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# Variability in Soil Organic Carbon Fractions Relevance to Different Agricultural Practices

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## Abstract

A field trail was conducted at The Experimental Farm, Fac. of Agric., Al-Azahar Univ., Assiut, located 375 km south of Cairo, Egypt (27° 12¯ 16.67¯̄ N latitude and 3° 09¯ 36.86¯̄ E longitude) during the growth seasons of summer 2016 and winter 2016/2017 to assess the effect of tillage and nitrogen fertilization practices on soil organic matter partitioning into the functional compartments with different dynamics. The study included three plowing manner (No plowing, NP, Minimum plowing, MP and Traditional plowing, TP) and two nitrogen sources (Urea 46.5% N as a fast nitrogen fertilizer and ureaform 40% N as a slow nitrogen fertilizer).

The obtained results indicated that plowing manner had the greatest effect on soil organic carbon (SOC) and its various fractions (permanganate oxidizable carbon, $KMnO_4$-C, particulate organic matter carbon, POM-C, microbial biomass carbon, MBC, and mineralized carbon, C min) under different crop growth. The trends observed with SOC fractions indicated that minimum plowing managements created a more favorable plant growth environment relative to traditional plowing. MBC was found to be sensitive to nitrogen management. The results supported the hypothesis that changes in surface SOC by tillage can be predicted by POM-C, $KMnO_4$-C and C min. On the average basis, POM-C was the most sensitive to tillage managements among all the SOC fractions and represented the largest portion of the total SOC (43.75%) followed by $KMnO_4$–C (4.75%) then C min (1.66%). The adoption of conservation tillage practices offers soil C sequestration opportunity and soil health improvement under sunflower- wheat rotation in Assiut region, Upper Egypt. It could be concluded that minimum plowing practice protected soil organic carbon compared to the other plowing treatments. Minimum plowing management increases soil organic matter and improves soil fertility and has potential for increasing the nutrient supply to crops through changes in the mineralization and immobilization of nutrients by microbial biomass.

***Keywords***: *Soil organic carbon, particulate organic matter carbon, microbial biomass carbon, plowing manner, Nitrogen fertilizers.*

## Introduction

Soil organic carbon (SOC) is directly linked to key functions in ecosystems, such as nutrient supply, improve soil aggregation and stimulate microbial activity. Soil organic carbon plays multiple roles in agricultural soils, acting as nutrient tural soils, acting as nutrient sources for crops and increasing the cation exchange capacity (CEC), bio neutralization of xenobiotic compounds, soil structural stability, water retention, soil aeration, biological a activity and biodiversity (Lal and Sanchez, 1992; clara *et al.*, 2017). The rate of SOC accumulation depends mainly on the quantity of dry matter produced by the cover plants and on environmental factors such as humidity and temperature (Carter, 2002 and Kirschbaum, 2006). Hobbs, *et al.*, (2018) concluded that agricultural management plays an important role in global warming. The amount of SOC in the surface 30 cm soil layer is about twice that in atmosphere. In agricultural systems changes in management can result in increases in the SOC stocks. Enhancing SOC levels positively contributes to crop production through improving soil fertility and water conservation. Carbon sequestration exists in the upper 20 cm soil layer. The change in total SOC content depends on agricultural management practices and is not always detectable in the short term. Thus, the partitioning of soil organic matter into the functional compartments with different dynamics represents an important tool to readily detect recent changes in the soil in response to changes in management practices. Increasing concern about global climate change, driven by rising atmospheric concentration of greenhouse gases, particularly $CO_2$, have enhanced the interest in soil carbon sequestration as a strategy to offset anthropogenic $CO_2$ emissions. Strategies for increasing the SOC pool is needed not only to mitigate $CO_2$ emissions but also to improve soil quality and economic crop production (Blanco-Moure *et al.,* 2013; Kahlon *et al.,* 2013; Lenka & Lal, 2013 and Xavier *et al*., 2013).

In contrast, labile C pools which turn over relatively rapidly can respond more quickly to land use change and soil management than SOC, and are thus suggested as early and sensitive indicators of SOC changes. Microbial biomass carbon (MBC), particulate organic carbon (POC), dissolved organic carbon (DOC), hot water extractable carbon (HWC), permanganate oxidizable carbon (POSC) have been recognized as labile soil organic C pools, and they are considered as important indicators for soil quality (Ghani *et al.*, 2003). Separation of SOC into different sized pools can be useful in identifying and understanding differences in structure, function and bioavailability. Soil microbial communities are extremely diverse, and the relation between their diversity and function influences soil stability, productivity and resilience. On the other hand, organic matter, water activity, soil fertility, physical and chemical properties influence soil microbial biomass (Tomich *et al.,* 2011).

