JOURNAL OF PURE AND APPLIED MICROBIOLOGY, March 2016. Vol. **10**(1), p. 787-793

# Effect of Integrated Nutrient Management on Yield and Active Pools of Soil Organic Carbon under Groundnut-Wheat System of Typic Haplustept in Long term Fertilizer Experiment

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https://doi.org/10.22207/JPAM.10.1.105

(Received: 10 January 2016; accepted: 20 February 2016)

**The effect of integrated nutrient management (INM) on active pools of soil organic carbon (SOC) under groundnut-wheat cropping sequence of a Haplustepts soil, was studied in a long-term field experiment initiated during kharif1999 at Junagadh, Gujarat. Effect of varying doses of N, NP, NPK with FYM, Zn, S and *Rhizobium* on active pools of SOC *viz*., soil microbial biomass carbon, soil microbial biomass nitrogen,soil microbial biomass phosphorus; water soluble carbon; water soluble carbohydrates and dehydrogenase activity after 12$^{th}$ year of groundnut-wheat crop sequence was studied. Application of 50% NPK + FYM @ 10 t ha$^{-1}$to groundnut and 100% NPK to wheat significantly increased the microbial biomass carbon (SMB-C), soil microbial biomass nitrogen (SMB-N), soil microbial biomass phosphorus (SMB-P) water soluble carbon (WS-OC) water soluble carbohydrates (WS-CHO) and dehydrogenase activity (DHA). Integrated use of FYM with chemical fertilizers or use of FYM alone exerted significant effect on the active pools of soil organic carbon.**

**Keywords:** Integrated Nutrient Management, active pools, soil organic carbon and soil organic matter..

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A key factor in maintaining sustainable production in the tropical soils is improvement in the soil organic matter (SOM) content. In the tropics, SOM determines the fertility and productivity of soils, especially when these are highly weathered, with small or no reserves of nutrients and are managed without any external inputs of organic or inorganic fertilizers (Feller and Beare, 1997).

Sustainable agriculture involves successful management of resources for increase agricultural production to satisfy changing human needs, while maintaining or enhancing the environment and natural resources (FAO, 1989). Integrated nutrient management (INM) or integrated nutrient supply (INS) system aims at achieving efficient use of chemical fertilizers in conjunction with organic manures. Long term fertilizer experiments involving intensive cereal based cropping systems reveal a declining trend in productivity even with the application of recommended levels of N, P and K fertilizers (Mahajan *et al*., 2002; Mahajan and Sharma, 2005). The crop productivity increases from the combined application of chemical fertilizers and organic manures. Such combination contributed to the improvement of physical, chemical and biological properties and soil organic matter and nutrient status. In sustainable agriculture the organic matter is a single property which influences soil fertility, soil formation, soil biology, physical and chemical properties, organo-chemical, biotic and hydrothermal characteristics of a soil (Katyal, 2000). The nature, content, composition and behaviour of organic matter in soil are fundamentally important for growth

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of crop under diverse climatic conditions.Crop production; nutrient uptake and physico-chemical, chemical and microbiological properties of soil an be potentially improved by continuous application of chemical fertilizers alone or in combination with FYM. Manure addition affects enzyme activities, microbial biomass and carbon mineralization as compared to inorganic fertilization or unamended control. Therefore, present study was carried out to study the effect of INM on active pools of SOM under groundnut-wheat cropping sequence of a *Typic Haplustept*.

