

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.701.160>

## Effect of INM on Soil Microbial Biomass Carbon and Enzyme Activity under Soybean of a *Typic haplustepts*

S.N. Verma<sup>\*</sup>, Mahendra Sharma and Urmila

Department of Agricultural Chemistry and Soil Science, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur-313001, India

*\*Corresponding author*

### ABSTRACT

#### Keywords

INM, Microbial biomass carbon, Enzymatic activity, Soybean

#### Article Info

##### Accepted:

12 December 2017

##### Available Online:

10 January 2018

A field experiment was conducted to study the effect of integrated nutrient management on soil microbial biomass carbon and enzyme activity under soybean of a *Typic Haplustepts* was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during consecutive *Kharif* seasons of the year 2014 and 2015. Among the integrated nutrient management practices, the microbial biomass carbon and enzymatic activity of soil found decreasing order from flowering to at harvesting stage as well as the depth 0-15 and 15-30 cm during both the years of experiment and pooled basis. The microbial biomass carbon and enzymatic activity *viz.*, dehydrogenase, phosphate and urease activity maximum obtaining by 75 % NPK + 25 % N through vermicompost + *Rhizobium* +PSB at flowering and harvesting stage as well as both the depth 0-15 and 15-30 cm over the 100% NPK treatment.

### Introduction

Modern agricultural practices have emphasized the widespread use of fertilizer and this approach has certainly increased grain yields in many countries in the last three decades.

However, long term use of chemical fertilizers also led to a decline in crop yields and soil fertility in the intensive cropping system. There is evidence that over fertilization has increased the concentration of many plant nutrients in both surface and ground water, which has created a potential health hazard.

There is need for integrated application of alternate source of nutrient for maintenance or adjustment of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity. The organic manures along with biofertilizers help in reducing the dose of inorganic fertilizer, which in turn reduces the cost of cultivation and help in improving the soil health. This is achieved, through the optimization of the benefits from all possible sources of plant nutrients in an integrated manner so as to attain maximum economic yield without deleterious effect on physico-chemical and biological properties of soil.

Bio-fertilizers are low-cost and Eco-friendly input have tremendous potential for supplying nutrients which can reduce the chemical fertilizer dose by 25-50 %. For increased 'N' supplies through bio-fertilizers, there is a need to inoculate the crops with effective environment of the soil by applying the deficient nutrients needed for biological nitrogen fixation. Soybean like most legumes performs nitrogen fixation by establishing symbiotic relationship with bacteria, *Rhizobium japonicum*. Soils containing a high microbial diversity are characteristic of a healthy soil-plant relationship, whereas those with low microbial diversity are characterized as an unhealthy soil that often hardly responds to environmental changes (Tejada *et al.*, 2011).

Soil enzymatic activities can be used as an index of soil fertility and microbial functional diversity (Nannipieri *et al.*, 2002; Maurya *et al.*, 2011) in catalyzing several biochemical reactions which are necessary for the life processes of soil micro-organisms, organic wastes decomposition, organic matter formation and nutrients cycling. Incorporation of organic manures influenced soil enzymatic activity either because of the composition of the added materials themselves or because they increased microbial activity of the soil (Deforest *et al.*, 2012). The use of organics plays a major role in maintaining soil health due to buildup of soil organic matter, beneficial microbes. Nutrients available in organic manures are released slowly, remain in the soil for longer time and are available to plants, thereby maintaining soil fertility (Belay *et al.*, 2001).

### **Materials and Methods**

The experiment was conducted at the Instructional Farm, Rajasthan College of Agriculture, Udaipur during *Kharif* 2014 and 2015. The site is situated at South-Eastern part