Soil biota is influenced by land use and management techniques. Therefore, changing in management practices could have significant effects on the soil microbial properties and processes. Organic farming has been shown to favour soil biota in comparison with intensive farming. More particulate organic matter (POM) in soil indicates that carbon and other nutrients are stored in the intermediately available pool and not subjected to losses and available upon demand. Articulate organic C and MBC are important C fractions that reflect key processes such as nutrient cycling and availability, soil aggregation, and soil C accumulation. A large number of studies have shown that both POC and MBC are sensitive to changes in management such as reduced tillage, cover cropping and land use. This sensitivity has led to wide adoption of these methods in soil science as indicators of change in the soil ecosystem (Wander, 2004; Grandy & Robertson, 2007; Stark *et al.,* 2007; Kaschuk *et al*., 2010 and Santos *et al.,* 2012). Melero, *et al.* (2009) studied the short and long-term effects of conservation tillage in comparison with traditional tillage on total organic carbon (TOC), active carbon (AC) and microbial biomass carbon (MBC). They concluded that conservation tillage promoted accumulation of crop residues as well as the other carbon parameter.

Permanganate oxidizable carbon (POSC) is a relatively new method that can quantify labile soil C rapidly and inexpensively. Carbon compounds oxidized by this method include the C most readily degradable by microorganisms and also include partially C that is bound to soil minerals. As POSC contains C from the mineral fraction also, it is rather treated as a chemical indicator, not as a biological indicator. However, POSC is significantly related to particulate organic carbon, soil microbial biomass carbon and soil organic carbon (Culman, *et al*., 2012). Lucas and Weil (2012) studied the permanganate oxidizable carbon as an estimate of labile soil carbon and hypothesized that soil lower in POSC show increased crop productivity in response to practice that increase SOM.

The current work aims to assess the effect of tillage and nitrogen fertilization practices on soil organic matter partitioning into the functional compartments with different dynamics.

## Materials and Methods

A field trial was conducted at The Experimental Farm, Fac. of Agric., Al-Azhar Univ., Assiut, located 375 km south Cairo, Egypt (27° 12ˉ 16.67˭ N latitude and 31° 09ˉ 36.86˭ E longitude). The site is characterized by a flat topography and is dominated by well drained entisols (Soil Survey Staff, 1996) that are clay loam in texture, slightly alkaline and have low organic matter but adequate potassium level in the top soil layers (50 cm depth). Some physical and chemical properties of the experimental site were analyzed according to Page *et al*. (1982) and Klute (1986) and are shown in Table (1a & 1b).

**Table 1. Some physical and chemical properties of the experimental site**
**a- Physical properties**

| Soil depth (cm) | Particles size (g/kg) | | | Texture Class | Moisture content (v/v %) | | AW (%) | SP (%) |
|---|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | FC | WP | | |
| **0-25** | 265 | 400 | 335 | Clay Loam | 41.0 | 20.3 | 20.7 | 80.0 |
| **25-50** | 251.1 | 391.4 | 357.5 | Clay Loam | 40.8 | 20.0 | 20.8 | 80.2 |

FC = field capacity WP = wilting point AW = available water SP= saturation percentage

**b- Chemical properties**

| Soil depth (cm) | O.M. (g/kg) | $CaCO_3$ (g/kg) | pH (1:2.5) suspension | $EC_e$ (dS/m) | Soluble ions (mmol/kg) | | | | | | | Available nutrients (ppm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Na | K | Ca | Mg | $Cl^-$ | $CO_3^= + HCO_3^-$ | $SO_4^=$ | N | P | K |
| **0-25** | 21.3 | 34.1 | 7.66 | 0.95 | 4.19 | 0.10 | 1.00 | 0.52 | 0.96 | 1.35 | 2.40 | 70.0 | 9.63 | 367 |
| **25-50** | 20.1 | 31.1 | 7.75 | 1.10 | 4.06 | 0.16 | 0.96 | 0.43 | 0.88 | 1.23 | 2.24 | 56.5 | 9.55 | 343 |

OM = organic matter pH= soil reaction ECe = electrical conductivity in soil paste extract
* Each value is the man of 3 replicates.

The experiment was laid out in split plot design with three replicates and 6 treatments. The study included three plowing manner and two nitrogen fertilizer sources at recommended level. The main plots were assigned for plowing manner as follows: a) No plowing (NP) where flat discs are used to create an opening in the soil which is followed by a tine to deliver the seed and fertilizer into the slot and a press wheel to close the slot; b) Minimum plowing (MP) where the residues of the previous crop were left on the soil surface, as mulch, and a minimum vertical plough (chiseling, 15 cm depth) and disc harrowing (5 cm depth) were carried out, the latter immediately before sowing and c) Traditional plowing (TP) where the soil was ploughed by chisel plough (consisted of 7 rigid shanks of 18 cm width and spaced 28 cm apart) to a 30 cm depth, after burning the residues of the preceding crop. The split plots were assigned for nitrogen sources at the recommended level (Urea 46.5% N as a fast nitrogen fertilizer and ureaform 40% N as a slow nitrogen fertilizer).

