# Effect of Different Types of Fertilization and Some Climatic Factors on Soil Carbon Dioxide ($CO_2$) Emission

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**Abstract:** As the atmospheric $CO_2$ concentration continues to increase, more attention is being focused on the soil as a possible sink for atmospheric $CO_2$. Fertilizer application to soil can play a vital role in influencing the losses of soil carbon by $CO_2$emission from the soil. This study was conducted to examine effect of different fertilization types on soil $CO_2$ emissions. Emission of $CO_2$ from wheat cultivated soil and fertilized with five different types of both organic and bio fertilizers were measured during seasons of 2011/2012 and 2012/2013, comparing with the emission in case of using chemical fertilizers at experimental farm and laboratory of Soils and Water Sci. Dept., Fac. of Agric., AL-Azhar Univ., Assiut, Egypt. Tested fertilizers were 150 L/fed., compost tea, 20 L/fed., K-Humate, 10 L/fed., EM, 150 L/fed., compost tea + 10 L/fed., EM, 20 L/fed., K-Humate + 10 L/fed., EM and common chemical fertilizers (NPK). Amount of $CO_2$ emission were measured frequently every 30 days after sowing date (30, 60, 90, 120 and 150 days) and total accumulated $CO_2$. Moreover, Soil properties as available nitrogen (AN), soil organic matter (SOM), soil pH content and yield and its components were determined. Results indicate that, the highest values of "AN" and "SOM" were recorded with compost tea + EM, while, the lowest values were obtained with chemical treatment. Chemical treatment increased soil pH more than other treatments except K-Humate and K-Humate + EM treatments. The compost tea + EM treatment gave the high reduction value of pH, while, control, K-Humate and K-Humate + EM treatments gave highest values without any significant between them. The greatest values of yield and its components were from applied compost tea + EM treatment. Meanwhile, the lowest values of tested parameters were recorded with added EM treatment. The lowest emission was taken by using compost tea + EM. While, the soil $CO_2$ emission was increased with added K-Humate + EM. In addition, amount of emission from soil was increased by the time to reach the peak after 120 days from sowing date. Furthermore, indicated that, the average air temperature, minimum air temperature, maximum air temperature and average soil temperature, respectively, had significant exponential relationship regression during the entire measuring period of $CO_2$ emission.

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## 1. Introduction

Carbon emissions related to human activities have been significantly contributing to the elevation of atmospheric ($CO_2$) and temperature. Recently, carbon emissions have greatly accelerated, thus much stronger effects on crops are expected **(DaMatta *et al.*, 2009).**

Carbon dioxide ($CO_2$) is an important greenhouse gas accounting for 60% of the total greenhouse effect. Soil is a major source for atmospheric $CO_2$. In the event of growing threats of global warming due to greenhouse gas emissions, reducing $CO_2$ emission by isolate C in the soil is prime importance. Soil management practices like increasing soil organic carbon content, reduced tillage, manuring, residue incorporation, improving soil biodiversity, micro-aggregation and mulching can play an important role in isolate C in soil **(Rastogi *et al.*, 2002).**

The $CO_2$ emitted from soils is a useful indicator to determine energy flow patterns, specifically the mineralization of nutrients and the rate of organic material decomposition. The $CO_2$ flow from soils is the result of plant roots, organic matter mineralization, microflora, fauna, and to a small extent, by chemical oxidation of carbon-bearing materials. **(Curtin *et al*, 2000; Matteucci *et al.*, 2000; Al-Kaisi and Yin, 2005; Sainju *et al.*, 2008; Muñoz *et al.*, 2010).**

The rate of soil $CO_2$ emission is normally controlled by several factors, such as $CO_2$ concentration gradient between the soil and the atmosphere, soil temperature, soil moisture, pore size, and wind speed **(Raich and Schlesinger, 1992**). In addition, soil $CO_2$ emission is affected by agricultural practices such as irrigation, tillage, cropping system and N fertilization can alter crop residue C inputs, nutrient dynamics, soil temperature, residue management and varies with climatic conditions

**(Fernandez *et al*., 1993; Burton and Beauchamp, 1994; Osozawa and Hasegawa, 1995; Yavitt *et al*., 1995; Curtin *et al*., 2000; Al-Kaisi and Yin, 2005; Sainju *et al*., 2008)**. The measurement of soil $CO_2$ emission could provide a more sensitive indication of soil C sequestration than low-resolution data such as total or organic C values **(Fortin *et al*., 1996; Grant, 1997)**.