of Rajasthan at an altitude of 579.5 m above mean sea level, at 24°35' N latitude and 74°42' E longitude. The mean annual rainfall of the region is 637 mm, most of which is contributed by south west monsoon from July to September. Maximum and minimum temperatures ranged between 25.9 to 33.7 °C and 7.7 to 22.4 °C, respectively during *kharif*. The soil of experimental site are well drained, clayey with moderate erosion and classified as clayey mixed, Hyperthermic (Calcareous) *Typic haplustepts* containing clay loam in texture, neutral to alkaline in reaction (7.55), medium in available nitrogen (231.30 kg ha<sup>-1</sup>) and phosphorus (16.00 kg ha<sup>-1</sup>), high in available potassium (309.20 kg ha<sup>-1</sup>), Microbial biomass carbon (168 mg kg<sup>-1</sup>), Dehydrogenase activity (9.60 µgTPFg<sup>-1</sup>soil), Phosphate activity (13.80 µg g<sup>-1</sup> h<sup>-1</sup>) and Urease activity (99.20 µg g<sup>-1</sup> soil h<sup>-1</sup>). The experiment was laid out in a Randomized Block Design (RBD) with four replications with soybean cultivar JS-336. Treatments were randomly distributed within the blocks as follows: 100 % NPK (T<sub>1</sub>), 100 % NPK + *Rhizobium* + PSB (T<sub>2</sub>), 75 % NPK + 25 % N through FYM (T<sub>3</sub>), 75 % NPK + 25 % N through FYM + *Rhizobium* + PSB (T<sub>4</sub>), 75 % NPK + 25 % N through VC (T<sub>5</sub>), 75 % NPK + 25 % N through VC + *Rhizobium* + PSB (T<sub>6</sub>), 50 % NPK + 50 % N through FYM (T<sub>7</sub>), 50 % NPK + 50 % N through FYM + *Rhizobium* + PSB (T<sub>8</sub>), 50 % NPK + 50 % N through VC (T<sub>9</sub>), 50 % NPK + 50 % N through VC + *Rhizobium* + PSB (T<sub>10</sub>), 50 % NPK + 25 % N through VC + 25 % N through FYM (T<sub>11</sub>), 50 % NPK + 25 % N through VC + 25 % N through FYM + *Rhizobium* + PSB (T<sub>12</sub>). Doses of P<sub>2</sub>O<sub>5</sub> (SSP) were applied before the sowing and thoroughly mixed in soil. The seeds were inoculated with and phosphate solubilizing bacteria (PSB) at 200 g each for 10 kg of seeds just before dibbling as per treatments. After inoculation seeds were dried in the shade for about one hour and then used for dibbling. The Microbial biomass carbon of

soil was determined by Standard serial dilution and plate count method (Vance *et al.*, 1987), Dehydrogenase activity by colorimetric determination of TPF (Casida *et al.*, 1964), Phosphate activity by modified universal buffer (MUB) method and Urease activity by Non-buffer method (Tabatabai and Bremner, 1969).

## Results and Discussion

### Soil microbial biomass carbon

It is evident from the data presented in (Table 1) revealed that the microbial biomass carbon (MBC) value in soil decreased from flowering to at harvesting stage as well as depths 0-15 and 15-30 cm.

The maximum microbial biomass carbon at 0-15 and 15-30 cm depth (287, 289, 288 and 233, 236, 235 mg kg<sup>-1</sup>) at flowering stage and (244, 250, 247 and 195, 237, 216 mg kg<sup>-1</sup>) at harvest stage of soybean were found in treatment receiving 75 % NPK + 25 % N through vermicompost + *Rhizobium* + PSB (T<sub>6</sub>) respectively, it is significantly superior over rest of the treatments and statically at par with the in the treatment obtaining by 75 and 50% NPK + 25 and 50% N through either vermicompost or FYM.

The minimum microbial biomass carbon recorded under application of inorganic treatment alone 100% NPK (T<sub>1</sub>) at both the depths. Use of FYM and vermicompost alone or in combination with chemical fertilizers significantly increased the soil microbial biomass carbon (SMB-C). It might be due to the supply of additional mineralizable and readily hydrolysable C due to organic manure application resulted in higher microbial activity and in return higher microbial biomass carbon. Wright and Hons (2005), Thakare and Bhojyar (2012) and Datt *et al.*, (2013) have also reported similar findings.

### Enzymatic activity (Dehydrogenase, phosphate and urease) in soil

#### Dehydrogenase activity

Data related to dehydrogenase activity under the influence of integrated nutrient management practices are presented in (Table 2) emphasized that the application of different organic manures and inorganic fertilizers were found significant with respect to dehydrogenase activity during both the years and pooled basis.

The dehydrogenase activity in soil was found in decreasing trend at flowering to harvest stage as well as depths *i.e.* 0-15 and 15-30 cm during both the years and pooled basis.

The highest dehydrogenase activity  $\mu\text{gTPFg}^{-1}\text{soil}$  produced at flowering and harvest of soybean was found (37.96, 39.09, 38.52 and 27.20, 27.48, 27.34  $\mu\text{gTPFg}^{-1}\text{soil}$ ) under application of 75 % NPK + 25 % N through vermicompost + *Rhizobium* + PSB (T<sub>6</sub>) which was significantly superior over rest of the treatments and statistically at par with the 75 % NPK + 25 % N through vermicompost (T<sub>5</sub>) and 50 % NPK + 25 % N through VC + 25 % N through FYM + *Rhizobium* + PSB (T<sub>12</sub>), respectively during both the years and pooled basis.