## MATERIALS AND METHODS

A long term field experiment on integrated nutrient management under groundnut – wheat sequence was initiated in the year 1999-2000 at the Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. The climate of the experimental site is sub-tropical. The maximum and minimum temperatures are 36.8 and 22.5 $^0$C. The mean annual rainfall of the region varies from 650 to 750 mm. The soil of the experimental field is clayey in texture and medium black calcareous in nature, having field capacity and permanent wilting point 41 % and 20%, respectively. Organic carbon is 0.65 %, $CaCO_3$ 48 %, Available N, $P_2O_5$ and $K_2O$ is 106.06, 28.16 and 272.00 kg ha$^{-1}$ respectively. The cation exchange capacity of the soil is 27.30 cmol ($P^+$) kg$^{-1}$. The experiment consisted of 12 treatments replicated four times in a randomized block design. These are: $T_1$ - 50 % NPK of recommended dose to Groundnut-Wheat sequence; $T_2$- 100% NPK of recommended dose to Groundnut-Wheat sequence; $T_3$- 150% NPK of recommended dose to Groundnut-Wheat sequence; $T_4$ - 100% NPK+ $ZnSO_4$ @ 50 kg ha$^{-1}$ once in three year to groundnut only; $T_5$ - NPK as per soil test; $T_6$ -100% NP of recommended dose to Groundnut-Wheat sequence; $T_7$ - 100% N of recommended dose to Groundnut-Wheat sequence; $T_8$ - 50% NPK + FYM @ 10 t ha$^{-1}$ to Groundnut and 100% NPK to wheat; $T_9$ - Only FYM @ 25 t ha$^{-1}$ to Groundnut only; $T_{10}$ - 50% NPK + Rhizobium + PSM to groundnut and 100 % NPK to wheat; $T_{11}$ - 100% NPK of recommended dose to Groundnut-Wheat sequence. (P as SSP); $T_{12}$ - Control; The recommended dose of fertilizers for groundnut 12.5 kg/ha N, 25 kg/ha P, and for wheat 120* kg/ha N, 60 kg ha$^{-1}$ $P_2O_5$ and 60* kg/ha $K_2O$; (*50% as basal dose and 50% at 21 DAS.). The fertilizers used were Urea, Diammonium phosphate, and muriate of potash, ($T_{11:}$ P source is single super phosphate) and zinc sulphate. Groundnut GG-20 and wheat GW- 496 were raised as test crop in the cropping system. At the harvest of wheat crop of year (2012), soil samples (0-15 cm) were drawn to assess the organic carbon by rapid titration method (Walkley and Black 1936), soil microbial biomass carbon by chloroform-fumigation incubation method (Jenkinson and Powlson, 1976; Jenkinson and Ladd, 1981), soil microbial biomass nitrogen by chloroform-fumigation extraction method (Brookes *et al,* 1985),soil microbial biomass phosphorus bychloro form-fumigation incubation method (Brookes *et al.,* 1982; Srivastava and Singh, 1988b),water soluble carbon by acid extraction method (Meloon and Sommers, 1996), water soluble carbohydrate by hydrolytic extraction with $H_2S0_4$ (Chebire and Mundie, 1966) and soil dehydrogenase activity by anthrone extraction method (Casida *et al,* 1964)

## RESULTS AND DISCUSSION

### Groundnut Yield

The pod and haulm yields of groundnut were significantly influenced by various treatments in 12 yearspan. Significantly the highest pod yield (1001 kg ha$^{-1}$) was recorded under application of 50 % NPK of RD + FYM @ 10 t ha$^{-1}$ to groundnut and 100 % NPK to wheat ($T_8$) as compared to rest of the treatments. Significantly higher haulm yield (2614 kg ha$^{-1}$) was recorded under application of 50 % NPK of RD + FYM @ 10 t ha$^{-1}$ to groundnut and 100 % NPK to wheat ($T_8$) which was statistically at par with $T_9$. The pod and haulm yield of groundnut were not influenced significantly by various treatments of experiment in 1$^{st}$ year.The combined application of organic and inorganic fertilizers in continuous manner, might have sustained the crop yield.

### Wheat Yield

The grain and straw yields of wheat were significantly affected by various fertilization treatments of LTFE in 12 years span. Significantly the highest grain and straw yield (3137 and 4055 kg ha$^{-1}$) of wheat were obtained under treatment of 50 % NPK of RD in groundnut-wheat sequence +

FYM @ 10 t ha$^{-1}$ in groundnut and 100 % NPK to wheat ($T_8$) as compared to rest of the treatments. Whereas, significantly the highest grain and straw yield (1898 and 2766 kg ha$^{-1}$) were recorded under $T_2$ (100 % N P K of RD) in first year result. The combined application of organic and inorganic fertilizers in continuous manner again sustained the crop yield of wheat.

