Soil Carbon Dioxide Flux Following Tillage Systems in Arid and Semi-arid Agro-ecosystems

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Abstract:

A field experiment was conducted at the experimental farm, Faculty of Agriculture, Al-Azahar University, Assuit, Egypt which is located at 27° 12' 16.67" N latitude and 31° 09' 36.86" E longitude for two successive sunflower growing seasons of 2011 and 2012. This study aims to asses the effect of soil management practices (conventional, reduced and no tillage) at different soil moisture content (65 and 85 % of field capacity, F.C.) with two fertilizer types (urea and ureaform) on soil carbon dioxide flux in order to mitigate its effect on global climate changes as well as sunflower growth.

The results indicated that the emitted soil CO_2 ranged from 12.49 to 22.65, 14.49 to 25.06 and 14.14 to 25.95 g/ 100 m^2 for no tillage (NT), reduced tillage (RT) and conventional tillage (CT), respectively at 65 % of F.C., with using urea fertilizer. The lowest emitted CO_2 values were observed in the second week while the highest ones were noticed in the 5th week for NT treatment and in the 7th week for RT or CT treatment. The trend line of CO_2 emission was less inclined under NT than under RT or CT tillage. The trend line of the emitted soil CO_2 under RT and CT treatments subsequently became approximately equal.

The young growing plants at 85% of F.C. using urea fertilizer showed more CO_2 uptake than it at 65% of F.C. using ureaform fertilizer. The no tillage treatment (NT) had higher CO_2 flux than RT treatment at the beginning of the evaluation period (till 4th week) and lower flux at the end. The trend line of emitted soil CO_2 from CT treatment showed almost a steady flux through the growing season (10 week), and the CO_2 flux values ranged between 17.71 and 25.40 g/ 100 m^2.

Sunflower grain yield was significantly affected by soil moisture content and fertilizer type as well as it was highly significantly affected by tillage manner. Sunflower grain yield was higher in the plots treated with ureaform at 65 % of F.C. than in those treated with urea at 85 % of F.C. It was superior under the conventional tillage followed by the reduced tillage then no tillage. On the average basis, sunflower grain yield was 1.97, 2.01 and 2.22 ton/ fed for NT, RT and CT, respectively at 65% of F.C. However, it was 1.05, 1.76 and 2.22 ton/ fed for the respective treatments at 85 % of F.C.

Keywords: Carbon dioxide flux, Tillage system, Soil moisture content, Nitrogen fertilizers, Sunflower crop.

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Introduction:

Tillage operations strongly control the soil environment by altering the soil geometry. Soil tillage management can affect factors controlling soil respiration, including substrate availability, soil temperature, water content, pH, oxidation-reduction potential, kind and number of microorganisms, and the soil ecology (Acquaah, 2002).

Alvarez and Alvarez (2000) found that active microbial biomass and carbon mineralization were higher under no tillage (NT) than under conventional tillage in the top 5 cm of the soil profile. A widespread adoption of conservation tillage could result in net increases in carbon sequestration in agricultural lands, reversing its decline caused by intensive tillage practices used for decades (Campbell *et al*. 2001). Carbon sequestration rates can be expected to peak in 5 to10 years with increasing soil organic carbon (SOC) reaching a new equilibrium in 15 to 20 years. Increased carbon storage has been frequently observed in soils under conservation tillage, particularly with no till (Zibilske *et al*., 2002). Yang *et al*. (2003) indicated that the conversion from conventional tillage to conservation tillage at an annual rate of 2%, particularly no till, could reverse the loss of SOC in Chinese Mollisols within 20 years. Soil plowing is a principal cause of CO_2 emission from croplands leading to a depletion of soil organic matter content (Lal, 2004). Valzano *et al.* (2005) stated that, in most instances, increased tillage levels or increased tillage periods resulted in reductions in soil carbon. There are confounding factors, however, that moderate the extent to which low or no tillage and stubble retention improve soil carbon levels. La Scala *et al.* (2006) reported that conventional tillage caused the highest CO_2 emission during almost the whole study period of 4 weeks. Tillage also stimulates soil organic matter decomposition, releases more CO_2 into the atmosphere, and contributes to global warming (Baker *et al.,* 2007). Chatskikh and Olesen (2007) observed a reduction in carbon dioxide emissions with a reduction in tillage. Carbon dioxide emissions following conventional tillage of 40 kg C/day were 25 % higher than carbon dioxide emissions measured for the direct drill treatment. Usually, short-term CO_2-C flux after tillage is higher in the conventional tillage plots or in some cases similar to the ones registered in the no-tillage plots (Costa *et al*., 2008). Recent estimation showed that conversion of cropland practice from conventional tillage to no-tillage will potentially sequester 4.60 Tg C/yr (Lu *et al*., 2009). The conversion from conventional till to no till restored some of the depleted SOC and N pools in a long-term tillage experiments in different soils of Ohio, USA (Mishra *et al*., 2010). Moussadek *et al*. (2011) found that immediately after fall tillage, the conventional tillage showed the highest CO_2 flux of 4.9 g m^2/ h; reduced tillage exhibited an intermediate value of 2.1 g m^2 / h whereas the lowest flux of 0.7 g m^2/ h was reported under no tillage. The aim of the current study is to asses the effect of soil management practices (conventional, reduce and no tillage) at different soil moisture content (65 and 85 %) with two fertilizer types (urea and ureaform) on soil carbon dioxide flux in order to mitigate its effect on global climate changes. The study also tends to obtain the most cropping productivity that can sequester CO_2 in soil and reduce its emissions by trying different management practices to asses the optimum ones.