In the summer season of year 2016 sunflower seeds (sakha 130, variety) were planted on 14$^{th}$ of June in hills 20 cm apart from each other and 60 cm distance between rows and were harvested 93 days later. All cultural management practices for growing sunflower had been conducted in the same way as carried out in the neighboring fields following the recommendation of the Egyptian Ministry of Agriculture. Superphosphate (15.5% $P_2O_5$) at amout of 100 kg/ fed. was broadcasted during soil preparation processes. Ureaform slow release nitrogen fertilizer, (75 kg/ fed) was added to the soil before sowing. While urea (66 kg/ fed.) was divided into three equal doses and added at 15, 6o and 75 days after plantation. Potassium sulphate at level of 48 kg $K_2O$/ fed. was divided into two equal doses added at 15 and 75 days after plantation.

In the winter season of 2016/17, wheat seeds (*Triticum aestivum vulgar. CV* Sids 1) were sown on December 1$^{st}$, in rows spaced 15 cm consuming 70 kg seed /fed. All the agronomic practices were applied as commonly used for growing wheat and carried out according to the recommendations set by the Ministry of Agriculture. Superphosphate (15.5% $P_2O_5$) at level of 100 kg/ fed. was broadcasted during soil preparation processes. Ureaform slow release nitrogen fertilizer (100 kg N/ fed) was added to the soil before sowing. While urea (100 kg N/ fed.) was divided into two equal doses added to soil before 1st and 3rd irrigation. Potassium sulphate at level of 48 kg $K_2O$/ fed. was divided into two equal doses added at the time of nitrogen fertilization. The plants were harvested 145 days after planting.

Soil sampling before each growth season was taken at depths of 0-25 and 25-50 cm and after harvest at depths of 0-25 cm by using a spiral auger. The samples were air dried, ground and sieved (particle size < 2mm) and prepared for physical and chemical analysis according to Page *et al*. (1982) and Klute (1986). Also, undisturbed soil samples were taken using the core method technique.

Total soil organic carbon (TOC) was determined using one gram of soil oxidized by10 ml $K_2Cr_2O_7$ (1N) in concentrated sulfuric acid for 30 min, then excess $K_2Cr_2O_7$ was titrated by ferrous-ammonium sulfate (0.5 N) and N-phenyl anthranilic acid to indicate the end point as described by the method of Nelson and Sommers (1982). Microbial biomass carbon (MBC) was analyzed by the fumigation incubation method (Jenkinson and Ladd, 1981), from the relationship

$Bc = Fc/ kc$ Where

$Bc$ = biomass of carbon

$Fc$ = [($CO_2$-C evolved from fumigated soil, 0-10 days) – ($CO_2$-C evolved from non-fumigated soil)]

$Kc$ = the proportion of microbial C evolved as $CO_2$ = 0.45 for 10 days incubations at 25°C.

Permanganate Oxidizable Carbon (POSC) was measured by weighing 5 g of air-dried soils into 50 ml polypropylene conical centrifuge tubes to which 2 ml of 0.2 M $KMnO_4$ and 18 ml of deionized water were added. The tubes were vigorously shaken for 2 min on a reciprocal shaker (200 strokes per min) and allowed to settle for 10 min. After that, 0.5 ml of the supernatant from the upper 1 cm of the suspension was transferred into another 50 ml centrifuge tube and mixed with 49.5 ml of deionized water. Finally, the diluted solution was measured for its absorbance in a Spectronic 20 D+ spectrophotometer (Thermo Fisher Scientific Inc., Madison, WI), set at 550 nm. as described by Weil *et al.* (2003). The values of $KMnO_4$-C were determined using the following equation:

$KMnO_4$-C (mg $kg^{-1}$ soil) = [(0.02 mol $L^{-1}$ – (A+B) x absorbance)] x (9000 mg C mol $^{-1}$) x (0.02 L solution / 0.005 kg soil).