The inorganic fertilizer treatment alone *i.e.*, 100% NPK failed to increase dehydrogenase activity in the soil.

The lower activity of soil enzyme activity in recommended dose of fertilizers as compared to other treatments with manures may be attributed to the lack of sufficient substrate *i.e.*, organic carbon which acts as energy source for proliferating microbial population. Similar results were also reported by Lizarazo *et al.*, (2005), Ramesh *et al.*, (2008) and Aher *et al.*, (2015).

**Table.1** Effect of INM on microbial biomass carbon (mg kg<sup>-1</sup>) at flowering and harvest stage of soybean at different depths

Treatments	At flowering stage						At harvest stage					
	(0-15 cm)			(15-30 cm)			(0-15 cm)			(15-30 cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	173	164	169	110	119	115	134	128	131	101	100	100
T <sub>2</sub>	172	181	177	112	127	119	136	142	139	105	109	107
T <sub>3</sub>	203	212	208	133	158	145	167	173	170	120	140	130
T <sub>4</sub>	257	266	262	157	182	169	191	197	194	122	165	143
T <sub>5</sub>	283	288	286	232	233	233	241	247	244	192	234	213
T <sub>6</sub>	287	289	288	233	236	235	244	250	247	195	237	216
T <sub>7</sub>	280	283	282	224	225	224	236	240	238	131	173	152
T <sub>8</sub>	280	283	282	225	225	225	236	240	238	142	187	165
T <sub>9</sub>	281	283	283	225	226	225	237	239	239	149	191	170
T <sub>10</sub>	282	283	282	226	227	227	236	242	239	173	215	194
T <sub>11</sub>	283	284	283	227	230	229	238	244	241	182	224	203
T <sub>12</sub>	284	286	285	228	231	230	242	248	245	187	229	208
SEM±	5.45	2.65	3.03	2.76	5.25	2.96	4.32	4.74	3.21	3.02	3.54	2.32
CD at 5 %	15.68	7.64	8.56	7.94	15.09	8.37	12.45	13.65	9.06	8.7	10.19	6.57

**Table.2** Effect of INM on dehydrogenase activity (µgTPFg<sup>-1</sup> soil) at flowering and harvest stage of soybean at different depths

Treatments	At flowering stage						At harvest stage					
	(0-15 cm)			(15-30 cm)			(0-15 cm)			(15-30 cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	12.70	16.06	14.38	10.10	12.01	11.06	11.70	11.86	11.78	10.55	10.71	10.63
T <sub>2</sub>	15.12	19.80	17.46	10.52	15.75	13.14	12.12	14.28	13.20	11.97	12.13	12.05
T <sub>3</sub>	21.10	24.13	22.62	20.32	22.08	21.20	18.10	20.26	19.18	14.95	15.11	15.03
T <sub>4</sub>	23.20	24.48	23.84	21.21	22.43	21.82	20.20	22.36	21.28	15.21	17.05	16.13
T <sub>5</sub>	37.22	38.60	37.91	26.80	26.87	26.84	29.05	30.21	29.63	21.80	27.06	24.43
T <sub>6</sub>	37.96	39.09	38.52	27.20	27.48	27.34	29.45	30.51	29.98	22.20	27.26	24.73
T <sub>7</sub>	34.72	38.20	36.46	20.40	20.67	20.53	26.65	27.81	27.23	16.40	21.66	19.03
T <sub>8</sub>	35.45	36.01	35.73	13.30	21.40	17.35	27.46	27.62	27.54	17.21	22.47	19.84
T <sub>9</sub>	36.28	37.12	36.70	15.40	22.23	18.81	27.57	27.73	27.65	19.32	24.58	21.95
T <sub>10</sub>	37.38	38.01	37.70	23.33	24.21	23.77	27.46	27.62	27.54	20.21	25.47	22.84
T <sub>11</sub>	35.92	36.25	36.09	18.45	21.87	19.81	24.70	26.86	25.78	14.45	19.71	17.08
T <sub>12</sub>	37.48	38.38	37.93	26.68	26.83	26.76	28.83	29.49	29.16	21.66	26.84	24.25
SEM±	0.48	0.73	0.44	0.35	0.41	0.27	0.61	0.32	0.34	0.39	0.24	0.23
CD at 5 %	1.38	2.10	1.24	1.02	1.20	0.77	1.76	0.94	0.98	1.13	0.69	0.65