Materials and Methods:

The experiment was conducted at the experimental farm, Faculty of Agriculture, Al-Azahar University, Assuit, Egypt (27° 12- 16.67= N latitude and 31° 09- 36.86= E longitude). The site is characterized by a flat relief and is dominated by well drained Torrifluvents (Soil Survey Staff, 1996) that are clay loam in texture, slightly alkaline and have low organic matter but adequate potassium level in the top layers of 60 cm soil depth (Table 1).

Table 1: Some chemical (a) and physical (b) properties of soil at the experimental site.

a- Chemical properties

Depth (cm)	O.M. (%)	$CaCO_3$ (%)	pH	EC_e (dS/m)	Soluble ions (meq/L) in the soil paste							Available nutrients (ppm)		
					CO^{-2}_3 + HCO^{-1}_3	Cl^{-1}	SO^{-2}_4	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	N	P	K
0-25	2.13	3.41	7.66	0.95	2.25	1.20	6.0	2.50	1.30	5.24	0.13	70.0	9.63	367
25-50	2.01	3.11	7.75	1.09	2.04	1.10	6.89	2.80	1.48	5.57	0.20	56.5	9.55	343

O.M. = organic matter EC_e = electrical conductivity of soil past extract

b- Physical properties

Depth (cm)	Particle-sized distribution %			Texture class	Moisture content %		A.W. (%)
	Sand	Silt	Clay		F.C.	W.P.	
0-25	26.50	40.00	33.50	Clay Loam	41.0	20.3	20.7
25-50	25.11	39.14	35.75	Clay Loam	40.8	20.0	20.8

F.C. = field capacity   W.P. = wilting point   A.W. = available water

The study included two levels of soil moisture content, with three tillage manner and two nitrogen fertilizers at the recommended level. The experiment was laid out in split split plots design with 12 treatments and three replications. The main plots were assigned for irrigation regimes (65 and 85% of F.C.) and they were bounded with a buffer zone of 3 m width to avoid the horizontal seepage of irrigation water. The split plots were assigned for three tillage manner as follows: a) No tillage (NT) where flat discs were 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) Reduced tillage (RT), where the residues of the previous crop were left on the soil surface, as mulch, and a minimum vertical tillage (chiseling, 15 cm depth) and disc harrowing (5 cm depth) were carried out immediately before sowing and c) Conventional tillage (CT), after burning the residues of the preceding crop, the soil was ploughed to a 30 cm depth by chisel plough (consisted of 7 rigid shanks of 18 cm width and spaced 28 cm apart). The split split plots were assigned for two nitrogen fertilizers at the recommended level (Urea 46.5%

N as a fast nitrogen fertilizer and ureaform 40% N as a slow nitrogen fertilizer). In addition to the previous treatments, a control uncultivated soil treatment was used as a base line for emitted carbon dioxide and to asses the changes in the ecosystem. The plot area was almost 100 m^2 (10 x 10 m^2, 1/40 fed.) and the previous crop was alfa alfa.

In the summer season of 2011 and 2012, sunflower seeds (cultivar *sakha 130*) were planted in the 14^{th} of June of both years in hills 20 cm apart from each other and 60 cm distance between rows. All cultural management practices for growing sunflower were conducted in the same way as they were carried out in the neighboring fields following the recommendation of the Egyptian Ministry of Agriculture. Phosphorus fertilizer in the form of superphosphate (15.5% P_2O_5) was broadcasted during soil preparation processes at a level of 100 kg superphosphate / fed. Ureaform slow release nitrogen fertilizer (75 kg N/ fed) was added to the soil before sowing. While urea fertilizer was added to plants in three doses: the 1^{st} does 22kg N/fed) was after 15 days, the 2^{nd} one (22kg N/fed) was after 60 days and the 3^{rd} one (22kg N/fed) after 75 days from planting. Potassium was added as K_2SO_4 in two doses, the 1^{st} dose (25kg K_2O/fed) was after 15 days and the 2^{nd} one (25kg K2O/fed) was after 75 days from plantation. In both seasons, the sunflower plants were harvested after 93 days from planting. Plant samples of sunflower were collected for growth and yield measurements from square meters of each plot.

Classical chamber method was used for CO_2 measurement by trapping it in alkali solution, which allows CO_2 fluxes from the soil to be measured directly (Davidson *et al.*, 2002). Each measurement chamber (38 cm in length x 23 cm in width x 22 cm in height) covered a soil surface of 0.0874 m^2 and had transparent PVC walls. To prevent CO_2 leakage to atmosphere, the chamber was inserted 5 cm deep into the soil. The soil surface CO_2 flux (Fs) measurements were taken in the daytime between 9 and 11 o'clock every week using a glass jar filled with 100 ml of 1 N sodium hydroxide. The jars were removed from the chambers, quickly capped, and sent to the laboratory for analysis according to Stevenson (1986). Carbon evolved as CO_2 was estimated by the formula outlined by Stotzky (1965). At the same times and locations when CO_2 emission was measured, soil samples were collected from surface layer (0–15 cm) to determine soil water content.