Where 0.02 mol/ L is the initial solution concentration

A is the intercept and B is the slope of the standard curve

9000 is mg C oxidized by 1 mol of $MnO_4$ changing from $Mn^{7+}$ to $Mn^{4+}$

0.02 L is the volume of $KMnO_4$ solution reacted, and 0.005 is the kg of soil used.

Particulate organic matter carbon (POMC) was determined by mixing ten grams of air-dried soils with 30 ml of 5 g $L^{-1}$ sodium hexametaphosphate solution and shaken in a reciprocal shaker for 18 h. Then, the dispersed materials were passed through a 53 $\mu$m sieve by rinsing several times with deionized water. The retained material (sand and POM) on the sieve was dried in an oven at 105 $^0$C for 24 h and weighed. The mass of sand free POM was determined by mass differences after burning the dried material at 550 $^0$C for 4 h in a Thermolyne Bench top Muffle Furnace (Thermo Fisher Scientific Inc., Beverly, MA) as described by Sollins *et al.* (1999). The POM fraction (i.e. POM of size ranging 53–2000 $\mu$m) measured represented the POMC.

Mineralized Carbon was estimated by weighing 100 g of air-dried soils into 1 L mason jars and de-ionized water was added to bring the soils at 50% of water holding capacity (WHC). The soils were then incubated in 20 mL of 0.5 M NaOH (in a vial) at 25 $^0$C for 30 day. Soil water contents were regularly monitored by weighing the jars containing soils and required amount of de-ionized water was added, if necessary. The vials containing NaOH were removed at 7, 14, 21 and 30 day then measuring the evolved $CO_2$–C by titration using 0.5 M HCl. The jars were replaced with vials containing fresh NaOH at each removal day until 21 day as described by Anderson (1982). The cumulative C mineralization within 30 d was calculated from the summation of the measured C mineralized at the respective days.

## Results and Discussion

### * Total soil organic carbon (TSOC).

The effect of plowing practices on total soil organic carbon after sunflower and wheat growth seasons when soil fertilized by urea or ureaform are shown in Fig. (1). In general, TSOC contents are higher when soil was fertilized by ureaform than those when soil was fertilized by urea no matter what the plowing treatments are. Data indicated that there was almost no differences in TSOC content among plowing treatments in both seasons when soil was fertilized by urea. The TSOC content values were 1.32, 1.50 and 1.32% for NP, MP and TP, respectively in both seasons.

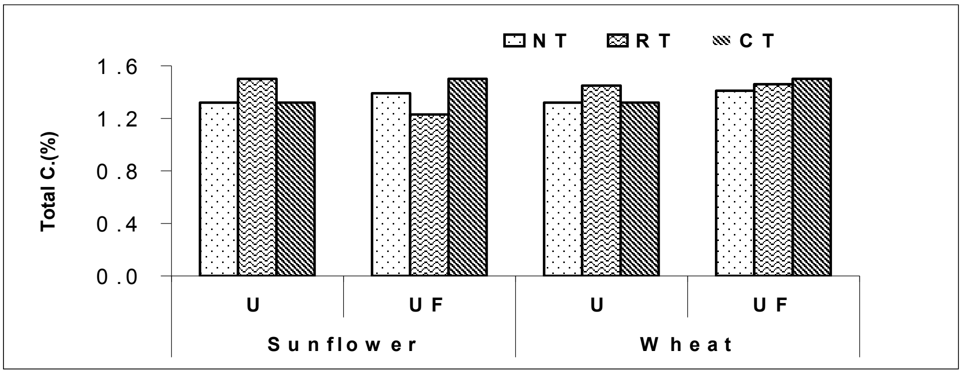


**Fig**. (1). Total soil carbon content in relation to plowing practices and nitrogen fertilizer after sunflower and wheat growth seasons.

Under ureaform fertilization, the TSOC contents were higher in the second growth season (wheat) than those in the first one (sunflower) regardless the plowing treatments. The TSOC content values were 1.39, 1.23 and 1.50% for NP, MP and TP, respectively after sunflower crop (Fig. 1). They were 1.41, 1.46 and 1.50 % for the corresponding treatments after wheat crop. From the TSOC preservation point of view, the plowing treatments could be arranged in descending order of MP > NP = TP.

West and Post (2002) found that changing conventional tillage (CT) to No tillage (NT) might increase carbon sequestration rate to 57 ± 14g C/ $m^2$/ year. The small differences between NT and CT could be also due to the high clay content of the soils that finally protects soil organic matter (SOM) from a quick degradation under intensive land use (Oue´draogo *et al*., 2005). The low annual input of organic carbon (~ 3.4 Mg C/ ha/ year) by soybean residue and stimulation of organic matter mineralization due to nitrogen generated by biological N-fixation from the symbiosis of this crop with rhizobia are the two main factors that explain the loss of carbon (Austin *et al*., 2006). Rangel *et al*. (2008) reported a decrease in the organic carbon (OC) level at 10 cm soil depth under CT compared to the NT system. However, the NT system was found to be most closely related to the accumulation of OC in the soil demonstrating the potential of this system to produce grain with a reduced in sun pact on the soil carbon balance. This pattern of behavior of the OC in NT is well established and is caused by the absence of mechanical incorporation of the crop residue (Figueiredo *et al*., 2013).