**Table.3** Effect of INM on phosphate activity ( $\mu\text{g g}^{-1} \text{h}^{-1}$ ) at flowering and harvest stage of soybean at different depths

Treatments	At flowering stage						At harvest stage					
	(0-15 cm)			(15-30 cm)			(0-15 cm)			(15-30 cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	30.78	32.14	31.46	21.53	25.87	23.70	21.23	24.89	23.06	18.34	21.73	20.04
T <sub>2</sub>	31.88	32.24	32.06	22.63	26.97	24.80	22.33	25.99	24.16	19.44	22.83	21.14
T <sub>3</sub>	24.30	26.66	25.48	15.05	19.39	17.22	14.75	18.41	16.58	10.99	15.25	13.12
T <sub>4</sub>	30.42	32.78	31.60	21.17	25.51	23.34	20.87	24.53	22.70	17.98	21.37	19.68
T <sub>5</sub>	32.42	33.78	33.10	22.66	27.14	24.90	23.87	25.53	24.70	22.98	23.07	23.03
T <sub>6</sub>	32.56	33.92	33.24	23.11	28.05	25.58	24.01	25.77	24.89	23.12	23.61	23.37
T <sub>7</sub>	20.56	22.92	21.74	14.89	15.65	15.27	11.01	14.67	12.84	10.25	11.51	10.88
T <sub>8</sub>	28.98	31.34	30.16	19.73	24.07	21.90	19.43	23.09	21.26	15.67	19.93	17.80
T <sub>9</sub>	28.63	30.99	29.81	19.38	23.78	21.58	19.08	22.74	20.91	15.32	19.58	17.45
T <sub>10</sub>	29.95	32.31	31.04	20.70	25.03	22.87	20.40	24.06	22.23	17.51	20.90	19.21
T <sub>11</sub>	29.22	31.58	30.40	19.97	24.31	22.14	19.67	23.33	21.50	16.78	20.17	18.48
T <sub>12</sub>	31.98	32.34	32.16	22.53	27.07	24.80	23.43	25.09	24.26	22.84	23.03	22.94
SEM $\pm$	0.66	0.51	0.42	0.36	0.55	0.33	0.35	0.25	0.21	0.28	0.22	0.18
CD at 5 %	1.89	1.48	1.18	1.03	1.59	0.93	1.01	0.73	0.66	0.80	0.64	0.50

**Table.4** Effect of INM on urease activity ( $\mu\text{g g}^{-1} \text{soil h}^{-1}$ ) at flowering and harvest stage of soybean at different depths

Treatments	At flowering stage						At harvest stage					
	(0-15 cm)			(15-30 cm)			(0-15 cm)			(15-30 cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T <sub>1</sub>	128.70	129.12	128.91	107.82	112.23	110.03	92.70	96.20	94.45	75.24	80.00	77.62
T <sub>2</sub>	130.00	130.42	130.21	108.12	111.53	109.83	93.00	96.50	94.75	76.54	81.30	78.92
T <sub>3</sub>	114.30	114.67	114.49	100.42	100.84	100.63	87.30	91.80	89.55	65.84	70.60	68.22
T <sub>4</sub>	116.20	116.91	116.56	100.32	100.73	100.53	89.20	93.70	91.45	66.74	71.50	69.12
T <sub>5</sub>	136.00	136.65	136.33	110.12	113.57	111.85	96.00	100.50	98.25	82.54	87.30	84.92
T <sub>6</sub>	136.80	137.25	137.03	111.92	114.24	113.08	97.80	102.30	100.05	84.34	89.10	86.72
T <sub>7</sub>	108.70	109.43	109.07	101.82	104.23	103.06	81.70	86.20	83.95	60.24	65.00	62.62
T <sub>8</sub>	110.30	111.11	110.70	103.42	107.83	105.63	83.30	87.80	85.55	61.84	66.60	64.22
T <sub>9</sub>	134.70	135.14	134.92	106.82	108.23	107.53	95.70	97.20	96.45	81.24	86.00	83.62
T <sub>10</sub>	132.40	132.83	132.62	104.52	105.93	105.23	96.00	98.50	97.25	78.94	83.71	81.32
T <sub>11</sub>	129.30	129.72	129.51	105.42	106.83	106.13	92.30	96.80	94.55	75.84	80.60	74.22
T <sub>12</sub>	135.00	135.44	135.22	110.02	113.53	111.78	96.40	99.90	98.15	82.49	86.99	84.74
SEM $\pm$	1.43	3.06	1.69	1.42	1.47	1.02	1.25	1.45	0.96	1.13	1.34	0.88
CD at 5 %	4.12	8.81	4.77	3.10	3.23	2.65	3.60	4.16	2.70	3.26	3.87	2.48