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

Sunflower plants were sampled at harvesting time and ten guarded sunflower plants were chosen randomly from each treatment to estimate plant height (cm), head diameter (cm), seed index (g) and grain yield (ton/ fed). The seed oil content of sunflower plants was determined as outlined by Bedov (1985). The collected data were subjected to a statistical analysis using the MSTAT micro computer program.

Results and Discussion:

The emission of carbon dioxide from soils depends on many factors such as tillage, fertilization, soil moisture regime, soil temperature and land use type. It is important to improve our understanding of soil processes in order to gain more confidence in projections about future changes in the global atmospheric CO_2 concentration.

Figure (1) shows the effect of tillage manner on soil CO_2 flux after week from planting and the 10 subsequent weeks through the summer sunflower growing season of 2011 and 2012 (average values) at 65% of the field capacity (F.C.) when the soil was fertilized by urea. Diurnal CO_2 patterns were evident in all weeks during the growing season as the emitted soil CO_2 increased with the time for all tillage manners. During this period (10 weeks) the emitted soil CO_2 ranged from 12.49 to 22.65, 14.49 to 25.06 and 14.14 to 25.95 g/ 100 m^2 for no tillage (NT), reduced tillage (RT) and conventional tillage (CT), respectively. The lowest CO_2 flux values were observed in the second week while the highest ones were noticed in the 5^{th} week for NT treatment and in the 7^{th} week for RT or CT treatments. The trend line was less inclined under NT than under RT or CT tillage. The trend line of the emitted soil CO_2 under RT and CT treatments subsequently became approximately equal. This might be related first to the temperature dependence of soil respiration, and then later related to the light dependence of photosynthesis (Rolston *et al.*, 2010).

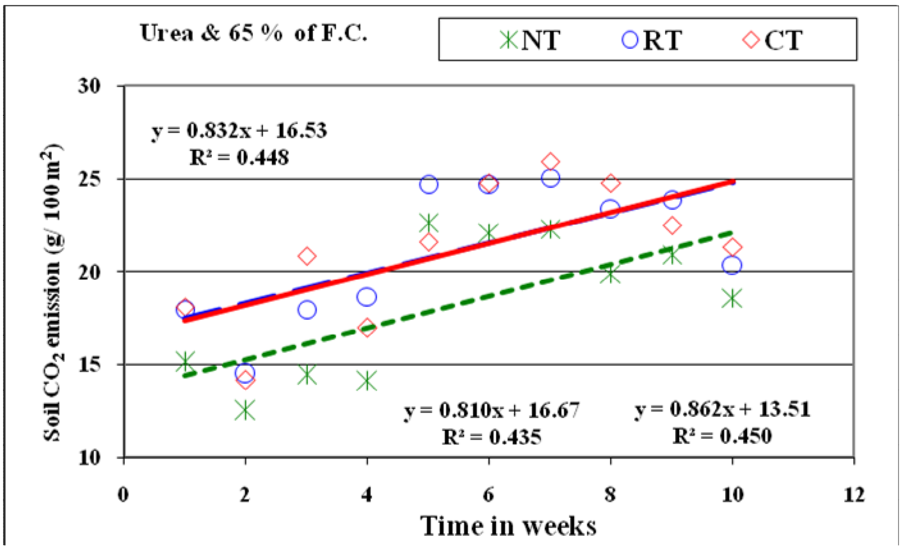

Fig. (1). Soil carbon dioxide emission (average values) in relation to time and tillage manner when soil was fertilized by urea at 65% of F.C. for sunflower.

A slight difference persisted in the emitted soil CO_2 as a result of tillage manner at 85 % of F.C. when the soil was fertilized by urea (Fig. 2). The trend lines of tillage manner are much closer and they increased as the time proceed. In the 2^{nd} week of both years following the planting of sunflower years, strong diurnal photosynthetic patterns (negative net ecosystem exchange) were observed by the young growing plants with 85% of F.C. showing more CO_2 uptake than with 65% of F.C. In general, the trend lines of emitted soil CO_2 were confined between 15 and 25 g/ 100 m^2 for 65 % of F.C. and between 15 and 27 g/ 100 m^2 for 85 % of F.C. Buchner *et al.* (2008) pointed out that surface CO_2 fluxes showed a significant dependence on soil hydraulic properties.

Figure (3) shows the effect of tillage manner on soil CO_2 flux through the summer sunflower growing season of 2011 and 2012 (average values) at 65% of F.C. when the soil was fertilized by ureaform. In general, the results indicated that the emitted soil CO_2 from NT treatment was less than from RT or CT. The no tillage treatment (NT) had higher CO_2 flux than RT treatment at the beginning of the evaluation period (till 4th week), but a lower flux at the end. The trend line of emitted soil CO_2 from CT treatment shows almost a steady flux through the growing season (10 weeks) and CO_2 flux values between 17.71 and 25.40 g/ 100 m^2.