*** Permanganate Oxidizable Carbon (PMOC)**

The influence of plowing practices when soil fertilized by urea or ureaform on PMOC after sunflower and wheat growth seasons is shown in Fig. (2). In the first season (sunflower), the result indicated that the $KMnO_4$–C evolved from MP or TP treatment is less than that resulted from NP treatment whatever the soil fertilizer is. The $KMnO_4$–C values were 67.3, 64.5 and 64.6 mg/100g soil in NP, MP and TP treatments, respectively when the soil fertilized by urea (Fig. 2). They were 69.2, 65.9 and 62.4 mg/100g soil for the corresponding treatments when the soil fertilized by ureaform. In the second season (wheat), the $KMnO_4$–C evolved from MP treatment is higher than that resulted from TP followed by NP treatment. This was true under both fertilizers. However, the $KMnO_4$– C evolved from different tillage practices could be arranged in ascending order of TP < MP < NP after sunflower growth season. Also, almost similar results are recognized after wheat growth season when soil fertilized by ureaform or urea and the $KMnO_4$– C values range between 62.4 and 69.2 g/100g. The differences of $KMnO_4$– C evolved from NP, MP, and TP treatments under urea fertilizer were significant than those under ureaform fertilizer after wheat growth season. On the average basis, the $KMnO_4$–C fraction represented 4.75% of the total SOC.

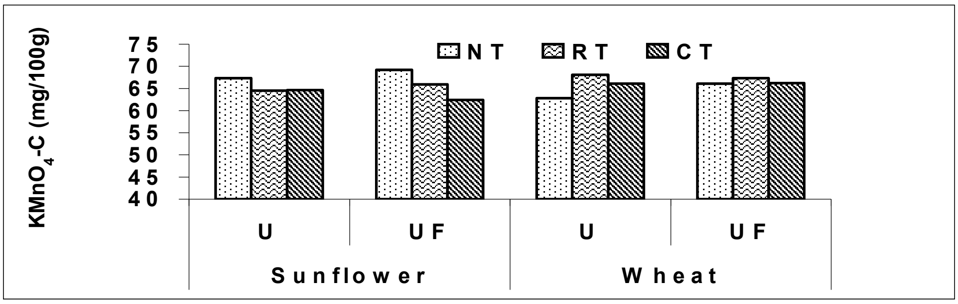


**Fig**. (2). Permanganate oxidizable carbon in relation to plowing practices and nitrogen fertilizer after sunflower and wheat growth seasons.

Yang *et al*. (2005) revealed that when wheat straw was added to the soil under water regime of continuous water logging, the PMOC and Particulate organic carbon (POC) decreased by 30.6 and 10.6 %, respectively compared to those under water regime of alternative wetting and drying. This confirmed that the adoption of soil water regimes is an important factor to improve the transformation of soil organic carbon pools after the addition of wheat straw. Weil *et al*. (2003) stated that TOC, PMOC estimated as C pool were more closely associated with soil biological functions. The PMOC was significantly higher in the high N soil at several depths, especially in the sub soil, suggesting that the more N-rich soil stimulated more root growth and rhizo deposition by both the corn and radish cover crop.

*** Particulate organic matter carbon (POM-C).**

The effect of plowing practices on particulate organic matter carbon (POM-C) after sunflower and wheat growth seasons when soil fertilized by urea or ureaform are shown in Fig. (3). The results indicated that the POM-C at TP treatment was significantly lower than that under NP or MP when soil fertilized by urea While, the POM-C at MP treatment was less than NP and TP under ureaform fertilization. The POM-C ranged between 0.50 and 0.86 g/100g soil for urea and between 0.44 and 0.85 g/ 100g under ureaform after sunflower growth season (Fig. 3). Also, almost similar results are obtained after wheat growth season. The POM-C ranged between 0.40 and 0.74 g/100g soil for urea and between 0.49 and 0.67 g/100g soil under ureaform fertilization (Fig. 3). On the average basis, the POM-C fraction represented 43.7% of the total SOC.