The atmospheric carbon dioxide ($CO_2$) concentration has increased about 85 ppm in the last 100 years **(Lal, 2004)** and approximately 10% of the $CO_2$ in the atmosphere passes through the soil each year **(Raich and Potter, 1995; Wilson and Al-Kaisi; 2008)**. The emission of $CO_2$ was affected by the phenological stage of the plant while organic fertilizer increased the $CO_2$ emission **(Fernández-Luqueño *et al*., 2009)**.

Moreover, soil $CO_2$ emission is the main pathway of carbon emission from soil to atmosphere in terrestrial ecosystems and an important source of atmospheric $CO_2$ **(Fang *et al*., 1998; Maljanen *et al*., 2003; Koponen *et al*., 2006; Nosalewicz *et al*., 2013)**. Annual global soil respiration is estimated at 68–100 Pg $year^{-1}$ of C **(Raich and Schlesinger, 1992; Raich and Potter, 1995)**, accounting for almost 10% of the atmospheric $CO_2$ cycles **(Raich and Schlesinger, 1992; Raich and Potter, 1995)** and more than 11 times of the $CO_2$ released from fossil fuel combustion **(Marland *et al*., 2000)**. Therefore, knowledge of soil respiration dynamics and its controlling factors in different terrestrial ecosystems is essential to find proper management policies and relevant technologies to decrease soil $CO_2$ emissions and enhance carbon isolate.

Many studies have proved that organic fertilizer contributes to $CO_2$ emissions after soil application and the introduction of appropriate manure management techniques represents one opportunity for greenhouse gases mitigation (**Bertora *et al*., 2008; Fernández-Luqueño *et al*., 2009; Cayuela *et al*., 2010)**.

Nitrogen has been regarded as a significant factor controlling soil respiration in N-deficient terrestrial ecosystems. Especially in the next few decades, with increasing rates of anthropogenic N deposition **(Galloway *et al*., 1994; Mosier *et al*., 2002)** and application of fertilizer, much N is to enter terrestrial ecosystems. This will change soil N status and plant N concentrations **(Houghton, 2002; Magill *et al*., 1997)**. As a result, this will affect plant growth **(Nadelhoffer *et al*., 1999)**, microbial activities **(Compton *et al*., 2004; Frey *et al*., 2004)**, litter decomposition **(Magill and Aber, 1998)**, and root respiration **(Vose and Ryan, 2002)**, and thus soil respiration is expected to change. Many studies on the effect of N additions on soil respiration have been conducted **(Bowden *et al*., 2000; 2004; Burton *et al*., 2004; Micks *et al*., 2004)** as well as agricultural ecosystems **(Ding *et al*., 2007; Al-Kaisi *et al*., 2008)**.

Since the application of organic fertilizers became rare during the last decade, at present the main source of organic matter for cultivated soils are roots and stubble residues of agricultural plants. The rate of $CO_2$ emission from the soil is an important indicator of its microbial activity and intensity of organic matter decomposition. As a rule, the measurements of $CO_2$ emission rate are carried out through the growing period under field conditions and at a temperature above 5°C in the model experiments. It is suggested that $CO_2$ production and emission are very poor at low temperatures, and total $CO_2$ emission is negligible beyond the growing season **(Lopes de Gerenyu *et al*., 2005)**.

It is well known that $CO_2$ production, transport and emission in soil depend on environmental factors such as aeration condition, soil temperature, soil moisture, supplies of organic carbon, fertilization, pH, etc. **(Janzen *et al*. 1998; Weitz *et al*., 2001; Bowden *et al*., 2004; Lin *et al*., 2010)**.