Futhermore, almost similar results were recognized when the soil was irrigated at 85 % of F.C. (Fig. 4).

The weekly soil CO_2 flux recorded in the NT plots ranged from 13.59 to 24.37 g/ 100 m^2, while it varied from 13.11 to 26.09 g/ 100 m^2 in the RT or CT ones. Generally, CT treatment showed the highest amount of emitted soil CO_2 during the entire growing season.

A number of possible mechanisms were reported to be involved in tillage-induced reductions in soil carbon. These mechanisms include:

- The physical disruption of soil carbon may result in a higher rate of microbial breakdown. Such a decline was due to increases in the decomposition rate by the shattering of macroaggregates, mixing of surface soil and increases in the intensity and number of wetting and drying cycles. The repeated cultivation of soils combined with limited carbon inputs eventually results in major aggregate breakdown leaving the soil vulnerable to erosion and compaction (Anderson, 2009). Also, the movement and incorporation of soil carbon deeper into a profile, moisture conditions facilitate microbial breakdown.

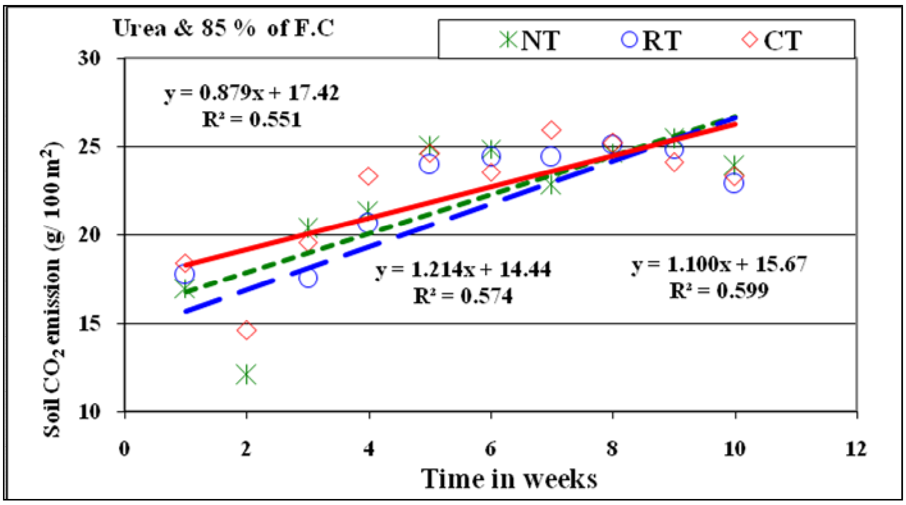

Fig. (2). Soil carbon dioxide emission (average values) in relation to time and tillage manner when soil was fertilized by urea at 85% of F.C. for sunflower.

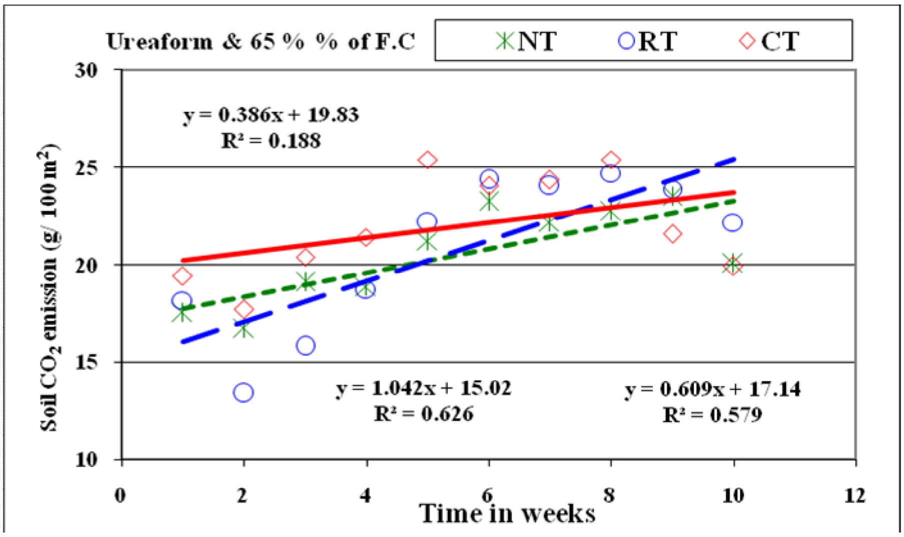

Fig. (3). Soil carbon dioxide emission (average values) in relation to time and tillage manner when soil was fertilized by ureaform at 65% of F.C. for sunflower.