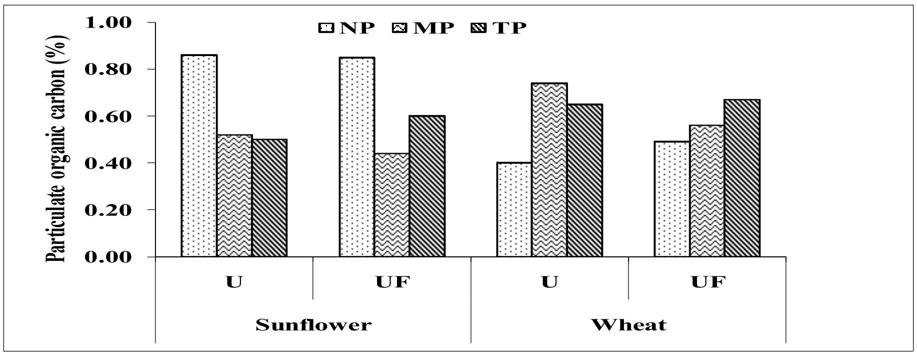


**Fig**. (3). Particulate organic matter carbon in relation to plowing practices and nitrogen fertilizer for sunflower and wheat growth seasons.

The POM-C has been reported as an early indicator that is more sensitive to changes in soil organic carbon due to agricultural management (Wander and Nissen, 2004). The differences observed in the POM-C contents are in agreement with those reported by many researchers who compared the effect of conservation tillage (ST and NT), to minimal soil disturbances and CT, with greater intensity of tillage (Chatterjee and Lal, 2009; Chen *et al*., 2009). According to Chatterjee and Lal (2009), crop residues are left on the soil surface under NT and ST practices whereas residues are incorporated in the soil during CT, thereby favoring increased mineralization of POM-C by soil microbes under the latter. Similarly, tillage induces the disruption of soil aggregates and increased exposure of soil aggregate protected POM-C from microbial decomposition following the collapse of aggregates by increased tillage intensity (CT) compared to the reduced tillage (ST and NT) may have contributed to the low levels of POM-C under CT treatment (Mikha and Rice, 2004).

***Microbial Biomass Carbon (MBC).**

Data presented in Fig. (4) Show the effect of plowing manner and nitrogen fertilizer on microbial biomass carbon after sunflower and Wheat growth seasons. In general, the MBC contents as affected by urea fertilizer were 14.9, 8.0 and 5.3 mg/100g soil under NP, MP and TP treatment, respectively. The corresponding values were 4.9, 1.5 and 13.1 mg/100g under ureaform fertilizer (Fig. 4). The microbial biomass carbon followed the descending order of TP > NP> MP after sunflower growing season while the reverse trend was observed after wheat growing season. The microbial biomass carbon ranged between 10.1to 13.6, 11.7 to 16.8 and 2.4 to 16.1 mg/100g soil for no plowing (NP), minimum plowing (MP) and traditional plowing (TP), respectively. On the average basis, the MBC fraction represented 0.71% of the total SOC.

According to Lopes *et al.* (2013), in the Cerrado region, the MBC levels in soils cultivated with grain are low even under the best management practices. Sharma *et al.* (2004) and Tracy & Frank (1998) found that microbial biomass C values ranged from 219 to 864 μg/g for different land uses (forest, agroforestry and agriculture) and from 166 to 1539 μg/g for pasture land. Yeboah *et al.*(2016) found that the

MBC content was significantly affected by different tillage practices. The observed trend for MBC was similar to that of soil carbon content. No tillage system (NTS) increased MBC by 37% and 40% compared to ST and CT in 0–30 cm soil depth at sowing stage.

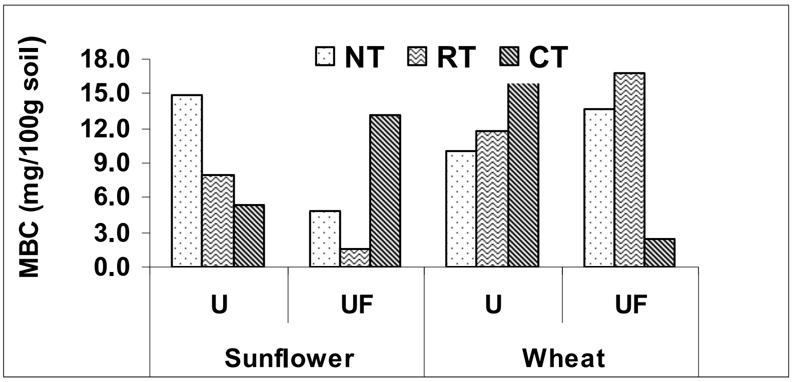


**Fig**. (4). Microbial biomass carbon (MBC) in relation to plowing manners and nitrogen fertilizer for sunflower and wheat growing seasons.

