10t /ha</b>	5.2	17.6	22.8	19.0	25.3	44.3	21.5
<b>FYM 10t /ha+50 %RF</b>	16.0	31.0	47.0	24.0	46.0	70.0	23.0
<b>FYM 10t /ha+75% RF</b>	10.0	30.0	40.0	15.0	50.0	65.0	25.0
<b>FYM 10t/ha+100%RF+ PSB+BF</b>	16.0	35.0	51.0	28.0	49.0	77.0	26.0
<b>FYM 10t /ha+50 % RF+BF</b>	12.0	36.0	48.0	29.0	46.0	69.0	27.0
<b>FYM 10t/ha+75 % RF+BF</b>	14.0	34.0	48.0	25.0	52.0	77.0	29.0
<b>FYM 10t/ha+100%RF+BF</b>	10.0	32.0	42.0	27.0	45.0	72.0	30.0
<b>VC 10t /ha</b>	12.0	30.0	42.0	35.0	40.0	75.0	33.0
<b>VC 10t /ha+50 % RF</b>	15.5	33.0	48.5	36.0	47.0	83.0	34.5
<b>VC 10t /ha+75% RF</b>	9.2	36.0	45.2	26.0	54.0	80.0	34.8
<b>VC 10t/ha+100%RF</b>	8.0	34.0	42.0	35.0	45.0	80.0	38.0
<b>FYM 10t /ha+BF</b>	10.0	36.0	46.0	37.0	49.0	86.0	40.0
<b>FYM 15t /ha</b>	11.0	37.0	48.0	38.0	50.5	88.5	40.5
<b>VC 15t /ha</b>	9.0	35.0	44.0	38.5	47.0	85.5	41.5
<b>RF</b>	4.8	11.6	16.4	12.0	24.8	36.8	20.4
<b>Control</b>	8.6	15.1	23.7	20.2	23.1	43.3	19.6
<b>C.D</b>							1.27

### Potentially mineralizable nitrogen

Potentially mineralizable nitrogen (PMN) is determined as the net flux of inorganic N from the mineralizable fraction and it indicates the balance between mineralization and immobilization by soil microbes. Nitrogen mineralization is often measured to assess the capacity of soil organic matter to supply inorganic N in the form of nitrate which is the main form of plant available nitrogen.

Potentially mineralizable nitrogen as affected by different organic amendments in wheat-guar rotation system at Bawal has been given in Table 3. Potentially mineralizable nitrogen ranged from 19.6 to 41.5 mg/kg soil and highest amount was recorded in soils receiving VC @ 15t /ha. Potentially mineralizable nitrogen was 2.5% higher in soil receiving VC @ 15t /ha than in soil receiving FYM @15t /ha and was lowest with inorganically fertilized soils. These results suggested that a larger mineralizable N pool in organic manure that might have build up from continuous use of organic amendments. The lower PMN in soils with inorganic fertilizers may be due to microbial immobilization of nutrients. Deboz *et al.* (2002) also observed that compost amendments had increased PMN by a factor of 1.8.

### Biological activity

The microbial biomass carbon (MBC) in different soils ranged from 162 to 320 mg/kg soil (Figure 1), microbial biomass nitrogen (MBN) from 25 to 40 mg/kg soil (Figure 2) and microbial biomass phosphorus (MBP) from 8.0 to 12.0 mg/kg soil (Figure 3) under wheat-guar rotation system at Bawal. Highest microbial biomass C, N, P was observed in soils receiving VC @15t /ha followed by treatments receiving a combination of FYM

and inorganic fertilizers. The biomass C/N ratio increased from 6.4 to 8.0 and C/P ratio from 20.0 to 26.6. Goyal *et al.* (2000) studied microbial biomass C, N and nitrifying activities along with other physicochemical parameters of soil such as organic matter, mineralizable carbon and nitrogen in a 100 cm deep andosol profile in an arable field in Matsudo city, central Japan. Microbial biomass C and P were highest at 15-20 cm depth, whereas microbial biomass C and N were highest i.e 202 and 26 mg kg soil, respectively at 15-20 cm, and these parameters showed a tendency to decrease with depth. Similar observations have also been reported by Boggs *et al.* (2000) who found highest microbial biomass C in soils treated with organic manures followed by inorganic fertilizers.

Leite *et al.* (2009) also found that soil microbial biomass was significantly greater in organic management regimes as compared to conventional management. The long-term studies of Gong *et al.* (2009) and Kong *et al.* (2011) also showed that application of organic matter to soil resulted in an increase in microbial biomass and activities.

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