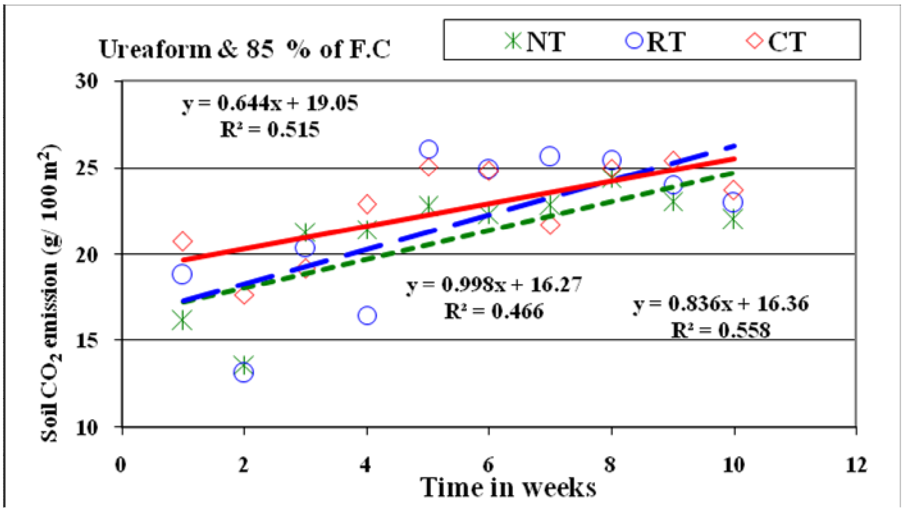

Fig. (4). Soil carbon dioxide emission (average values) in relation to time and tillage manner when soil was fertilized by ureaform at 85% of F.C. for sunflower.

Each tillage system should adapt to the local characteristics of soil, climate and crop. These variables determine the management required in each specific situation. Conservation tillage usually has positive re-percussions on soil quality and crop yield mainly due to the improvements achieved in soil water storage, especially in regions where this parameter is often limiting under conditions of drought (Murillo *et al.*, 2001). West and Marland (2002) found that compared to conventional tillage systems, a no-tillage system was found to sequester 337±108 kg C/ha/yr more C to a sampling depth of 30 cm. In contrast, the difference between the ability of reduced tillage and no tillage systems to sequester carbon was insignificant.

Tillage also could disrupt soil aggregate and transfer labile or fresh organic matter once protected by aggregates to unprotected readily decomposable organic matter, thus exposing them to microbial attack (De Gryze *et al.*, 2006; Grandy and Robertson, 2007 ; La Scala *et al.*, 2008). Chavez *et al.* (2009) revealed that at a low soil temperature and soil water content conditions, soil tillage caused a limited increase in soil CO_2-C flux. The lower soil CO_2 efflux (SCE) before the tillage might be due to slower decomposition of crop residues placed on the soil surface than when they were incorporated into mineral soils after the tillage (Curtin *et al.*, 2000).

The tillage-induced increase in SCE might partially be attributed to the increases in temperature and moisture sensitivity of SCE. The SCE significantly increased after the tillage, especially immediately after irrigation. The mean SCE increased from 2.56 ±0.66 μmol/ m^2 /sec before the tillage to 6.73 ±3.61 μmol/ m^2 /sec after the tillage, with an increment of 2.6 times. By comparing SCE measured before and after the tillage in the same ranges of soil temperature and moisture, the CO_2 efflux increased by 1.2 to 2.2 times.

Also, tillage could change soil physical factors, such as soil temperature, soil moisture, O_2 concentration, the contact of soil microbes with substrate, and substrate distribution. The reason may be that the tillage-loosed soil was favorable to heat exchange and irrigation water infiltration (Zhang *et al.*, 2011).

Activities used to sequester carbon in cropland soils have the potential to alter land use and land cover indirectly through their effect on crop yields. In general, the results obtained in this investigation show that sunflower grain yield was significantly affected by soil moisture content and fertilizer type as well as it was highly significantly affected by tillage manner (Table 2). In both seasons sunflower grain yield was superior under the conventional tillage followed by the reduced tillage and then the no tillage. Under the CT tillage, sunflower showed highest plant height head diameter, grain yield and seed index, either when irrigated at 65% F.C. or 85% F.C. Mean sunflower grain yield was 1.97, 2.01 and 2.22 ton/ fed for NT, RT and CT, respectively at 65% of F.C. It was 1.05, 1.76 and 2.22 ton/ fed for the respective treatments at 85 % of F.C. The yield component of sunflower (head diameter, plant height, seed index and seed oil) followed the same trend of sunflower yield.

The ureaform fertilizer at the used recommended rate gave significantly higher grain yield and seed index than those obtained with the urea fertilizer in both seasons. Also, the application of irrigation regime of 65% F.C. was superior for sunflower growth and yield in both seasons than of 85% F.C. regime. This means that frequent irrigation of sunflower plants (at 85% F.C.), even though at the high temperature in summer season, may supress vegetative plant growth and could result in reduction in grain yield and seed index, especially under the NT treatment. The interaction of soil moisture content (irritation at different % F.C.) and tillage manner, showed significant (year 2011) and highly significant (year 2012) effects on sunflower yield and yield components (table 2).

It is thus evident that tillage practices have major effects on soil properties and amount of emitted CO_2 from soil. The adoption of conservation tillage for reversing the decline of SOC in agricultural lands is possible in the clay soil of Egypt, as it has been in many other countries. But, cultivation and crop type, high temperature during summer season and a semiarid climate accelerate organic carbon loss and weaken soil structure.