The lowest value of MBC was recorded in the CT treatment. Significant ($P < 0.05$) increases were found among the treatments; the mean values recorded for the three sampling times ranged from 315.79– 161.85 mg/kg at sowing and 260.00–152.67 mg/kg soil at harvest. These results are similar to other studies which indicated that no tillage generally increased MBC relative to the conventional tillage (Bausenwein *et al.* 2008). The minimal soil disturbance and soil cover protect the biological components of the soil and enhance nutrient availability for microbial growth.

*** Mineralized Carbon.**

The impact of plowing manner and nitrogen fertilizers on mineralized carbon (C min) when soil cultivated by sunflower and wheat are shown in figure 5 and 6, respectively. In general, the maximum and minimum emitted soil $CO_2$ were at 16 and 21 days after planting, respectively. This trend was true for both seasons. The amount of emitted soil $CO_2$ from minimum plowing (MP) treatment was the highest one during the early growth stage when soil fertilized by ureaform. The emitted soil $CO_2$ ranged between 4.2 – 6.36, 4.08- 7.5 and 3.42- 6.06 mg/100g soil for no plowing (NP), minimum plowing (MP) and traditional plowing (TP), respectively when soil cultivated by sunflower and treated by urea (Fig. 5). The corresponding values were 4.2 – 6.66, 6.0- 10.9 and 4.5- 7.8 mg/100 g soil when soil fertilized by ureaform.

Also, almost similar results are recognized after wheat growing season (Fig. 6). The amounts of mineralized Carbon at 8, 16, 21, and 30 days were generally higher in MP treatment than that from either NP or TP treatment. Soil $CO_2$ flux increased in 16 and 30 day compared to 8 or 21 day when soil fertilized by urea. Soil $CO_2$ flux ranged from 4.26 to 6.0, 6.54 to 9.84 and from 4.2 to 5.58 mg/100g soil in NP, MP and TP treatments, respectively. The corresponding amounts were 2.82 to 5.52, 4.62 to 6.82 and from 4.2 to 6.72 mg/100g soil when soil fertilized by ureaform. On the average basis, the C min fraction represented 1.66% of the total SOC.

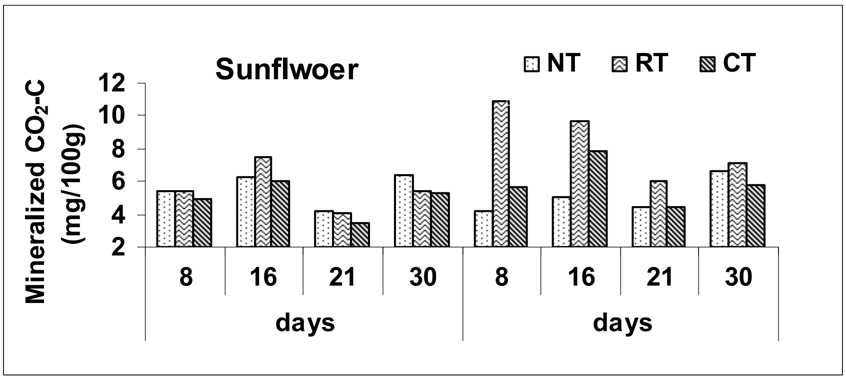


**Fig**. (5). Mineralized Carbon in relation to plowing manners and nitrogen fertilizer for sunflower growing season.

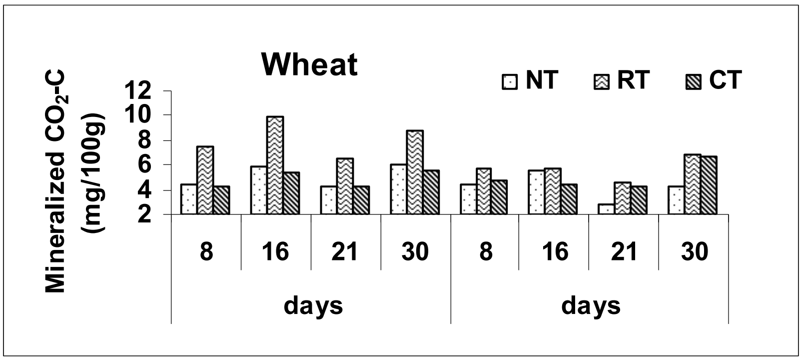


**Fig**. (6). Mineralized Carbon in relation to plowing manners and nitrogen fertilizer for wheat growing season.

Lou *et al.* (2007) found that soil $CO_2$ fluxes positively correlated with decomposed organic carbon (DOC) and Microbial Biomass Carbon (MBC) ($r = 0.764$ and $0.981$ at $p < 0.05$ and $0.01$, respectively) after 55 days from the experiment beginning. Reduced tillage practices allow C to build-up in the plow layer by enhancing soil aggregation and reducing oxidation (Carpenter-Boggs *et al.,* 2003). In contrast, frequent tillage under CT increases the loss of aggregate protected C through microbial decomposition (Mikha and Rice, 2004). Higher mineralized Carbon under NT and ST could be attributed to higher availability of C substrates for decomposition by microbial biomass (Chen *et al*., 2009).