**Table 1.** Influence of different treatments on Groundnut and wheat yield in 1$^{st}$ and 12$^{th}$ year of LTFE

| Treatment | Groundnut yield (kg ha$^{-1}$) | | | | Wheat yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Pod yield | | Haulm Yield | | Grain yield | | Straw Yield | |
| | 1$^{st}$ Year | 12 Year | 1$^{st}$ Year | 12 Year | 1$^{st}$ Year | 12 Year | 1$^{st}$ Year | 12 Year |
| **$T_1$** | 962 | 836 | 2104 | 2233 | 1589 | 2079 | 2696 | 2675 |
| **$T_2$** | 984 | 906 | 2272 | 2395 | 1908 | 2580 | 3090 | 3330 |
| **$T_3$** | 916 | 946 | 2366 | 2532 | 1878 | 2692 | 2847 | 3447 |
| $T_4$ | 1048 | 917 | 2158 | 2365 | 1806 | 2512 | 2650 | 3224 |
| $T_5$ | 929 | 894 | 2088 | 2282 | 1856 | 2560 | 2819 | 3253 |
| $T_6$ | 1101 | 787 | 2343 | 2382 | 1718 | 2448 | 2696 | 3067 |
| $T_7$ | 927 | 749 | 2048 | 2104 | 1111 | 1515 | 1921 | 2052 |
| $T_8$ | 916 | 1001 | 2292 | 2614 | 1898 | 3137 | 2766 | 4055 |
| $T_9$ | 875 | 915 | 2154 | 2458 | 1289 | 2824 | 2141 | 3356 |
| $T_{10}$ | 963 | 882 | 2247 | 2364 | 1419 | 2435 | 2581 | 3127 |
| $T_{11}$ | 1017 | 879 | 2272 | 2421 | 1608 | 2555 | 2963 | 3289 |
| $T_{12}$ | 968 | 727 | 2062 | 2059 | 1309 | 1781 | 2072 | 2202 |
| S.Em.± | 74 | 23 | 83 | 68.93 | 107 | 69 | 155 | 86 |
| C.D. at 5 % | NS | 65 | NS | 194 | 309 | 191 | 448 | 240 |
| C.V. % | 15.3 | 12.1 | 9.1 | 12.0 | 13.2 | 10.1 | 11.9 | 10.8 |
| Mean | 968 | 870 | 2201 | 2351 | 1616 | 2079 | 2696 | 2675 |

**Table 2.** Influence of different treatments onstatus of organic carbon in 1$^{st}$ and 12$^{th}$ year of LTFE soils in groundnut-wheat sequence

| Treatments | Organic Carbon(g kg$^{-1}$) | |
|---|---|---|
| | 1$^{st}$ year | 12$^{th}$ year |
| $T_1$ | 6.53 | 7.13 |
| $T_2$ | 6.00 | 7.55 |
| $T_3$ | 6.30 | 7.20 |
| $T_4$ | 6.00 | 7.25 |
| $T_5$ | 6.23 | 7.30 |
| $T_6$ | 5.40 | 7.53 |
| $T_7$ | 5.18 | 6.48 |
| $T_8$ | 6.15 | 8.40 |
| $T_9$ | 6.45 | 8.83 |
| $T_{10}$ | 6.08 | 7.03 |
| $T_{11}$ | 5.78 | 7.33 |
| $T_{12}$ | 6.15 | 6.90 |
| S.Em.± | 6.02 | 7.41 |
| C.D. at 5 % | 0.56 | 0.24 |
| C.V. % | NS | 0.69 |