Also, tillage and residue incorporation enhance C mineralization and atmospheric fluxes, suggesting that tillage intensity should be decreased to reduce C loss. Continuous monitoring of long-term changes in the soil organic carbon and soil quality under conservation tillage in different agro-ecological zones is essential. There is also a need to obtain more data on long-term effects of different tillage systems on carbon and nitrogen mineralization and immobilization in field situations. It is worthy to mention that tillage is still a farming practice widely used in Egypt and overlaps with hot and dry summer. From this point of view, the conventional tillage practice should be revaluated.

Table 2. Effect of tillage manner, fertilizer type and irrigation at different moisture content of field capacity on sunflower yield and its component.

summer 2011									
parameter	fertilizer type	65% of F.C.				85% of F.C.			
		NT	RT	CT	mean	NT	RT	CT	mean
Grain yield(ton/fed)	U	1.96	1.85	2.13	1.98	1.33	1.74	2.13	1.73
	UF	2.03	2.11	2.23	2.12	1.39	1.83	2.16	1.79
	mean	2.00	1.98	2.18	2.05	1.36	1.79	2.14	1.76
	LSD	A*=0.142	B*=0.10	C**=0.01	AC*=0.31				
Head diamter (cm)	U	21.80	22.17	23.07	22.34	17.67	20.40	22.67	20.24
	UF	21.53	23.00	24.47	23.00	17.20	21.60	23.10	20.63
	mean	21.67	22.58	23.77	22.67	17.43	21.00	22.88	20.44
	LSD	A*=2.07	C**=0.43	AC*=1.75					
Plant height(cm)	U	179.7	197.0	212.7	196.44	166.7	199.0	231.0	198.89
	UF	202.7	222.3	224.3	216.44	171.0	235.0	222.0	209.33
	mean	191.2	209.7	218.5	206.44	168.8	217.0	226.5	204.11
	LSD	B**=6.99	C**=8.13	BC**=11.5	AC**=11.5				
Seed index(g)	U	6.45	6.13	7.05	6.54	5.71	6.44	7.06	6.40
	UF	6.74	6.80	8.08	7.20	5.67	6.55	7.95	6.72
	mean	6.59	6.47	7.56	6.87	5.69	6.50	7.50	6.56
	LSD	B**=1.29	C**=0.30	AC**=0.46	BC*=0.46				
Seed oil %	U	45.84	37.10	42.15	41.70	38.05	39.28	42.44	39.93
	UF	46.29	40.38	47.37	44.68	41.95	39.60	43.03	41.53
	mean	46.07	38.74	44.76	43.19	40.00	39.44	42.74	40.73
	LSD	A*=2.01	C**==2.68						
summer 2012									
Grain yield(ton/fed)	U	1.77	1.83	2.42	2.01	0.74	1.67	2.40	1.60
	UF	2.11	2.23	2.09	2.14	0.76	1.81	2.19	1.59
	mean	1.94	2.03	2.26	2.08	0.75	1.74	2.30	1.59
	LSD	A*=0.31	C**=0.05	AC**0.26	BC*26				
Head diamter (cm)	U	21.00	22.00	23.67	22.22	16.00	19.67	24.67	20.11
	UF	21.00	22.33	23.67	22.33	15.67	21.00	23.33	20.00
	mean	21.00	22.17	23.67	22.28	15.83	20.33	24.00	20.06
	LSD	A*=1.04	C**=1.00	AC**=1.42					
Plant height(cm)	U	165.0	198.7	213.7	192.44	153.3	186.0	238.3	192.56
	UF	195.7	206.7	203.3	201.89	163.7	221.7	223.3	202.89
	mean	180.3	202.7	208.5	197.17	158.5	203.8	230.8	197.72
	LSD	B*=5.76	C**=4.53	AC**=6.41	BC**=6.41	ABC**=9.06			
Seed index(g)	U	8.41	6.74	8.22	7.79	4.85	6.44	7.59	6.30
	UF	6.78	6.19	7.04	6.67	4.69	7.57	6.69	6.32
	mean	7.59	6.47	7.63	7.23	4.77	7.01	7.14	6.31
	LSD	A**=0.39	B**=0.27	AB**=0.38	B**=0.21	C**=0.29	AC**=0.29	ABC**=0.41	
Seed oil %	U	44.84	37.52	42.95	41.77	38.97	40.103	42.503	40.53
	UF	46.79	40.15	48.04	44.99	41.91	41.70	42.26	41.96
	mean	45.81	38.83	45.50	43.38	40.44	40.90	42.38	41.24
	LSD	A*=5.96	C**=2.87	AC*=4.06					
A= Irrigation at F.C.				B= Fertilyzer type			C= Tillage manner		

References:

Acquaah, G. (2002). Principles of Crop Production: Theory, Techniques, and Technology. Pearson Education, Inc., Upper Saddle River, New Jersey.

Alvarez, C.R. and R. Alvarez (2000). Short-term effects of tillage systems on active soil microbial biomass. Biol. Fert. Soils, 31: 157–161.

Anderson, G. C. (2009). The impact of tillage practices and crop residue (stubble) retention in the cropping system of western Australia. Western Australia Agricultural Authority. Bulletin No.4786.