Temperature (soil or air) is the best predictor of the annual and seasonal dynamics of $CO_2$ evolution rate of soils **(Fung *et al*., 1987; Kätterer *et al*., 1998; Kirschbaum, 2000; Raich *et al*., 2002; Perrin *et al*., 2003)**. Meanwhile, soil temperature is the main ecological factors controlling the process of soil organic matter decomposition, $CO_2$ production and emission from soils **(Kowalenko, *et al*., 1978; Swift *et al*., 1979; Lomander *et al*., 1998; Rustad *et al*., 2000)**. A high positive correlation between $CO_2$ emission rate and soil temperature was found for many soils under natural and agricultural conditions **(Raich and Schlesinger, 1992; Lloyd and Taylor, 1994; Kudeyarov and Kurganova, 1998; Kurganova and Kudeyarov, 1998; Raich *et al*., 2002; Lopes de Gerenyu *et al*., 2005)**. In addition, a positive correlation between soil temperature and soil $CO_2$ efflux is well described by several reviews **(Singh and Gupta, 1977; Reich and Schlesinger, 1992; Lloyd and Taylor, 1994; Kätterer *et al*., 1998)**.

Concerning effects of air temperature, results of mathematical modeling suggest that, in mid- to high-latitude regions, moderate to medium local increases in temperature (1– 3 °C), along with associated $CO_2$ increase and rainfall changes, can have beneficial impacts on crop yields, but in low-latitude regions even moderate temperature increases (1–2 °C) are likely to have negative impacts on yield of major cereals **(Easterling *et al*., 2007)**.

The aims of the present study were first to quantify the seasonal fluxes of $CO_2$ from cultivated wheat with using different types of fertilizers. Second is to determine the impact of soil and air temperature on $CO_2$ evolution rate from the soil.

## 2. Materials and Methods

### Site and treatment description:

The present investigation was carried out on the experimental farm and laboratory of Soils and Water Sci. Dept., Fac. of Agric., AL-Azhar Univ., Assiut, Egypt, during two successive winter seasons of 2011/2012 and 2012/2013. The aim of conducted field experiment to study the effect of organic sources of nutrients use (Compost tea and K-Humate), and EM "Effective Microorganisms" bio-fertilization on soil $CO_2$ emissions as well as improving chemical and biological activity properties through 5 periods (30, 60, 90, 120 and 150 days from sowing date) and total accumulated $CO_2$. The experiment was designed as randomized completed blocks design with three replicates. Experimental treatments included six treatments as are presented as follow:

1. NPK (Control),
2. 150 L/fed. Compost tea,
3. 20 L/fed. K-Humate.
4. 10 L/fed. EM,
5. 150 L/fed. Compost tea + 10 L/fed EM and
6. 20 L/fed. K-Humate + 10 L/fed EM.

Experimental plots area was 3 × 3.5 m = 10.5 $m^2$ (1/400 fed.). Physical and chemical properties of the experimental soil sample collected before planting wheat seeds were presented in Table (1):

**Table 1: Soil physical and chemical properties of the soil.**

| Particle-Size distribution | | | Texture grade | Saturation capacity (%) | Field capacity (%) | Wilting point (%) | Bulk density (g/cm3) | Particle density (g/cm3) |
|---|---|---|---|---|---|---|---|---|
| Sand % | Silt % | Clay % | | | | | | |
| Season 2011/12 | | | | | | | | |
| 55.20 | 29.60 | 15.20 | Silt loam | 51.50 | 25.75 | 12.87 | 1.49 | 2.54 |
| Season 2012/13 | | | | | | | | |
| 57.68 | 27.31 | 15.01 | Silt loam | 52.32 | 26.16 | 13.08 | 1.50 | 2.57 |
| C.E.C (cmolc $kg^{-1}$) | $CaCO_3$ (%) | O.M (%) | ECe ($dSm^{-1}$) | pH soil past | Total-N (%) | Ava-N (mg/kg) | Ava-P (mg/kg) | Ava-K (mg/kg) |
| Season 2011/12 | | | | | | | | |
| 13.90 | 1.29 | 1.59 | 1.43 | 7.12 | 0.18 | 62.72 | 11.57 | 169.41 |
| Season 2012/13 | | | | | | | | |
| 12.84 | 1.33 | 1.63 | 1.38 | 7.23 | 0.20 | 68.98 | 10.47 | 156.85 |