## Soil organic carbon status

The soil organic carbon pool comprises of active, intermediate/slow and passive pools, which act as highly sensitive indicators of soil quality. The active pools generally contribute about 10-20% towards total SOM, whereas the stable or passive pools have 50-90% contribution towards total SOM (Brady and Weil 2002). Results presented in table 2 indicated that significantly the highest organic carbon of soil was observed under treatment receiving FYM @ 25 t ha$^{-1}$ ($T_9$) in 1$^{st}$ as well as 12$^{th}$ year and was at par with $T_8$. Significantly the highest organic carbon (8.40& 6.15 g kg$^{-1}$) was observed under treatment $T_9$ in 12$^{th}$ and 1$^{st}$ year respectively. Status of organic carbon increased to the tune of 36.51% with application of FYM @10 t ha$^{-1}$ during 12 year span. Reason attributed is the direct incorporation of organic matter, better root growth and more plant residues addition after harvest of crops. These findings are in agreement with the observation of Kumar and Yadav (2003) and Varalakshmi *et al.,* (2005). Katyal *et al.* (2003) studying the soil fertility status also found application of FYM to be highly essential for maintenance of organic carbon, reducing the pH and increase CEC of soil. Such improvements in chemical properties have also been observed in long term fertilizer experiments.

**Active pools of soil organic carbon**

**Soil microbial biomass carbon**

The soil microbial biomass acts as the transformation agent of the organic matter in the soil. As such, the biomass is both a source and sink of the carbon, nitrogen and phosphorus contained in the organic matter. It is the centre of majority of biological activity in soil and therefore, the knowledge of the microbial biomass carbon is essential. The soil microbial biomass carbon content of soils of different treatments under the LTFE are presented in Table 3. Significantly higher SMBC (316.5 and 243 ppm) was observed under treatment $T_8$ (50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t $ha^{-1}$ to G'nut and 100 % N P K to Wheat) which was at par with $T_9$ (FYM @25 t $ha^{-1}$) in 12th year and 1st year respectively. The addition of FYM alone and FYM in combination with in organics almost doubled the biomass compared to that on soils treated with NPK alone in 1st and 12th years. SMBC increased to the tune of 30.24 % in 12 year span due to application of FYM with inorganics. Similar results were also found by Verma and Mathur(2007). The supply of additional mineralizable and readily hydrolysable C due to organic manure application resulted in higher microbial activity and higher SMBC.

**Table 3.** Influence of different treatments on status of active pools of organic carbon in 1st and 12th year of LTFE soils in groundnut-wheat sequence

| Treatments | SMBC (ppm) | | SMBN (ppm) | | SMBP (ppm) | |
|---|---|---|---|---|---|---|
| | 1st Year | 12th Year | 1st Year | 12th Year | 1st Year | 12th Year |
| $T_1$ | 87.7 | 134.5 | 6.70 | 14.85 | 12.5 | 9.4 |
| $T_2$ | 104.8 | 150.5 | 6.96 | 13.18 | 11.3 | 8.7 |
| $T_3$ | 101.0 | 294.5 | 7.04 | 13.70 | 14.4 | 7.1 |
| $T_4$ | 100.8 | 270.5 | 7.88 | 13.83 | 12.9 | 9.9 |
| $T_5$ | 232.5 | 272.5 | 8.00 | 14.48 | 10.1 | 8.0 |
| $T_6$ | 184.3 | 247.5 | 6.95 | 14.88 | 11.7 | 6.3 |
| $T_7$ | 180.5 | 235.5 | 8.18 | 11.68 | 14.3 | 8.9 |
| $T_8$ | 243.0 | 316.5 | 10.18 | 18.90 | 16.8 | 9.9 |
| $T_9$ | 222.3 | 310.5 | 8.85 | 17.63 | 15.0 | 8.9 |
| $T_{10}$ | 196.3 | 235.5 | 7.08 | 13.68 | 14.0 | 7.0 |
| $T_{11}$ | 124.3 | 170.5 | 7.88 | 9.83 | 14.2 | 4.9 |
| $T_{12}$ | 86.5 | 123.5 | 6.40 | 9.90 | 8.5 | 4.2 |
| S.Em.± | 7.0 | 8.3 | 0.40 | 0.93 | 0.5 | 0.4 |
| C.D. at 5 % | 20.2 | 23.9 | 1.10 | 2.6 | 1.5 | 1.4 |
| C.V. % | 9.0 | 7.2 | 10.3 | 13.4 | 8.0 | 12.7 |