Baker, J. M., T. E. Ochsner, R. T. Venterea and T. J. Griffis (2007). Tillage and soil carbon sequestration—What do we really know? Agriculture, Ecosystems and Environment 118, 1–5.

Bedov, S. (1985). A study of combining ability for oil and protein contents in seed of different sunflower inbreds. In Proc. 10th Int. Sunflower Conf. Mar del Plata, Argentina. 10-13 Mar. 1985. Int. Sunflower Assoc. Paris, France. P 675-682.

Buchner, J. S., J. Ŝimůnek; J. Lee, D. E. Rolston, J. W. Hopmans, A. P. King and J. Six (2008). Evaluation of CO_2 fluxes from an agricultural field using a process-based numerical model. J. Hydrology 361: 131–143.

Campbell, C.A., F. Selles, G.P. Lafond, V.O. Biederbeck and R.P. Zentner (2001). Tillage-fertilizer changes: Effect on some soil quality attributes under long-term crop rotation in a thin Black Chernozem. Can. J. Soil Sci., 81: 157–165.

Chatskikh, D and J.E. Olesen (2007). Soil tillage enhanced CO_2 and N_2O emissions from loamy sand soil under spring barley. Soil and Tillage Research 97: 5–18.

Chavez ، L. F, J. C. A Telmo, B. Cimélio, J. L. S. Newton, F. E Luisa and E. Jackson (2009). Carbon dioxidx efflux in a rhodic hapluxox as affected by tillage systems in southern BrazilR. Bras. Ci. Solo, 33:325-334.

Costa, F. S., C. Bayer, J.A. Zanatta and J. Mielniczuk (2008). Estoque de carbono orgânico no solo e emissões de dioxide de carbono influenciadas por sistemas de manejo no sul do Brasil. R. Bras. Ci. Solo, 32:323-332.

Curtin, D., H. Wang; F. Selles, B.G. McConkey and C.A. Campbell (2000). Tillage effects on carbon fluxes in continuous wheat and fallow-wheat rotations. Soil Sci. Soc. Am. J. 64: 2080-2086.

Davidson, A.; K. Savage, L. V. Verchot and R. Navarro (2002). Minimizing artifacts and biases in chamber-based measurements of soil respiration. Agr. Forest Meteor., 113(1–4): 21–37.

De Gryze S., J. Six and R. Merckx (2006). Quantifying water-stable soil aggregate turnover and its implication for soil organic matter dynamics in a model study. European Journal of Soil Sci., 57(5): 693–707.

Grandy, A. S. and G. P. Robertson (2007). Land-use intensity effects on soil organic carbon accumulation rates and mechanisms. Ecosystems, 10(1): 58–73.

Klute, A. (1986). Methods of soil analysis. Part 1: Physical and mineralogical methods (2nd edition). American Society of A gronomy Inc., Madison, Wisconsin, USA.

La Scala, J. N., A. Lopes, K. Spokas, D. Bolonhezi, D. W. Archer and D. C. Reicosky (2008). Short-term temporal changes of soil carbon losses after tillage described by a first-order decay model. Soil and Tillage Research, 99(1): 108–118.

La Scala, J. N., D. Bolonhezi and G. T. Pereira (2006). Short-term soil CO_2 emission after conventional and reduced tillage of a no-till sugar cane area in southern Brazil. Soil and Tillage Research, 91(1-2): 244–248.

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. Geoderma. 123: 1-22.

Lu, F., X. Wang, B. Han, Z. Quyang, X. Duan, H. Zheng, and H. Miao (2009), Soil carbon sequestrations by nitrogen fertilizer application, straw return and no tillage in China's cropland. Global Change Biol., 15: 281–305, doi:10.1111/j.1365-2486.2008.01743.x.

Mishra, U., D.A.N. Ussiri, and R. Lal (2010). Tillage effects on soil organic carbon storage and dynamics in Corn Belt of Ohio USA. Soil & Tillage Research 107:88-96.

Moussadek, R., R. Mrabet, R. Dahan, A. Douaik; A. Verdoodt, E. Van Ranst and M. Corbeels (2011). Effect of tillage practices on the soil carbon dioxide flux during fall and spring seasons in a Mediterranean Vertisol. Journal of Soil Science and Environmental Management Vol. 2(11), pp. 362-369,

Murillo, J. M., F. Moreno and F. Pelegrin (2001). Respuesta del trigoy girasolal laboreo tradicional y de conservación bajo condiciones de secano (Andalucía Occidental). Invest Agr: Prod Prot Veg 16: 395-406.

Page, A. L. (1982). Methods of Soil analysis. Part 2: Chemical and microbiological properties ,(2nd Ed). Am. Soc. of Agron. Inc. Soil Sci. Soc. of Am., Madison, Wisconsin, USA.

Rolston, D. E.; J. Lee.; K. T. Paw and J. Six (2010). Flux of carbon dioxide and nitrous oxide across scales of two tillage systems in a California agricultural system. World Congress of Soil Science, Soil Solutions for a Changing World, 1 – 6 August 2010, Brisbane, Australia. Published on DVD.

Soil Survy Staff (1996). Keys to Soil Taxonomy, 7th ed. USDA. Soil. Conservation Service, U. S. Gov. print. Office, Washington, DC. 644 pp.