### Phosphate activity

Data presented in (Table 3) application of nutrients either through inorganic or in combination with organic sources and biofertilizers significantly influenced phosphate activity at 0-15 and 15-30 cm depth during both the years of experiment and pooled basis. The maximum phosphate activity at 0-15 and 15-30 cm depth (32.56, 33.92, 33.24 and 23.11, 28.05, 25.58  $\mu\text{g g}^{-1} \text{h}^{-1}$ ) at flowering and (24.01, 25.77, 24.89 and 23.12, 23.61, 23.37  $\mu\text{g g}^{-1} \text{h}^{-1}$ ) at harvest were found in treatment obtaining by 75 % NPK + 25 % N through vermicompost + *Rhizobium* + PSB (T<sub>6</sub>) which was significantly superior over rest of the treatments (Table 3). Enzyme activity decreased from flowering to harvest stage of crop. The minimum phosphate activity at 0-15 and 15-30 cm depths were observed under application of 50 % NPK + 50 % N through FYM (T<sub>7</sub>). Soil phosphatase activity are the most important in plant nutrition, these are involved in mineralization of organically bound phosphorus to inorganic phosphorus compounds in soil. The sharp increase in the enzyme activities at flowering which coincides with the active growth stage of the crop, enhanced root activity and the release of extracellular enzymes like urease and phosphatase into soil solutions during the active growth phase which resulted in higher rate of mineralization of nutrients in the soil. The results were in conformity with the findings of Jagadeesh (2000), Datt *et al.*, (2013) and Aher *et al.*, (2015).

### Urease activity

An assessment of data presented in (Table 4) showed that urease activity in soil affected due to enriched fertility of soil via application of nutrients either through inorganic or in combination with organic sources to soybean crop during both the years of experiment and pooled basis as well as both depths.

Significantly highest urease activity in soil (136.80, 137.25 and 137.03  $\mu\text{g g}^{-1} \text{soil h}^{-1}$ ) at 0-15 cm and (111.92, 114.24 and 113.08  $\mu\text{g g}^{-1} \text{soil h}^{-1}$ ) at 15-30 cm depth at flowering and (97.80, 102.30 and 100.05  $\mu\text{g g}^{-1} \text{soil h}^{-1}$ ) at 0-15 cm and (84.34, 89.10 and 86.72  $\mu\text{g g}^{-1} \text{soil h}^{-1}$ ) at 15-30 cm depth at harvest of crop were estimated under influence of 75 % NPK + 25 % N through vermicompost + *Rhizobium* + PSB (T<sub>6</sub>) which statistically remained at par with crop receiving treatments 75 % NPK + 25 % N through vermicompost (T<sub>5</sub>) and 50 % NPK + 25 % N through VC + 25 % N through FYM + *Rhizobium* + PSB (T<sub>12</sub>) during both the years of experiment and pooled basis as well as both the depths (Table 4) over 100% NPK through chemical fertilizer. Urease is unique among soil enzymes and greatly affects the fate and performance of important fertilizer like urea. Soil urease catalysis the hydrolysis of urea to carbon dioxide and  $\text{NH}_4^+$  a form assimilable by plants. The results of investigation corroborate the findings of Suryanarayan Reddy (2002), Raju *et al.*, (2013) and Datt *et al.*, (2013).

From the above study it can be concluded that the application of chemical fertilizer with organic manure and biofertilizers with integration *viz.*, 75 % NPK through chemical fertilizer + 25 % other rest of N through vermicompost and seeds should be dual inoculated with *Rhizobium* + PSB significantly improved soil microbial biomass carbon and enzymatic activity in soil. Thus the objective of maximizing organic carbon content and enzymatic activity for sustaining soil fertility for long term basis and maintain soil health can be furnished by a balanced use of inorganic fertilizers conjunctively with biological and organic manure.