**Soil microbial biomass nitrogen**

The soil microbial biomass nitrogen content of soils of different treatments under the LTFE is presented in Table 3. Significantly higher SMBN (18.90 and 10.18 ppm) was observed under treatment $T_8$(50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t $ha^{-1}$ to G'nut and 100 % N P K to Wheat.) However, it was at par with treatment $T_9$ (FYM @25 t $ha^{-1}$) in 12th year and 1st year respectively. The SMBN increased to the tune of 85.65 % in 12 year spandue to application of FYM with inorganic. SMBN varied from 6.70 ppm (control) to 10.18 ppm ($T_8$) in 1st year and 9.83 ppm (control) to 18.90 ppm ($T_8$) in 12th year. Application of FYM in combination with inorganic fertilizers resulted in significantly higher soil microbial biomass nitrogen (SMB-N) content as compared to the rest of the treatments. But these two treatments were at par with each other. High soil organic carbon content, more root proliferation and additional supply of N by FYM to microorganisms might be responsible for increasing the level of SMB-N. Farmyard manure is not only rich in C but also in N and other macro- and micronutrients. But the availability of nutrients to the crop from FYM is generally lower than N from inorganic fertilizer because of the slow release of organically bound N and volatilization of $NH_3$ from the manure, especially in calcareous soils (Beauchamp 1983). Therefore, a combined application of FYM and fertilizer in the present study apparently provided supply of nutrients in balanced proportion which was reflected in terms of increased amount of microbial biomass N.

**Soil microbial biomass phosphorus**

Soil Microbial biomass phosphorus content of soils of different treatments under the LTFE is presented in Table 3. Significantly the highest SMBP (16.8 & 9.9 ppm) were observed under treatment $T_8$(50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t $ha^{-1}$ to G'nut and 100 % N P K to Wheat.) A significant increase in the microbial phosphorus was observed in all the treatments over control. Continuous application of chemical fertilizers either alone or incombination with FYM increased the soil microbial biomass phosphorus (SMB-P) content as compared to unfertilized plots. The SMBP decreased in all the treatments in 12 year span. The low SMB-P content in control plot could be due to no addition of any external input into the soil over the years and also the poor crop productivity. Low content of SMB-P in 100% N alone was observed. Reason attributed is the reduction/ death of microbial cells due to absence of any phosphate substrate. The addition of higher levels of phosphorus through external sources might have influenced the metabolism of microorganisms, which are responsible for higher levels of SMB-P. Similar elevation in SMB-P with the application of super-optimal dose of NPK was observed by Bolton *et al*., (1985); rise in content of SMB-P was also reported by Santhy *et al*., (2004).

**Water soluble carbon and carbohydrates**

Water soluble organic carbon is considered as the most labile and mobile form of SOC and an immediate organic substrate for microorganisms and the water soluble carbohydrates (WS-CHO) are the most readily available source of energy for microorganisms and contribute to soil quality through their role in the formation and stabilization of soil structure. Water soluble carbon and water soluble carbohydrates content of soils of different treatments under the LTFE is presented in Table 4. Significantly higher water soluble carbon(44.5 & 51.8 ppm) was observed in the treatments receiving treatment $T_8$ (50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t $ha^{-1}$ to G'nut and 100 % N P K to Wheat.) followed by treatment $T_9$ (FYM @ 25 t $ha^{-1}$) in 1st & 12th year, respectively. The water soluble carbon increased to the tune of 16.40 % in 12 year span due to 50