Stevenson, F. J. (1986) Cycles of Soil. Carbon, Nitrogen, Phosphorus, Sulfur, Micronutrients. John Wiley & Sons, New York, NY.

Stotzky, G. (1965). Microbial respiration. p. 1550-1569. In Black, C.A. *et al*. (ed.), Methods of soil analysis. Part 2. Agronomy 9. ASA, Madison, Wisconsin, USA.

Valzano, F., B. Murphy and T. Koen (2005). The impact of tillage on changes in soil carbon density with special emphasis on Australian conditions. National Carbon Accounting System Technical Report 43.

West, T. O. and G. Marland (2002). A synthesis of carbon sequestration, carbon emissions, and net carbon flux in agriculture: comparing tillage practices in the United States, Agriculture, Ecosystems and Environment 91: 217–32.

Yang, X. M.; X.P. Zhang; W. Deng and H. J. Fang (2003). Black soil degradation by rainfall erosion in Jilin, China. Land Degrad. Dev., 14: 409–420.

Zhang, H., X. Wang., Z. Feng; J. Pang, F. Lu, Z. Ouyang, H. Zheng, W. Liu and D. Hui (2011). Soil temperature and moisture sensitivities of soil CO_2 efflux before and after tillage in a wheat field of Loess Plateau, China J. of Environ. Sci., 23(1): 79–86.

Zibilske, L. M., J. M. Bradford and J. R. Smart (2002). Conservation tillage induced changes in organic carbon, total nitrogen and available phosphorus in a semiarid alkaline subtropical soil. Soil Till. Res., 66: 153–163.

انبعاث ثاني أوكسيد كربون التربة نتيجة أساليب الحرث في نظم البيئه الزراعية

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أجريت تجربة حقلية بمزرعة كلية الزراعة جامعة الأزهر أسيوط– مصر (خط عرض *27° 12' 16.67"* شمالا وخط طول *31° 09' 36.86"* جنوبا) خلال موسمين متتالين لمحصول عباد الشمس (2011 ، 2012) بهدف تقييم تأثير اساليب الحرث (حرث عادي و شبه حرث وبدون حرث) والمحتوي الرطوبي (65% ، 85% من السعة الحقلية) ونوع السماد (اليوريا ، اليوريا فورم) علي انبعاث ثاني اوكسيد كربون التربة وكذلك علي النمو والمحصول لعباد الشمس بهدف تقليل أثره علي التغيرات المناخية.

أوضحت النتائج ان كمية ثاني اوكسيد الكربون المنبعث من التربة تراوحت ما بين 12.49 الي 22.65 ، 14.49 الي 25.06 ، 14.14 الي 25.95 جم/100م^2 مع معاملات بدون حرث و شبه الحرث والحرث علي التوالي عند محتوي رطوبي 65% من السعة الحقلية والتسميد باليوريا. وقد تم تسجيل أقل قيم لثاني اوكسيد الكربون المنبعث في الأسبوع الثاني بينما كانت أعلي القيم في الاسبوع الخامس للمعاملة بدون حرث وفي الأسبوع السابع مع معاملات الحرث الأخري. وكان اتجاه خط الانبعاث أقل انحدارا مع معاملة بدون حرث عنه في باقي معاملات الحرث ثم كان اتجاه خط الانبعاث تقربيا متساوي لمعاملات الحرث العادي وشبه الحرث. وكما أظهرت النباتات حديثة النموعند محتوي رطوبي 85% من السعة الحقلية مع سماد اليوريا تثبيت أكثر لثاني اوكسيد الكربون عنه عند محتوي رطوبي 65% من السعة الحقلية. وقد كان انبعاث ثاني اوكسيد الكربون أعلي في المعاملة بدون حرث عنها في معاملة شبه الحرث وذلك في بداية فترة التقيم (4 أسابيع) ثم انخفض عند نهاية الموسم وذلك مع استخدام سماد اليوريا فورم. وكان اتجاه خط انبعاث ثاني اوكسيد كربون للتربة المعاملة بالحرث العادي تقربيا ثابت خلال موسم النمو (10 اسابيع) حيث تراوحت قيم الأنبعاث بين 17.71الي 25.40 جم/100م^2.

تأثر محصول حبوب عباد الشمس معنويا بالمحتوي الرطوبي للتربة ونوع السماد وكان تأثره معنويا جدا باسلوب الجرث . وكان محصول حبوب عباد الشمس أعلي في الاحواض المعاملة باليوريا فورم عند محتوي الرطوبي 65% من السعة الحقلية عنه في الاحواض المعاملة باليوريا عند محتوي رطوبي 85% من السعة الحقلية. كما كان محصول الحبوب الأكبر تحت معاملة الحرث يليها معاملة شبه الحرث ثم معاملة بدون حرث. حيث كان 1.96 ، 2.01 ، 2.22 طن/فدان في المعاملة بدون حرث و شبه الحرث والحرث العادي علي التوالي عند محتوي الرطوبي 65% من السعة الحقلية بينما كان 1.05 ، 1.67 ، 2.22 طن/فدان مع المعاملات السابقة علي نفس الترتيب عند محتوي رطوبي 85% من السعة الحقلية.