There has been very little, if any, previous investigations about the carbon distribution in soil profile and its sequestration potential. Across the management practices evaluated in the present study, plowing manner had the greatest effect on SOC and its various fractions (KMnO4-C, POM-C, MBC, and C min) under different crop growth. However, the trends observed with SOC fractions in this experiment indicated that minimum plowing managements created a more favorable plant growth environment relative to traditional plowing. Soil MBC was found to be sensitive to N management. Our results supported the hypothesis that changes in surface SOC by tillage can be predicted by POM-C, KMnO4-C and C min. On the average basis, POM-C was the most sensitive to tillage managements among all the SOC fractions and represented the largest portion of the total SOC (43.7%) followed by $KMnO_4$–C (4.75%) then C min (1.66%). The adoption of conservation tillage practices offers soil C sequestration opportunity and soil health improvement under sunflower-wheat rotation in Assiut region, Upper Egypt. It could be concluded that minimum plowing practice protected soil organic carbon compared to the other plowing treatments. Minimum plowing management increases soil organic matter and improves soil fertility and has potential for increasing the nutrient supply to crops through changes in the mineralization and immobilization of nutrients by microbial biomass. However, SOC changes in clay enriched soils should be further investigated in relation to nitrogenous fertilizer management and crop rotation.

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# تغير صور الكربون العضوي فى التربة نتيجة للممارسات الزراعية المختلفة

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**الملخص**

أجريت تجربة حقلية بالمزرعة البحثية لكلية الزراعة جامعة الأزهر بأسيوط والتي تقع علي بعد ٣٧٥ كم جنوب القاهرة وعند خط عرض 16.67" 12' 27° شمالا وخط طول 36.86" 09' 31° جنوبا. خلال الموسم الصيفي ٢٠١٦ والموسم الشتوي ٢٠١٦/٢٠١٧ لتقييم تأثير ممارسات الحرث والتسميد النيتروجيني علي صور الكربون العضوى بالتربة وتحولاته كيماويا وكميا. وقد اشتملت الدراسة علي ثلاثة طرق للحرث (بدون حرث، وأقل حرث، والحرث التقليدى) مع مصدرين للنيتروجين (اليوريا كسماد سريع الذوبان ٤٦,٥ % نيتروجين واليوريافورم كسماد بطئ الذوبان ٤٠ % نيتروجين).

وقد أوضحت النتائج المتحصل عليها أن طرق الحرث كان لها الأثر الأكبر علي صور الكربون العضوي بالتربة وتحولاته (كربون معدنى C min، الكتلة الحيوية للكربون الميكروبى MBC، الكربون القابلة للأكسدة بالبوتاسيوم برمنجنات $KMnO_4$-C، جزيئات كربون المادة العضوية POM-C) تحت نمو محاصيل مختلفة. وقد بينت النتائج أن صور الكربون العضوى بالتربة تحت أسلوب أقل حرث أدى الى خلق ظروف بيئية أفضل لنمو النبات بالمقارنة لأسلوب الحرث التقليدى. وكانت صورة MBC حساسة للتسميد النيتروجيني.

وقد أيدت النتائج فرضية أن التغيرات في الكربون العضوى بالتربة السطحية نتيجة عمليات الخدمة يمكن التبؤ بها من خلال صور الكربون POM-C ، $KMnO_4$-C ، C min . وكانت صورة الكربون POM-C أكثر الصور حساسية لاساليب الحرث من كل صور الكربون العضوي للتربة الاخري ومثلت الجزء الأكبر منه بحوالي ٤٣,٧٥ % تلتها الصورة $KMnO_4$–C بنسبة ٤,٧٥ % ثم صورة C min بنسبة ١,٦٦ %. وممارسة أسلوب أقل خدمة ممكنة يؤدى الى حفظ الكربون بالتربة وتحسين الظروف البيئية للتربة تحت دورة زراعية من محصول عباد الشمس والقمح في منطقة أسيوط – مصر العليا. ويمكن القول ان ممارسة أسلوب أقل حرث تحمي الكربون العضوي للتربة مقارنة مع أساليب الحرث الاخري. كما أن ممارسة أسلوب أقل حرث تزيد من المادة العضوية للتربة وتحسن خصوبتها وتزيد من فرصة امداد المحاصيل بالمغذيات من خلال التغيرات في معدنة المغذيات والتحكم فيها بواسطة الكتلة الحيوية الميكروبية.