**Table 4.** Influence of different treatments onStatus of organic carbon and active pools in 1st and 12th year of LTFE soils in groundnut-wheat sequence

| Treatments | WSC (ppm) | | WS-CHO (ppm) | | DHA(µg $TPF^{-1}$ 24 $hr^{-1}$ $g^{-1}$ soil) | |
|---|---|---|---|---|---|---|
| | 1st year | 12th Year | 1st Year | 12th Year | 1st Year | 12th Year |
| $T_1$ | 24.0 | 31.5 | 36.5 | 46.5 | 36.5 | 26.5 |
| $T_2$ | 30.0 | 37.5 | 37.5 | 46.0 | 42.5 | 32.5 |
| $T_3$ | 38.0 | 46.3 | 38.5 | 42.8 | 30.0 | 30.5 |
| $T_4$ | 34.8 | 47.8 | 31.5 | 40.0 | 46.5 | 31.5 |
| $T_5$ | 29.5 | 38.5 | 41.5 | 48.3 | 33.5 | 22.5 |
| $T_6$ | 34.5 | 41.3 | 40.5 | 48.5 | 38.3 | 33.5 |
| $T_7$ | 36.5 | 44.0 | 33.5 | 43.0 | 46.5 | 36.5 |
| $T_8$ | 44.5 | 51.8 | 46.5 | 55.0 | 52.5 | 42.5 |
| $T_9$ | 40.5 | 50.8 | 42.5 | 51.0 | 49.5 | 35.5 |
| $T_{10}$ | 21.5 | 30.5 | 27.5 | 36.0 | 31.5 | 21.5 |
| $T_{11}$ | 28.5 | 40.0 | 41.0 | 47.5 | 40.5 | 28.5 |
| $T_{12}$ | 20.5 | 32.5 | 26.5 | 35.0 | 29.5 | 19.5 |
| S.Em.± | 31.9 | 41.0 | 36.9 | 44.9 | 39.7 | 30.0 |
| C.D. at 5 % | 1.3 | 1.6 | 1.3 | 2.3 | 2.3 | 1.5 |
| C.V. % | 3.7 | 4.8 | 3.9 | 6.7 | 6.6 | 4.4 |

% N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t $ha^{-1}$ to G'nut and 100 % N P K to Wheat. This built-up was after decades as a result of large amount of clay particles enriched with water soluble carbon through addition of FYM and chemical fertilizers (Liang *et al.,* 1995). Thus balance fertilization favoured enrichment of water soluble carbon.

Significantly higher water soluble carbohydrate (WS-CHO) (46.5 and 55.0 ppm) was observed under treatment $T_8$ (50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t $ha^{-1}$ to G'nut and 100 % N P K to Wheat.) However, it was at par with treatment $T_9$ (FYM @ 25 t $ha^{-1}$) in 1st & 12th year, respectively. The water soluble carbohydrate increased up to 18.27 % in 12 year span due to application of FYM along with inorganics. The water soluble carbohydrates serves as source and sink for mineral nutrients and organic substrates in a short-term and as a catalyst for conversion of plant nutrients from over a longer period and there four influence crop productivity and nutrient cycling (Geeta Kumari *et al*., 2011).

**Dehydrogenase Activity**

All biological reactions in soil are catalysed by enzymes. Soil enzyme activities are believed to indicate the extent of specific processes in soil and in some cases act as indicators of soil fertility. The activity of dehydrogenase enzyme was strongly affected by long-term fertilizer use. The dehydrogenase activity of soils of different treatments under the LTFE are presented in Table 3. Significantly higher Dehydrogenase activity (52.5 & 42.5 ìg $TPF^{-1}$ 24 $hr^{-1}$ $g^{-1}$ soil) was recorded under treatment $T_8$ (50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t $ha^{-1}$ G'nut and 100 % N P K to Wheat) in 1st and 12th year, respectively. Application of N fertilizers half as well as full doze although affect the activity because of Dehydrogenase activity is strongly influenced by the presence of nitrate, which serves as an alternative electron acceptor resulting in low *Dehydrogenase* activity (Sneh *et al.,* 1998).

## CONCLUSION

Beneficial and significant effect of FYM along with in organics was found on status of organic carbon and its different pools. Significant increased in organic carbon status and different pools with 12 years span with application of FYM alone or combined with inorganics**.**

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