### References

- Aher, S. B., Lakaria, B. L., Kareshananda, S., Singh, A. B., Ramana, S., Ramesh K. and Thakur, J. K. 2015. Effect of organic farming practices on

- soil and performance of soybean (*Glycine max*) under semi-arid tropical conditions in Central India. *Journal of Applied and Natural Science*, 7(1): 67– 71.
- Belay, A., Classens, A. S., Wehner, F. C., De Beer, J. M. 2001. Influence of residual manure on selected nutrient elements and microbial composition of soil under long-term crop rotation. *South African Journal of Plant and Soil*, 18: 1-6.
- Casida, I. E., Klein, D. A. and Santore, T. 1964. Measurement of dehydrogenase activity by incubating the soil with TTC method. *Soil Science*, 98: 373.
- Datt, N., Dubey, Y. P. and Chaudhary, R. 2013. Studies on impact of organic, inorganic and integrated use of nutrients on symbiotic parameters, yield, and quality of French-bean (*Phaseolus vulgaris* L.) vis-à-vis soil properties of an acid Alfisol. *African Journal of Agricultural Research*, 8 (22): 2645-2654.
- Deforest, J. L., Smemo, K. A., Burke, D. J., Elliott, H. L. and Becker, J. C. 2012. Soil microbial responses to elevated phosphorus and pH in acidic temperate deciduous forests. *Biogeochemistry*, 109:189-202.
- Jagadeesh, B. R. 2000. Chemical and biochemical properties of soil subjected to permanent manurial and cropping schedule. *Journal of the Indian Society Soil Science*, 48 (2): 283-286.
- Lizarazo, M. L., Jorda, J. P. S. and Juarez, M. 2005. Effect of humic amendments on inorganic N, dehydrogenase and alkaline phosphates activities of a Mediterranean soil. *Biol. Fert. Soil*, 42: 172-177.
- Maurya, B. R., Vimal, S. and Dhyani, P. P. 2011. Enzymatic activities and microbial population in agri-soils of Almora district of central Himalaya as influenced by altitudes. *International Journal of Soil Science*, 6: 238-248.
- Nannipieri, P., Kandeler, E., and Ruggiero P. 2002. Enzyme activities and microbial and biochemical processes in soil. In: Burns, RG and Dick RP (Eds.), *Enzymes in the Environment: Activity, Ecology and Applications*. Marcel Dekker, New York, 1-33.
- Raju, B., Chandrasekhar, P. Rao, A., Reddy, P. K. and Padmavathi, P. 2013. Effect of Various INM Practices on Yield, Urease and Dehydrogenase activity in Safflower. *Helix Vol. 6*: 405 – 408.
- Ramesh P., Panwar, N. R., Singh, A. B. and Ramana, S. 2008. Effect of organic manure on productivity, soil fertility and economics of soybean (*Glycine max*) – durum wheat (*Triticum durum*) cropping system under organic farming in vertisols. *Indian Journal of Agriculture Science*, 78 (12): 1033-1037.
- Suryanarayan Reddy, M. 2002. Relationship between organic carbon and soil enzymes. *Journal of Research ANGRAU*, 30 (2): 143-146.
- Tabatabai M. A. and Bremner, J. M. 1969. Use of p-nitrophenol for assess of soil phosphatase activity. *Soil Biology and Biochemistry*, 1: 301-307.
- Tejada M, Benítez C, Gómez I, Parrado J. 2011. Use of bio stimulants on soil restoration: Effects on soil biochemical properties and microbial community. *Applied Soil Ecology*, 49: 11-17.
- Thakare, R. and Bhoyar, S. 2012. Dynamics of soil biological fertility as influenced by organic and inorganic inputs under soybean in vertisols. *Asian Journal of Soil Science*, 7 (1): 18-22.
- Vance, E. D., Brookes, P. C. and Jenkinson, D. S. 1987. An extraction method for measuring soil microbial biomass carbon. *Soil Biology and Biochemistry*, 19: 703- 707.
- Wright, A. L. and Hons, F. M. 2005. Soil carbon and nitrogen storage in aggregates from different tillage and crop regimes. *Soil Science Society of America Journal*, 69: 141-147.

#### How to cite this article:

Verma, S.N., Mahendra Sharma and Urmila. 2018. Effect of INM on Soil Microbial Biomass Carbon and Enzyme Activity under Soybean of a *Typic haplustepts*. *Int.J.Curr.Microbiol.App.Sci*. 7(01): 1312-1318. doi: <https://doi.org/10.20546/ijcmas.2018.701.160>