### Sources of nutrients:

(I) NPK: mineral fertilizer as ammonium nitrate, calcium super phosphate and potassium sulphate as they are commonly used for growing wheat plants and recommended by Ministry of Agriculture were applied to be the control treatment.

(II) K-Humate: Potassium humate was extracted and using the classic alkali/acid fractionation procedure and analysis conducted according to standard methods **(Valdrighi *et al.,* 1996)**.

(III) Compost tea: Technical approaches to making are aerobic compost tea was procedure **(Ingham, 2005)**, Chemical analysis of the compost tea and soil was conducted according to **Page *et al.* (1982)**.

(IV) EM (Effective microorganisms): Technology of nature farming was introduced by Japanese scientists **(Higa, 1989)** was provided from the ministry of Agriculture.

The total amounts of K-Humate, compost tea, EM, K-Humate + EM and compost tea + EM add to soil during irrigation in equal three doses.

**Table 2: Chemical analyses of organic fertilizers applied.**

| Organic fertilizer | pH (1:2.5) | EC $dSm^{-1}$ (1:2.5) | O.M (%) | N ($mgkg^{-1}$) | P ($mgkg^{-1}$) | K ($mgkg^{-1}$) |
|---|---|---|---|---|---|---|
| Season 2011/12 | | | | | | |
| K-Humate | 11.92 | 4.49 | 14.82 | 961 | 48 | 1462 |
| Compost tea | 7.61 | 1.84 | 8.61 | 245 | 19 | 206 |
| Season 2012/13 | | | | | | |
| K-Humate | 12.62 | 4.69 | 14.51 | 954 | 50 | 1470 |
| Compost tea | 7.73 | 1.89 | 7.83 | 235 | 18 | 212 |

**Cultivation and sampling:**

Wheat seeds (*Triticum aestivum vulgar.,* CV. Sids 1) at rate of 15 kg/fed were sown on December 1st under the surface irrigation method and harvested after 160 days from planting in the two seasons. Plant samples of one $m^2$ from each plot were harvested and ten plants were taken randomly to determine yield attributes (straw, grain and biological yield). Nitrogen was determined in wheat grain by the distillation in a Macro-Kjeldahle apparatus (Black, 1983), and protein content in wheat grains was determined according to **(A. O. A. C., 2000)**.

**Climatic data:**

Climatic factors considered in this study were: maximum, minimum, average air temperature (°C) and soil temperature (°C). All climatic factors were measured and recorded by automatic weather station (Latitude 27.5 °N, Longitude 31.1°E and Altitude 71 m), Campbell scientific, Inc, Central Laboratory for Agricultural Climate (CLAC).

**Soil sampling:**

Surface soil samples (0-30 cm) were collected after wheat harvest to determine the available nitrogen "AN", soil organic matter content "SOM" and soil pH.

*Soil $CO_2$ emission measurements:*

Twenty five $cm^2$ plastic boxes were placed in each experimental plot with a Kilter glass bottle containing 100 ml of 1.0 normal sodium hydroxide placed in the middle of the plastic boxes to trap the evolved $CO_2$ (samples were taken at 60% soil moisture). The plastic boxes were sealed (air-tight) during all periods.

The glass bottles with 1.0 N sodium hydroxyl (NaOH) were retrieved daily at end period (30 days). At each retrieval time, the plastic boxes were left open up to half hour to prevent the development of anaerobic condition. The amount of $CO_2$-C trapped was determined by back titration according to **Page *et al.* (1982)**.

The net $CO_2$-C was calculated by subtracting the value of the blank from that of the treatments, using the relationship of **Anderson (1985)**.

$$CO_2 = (B - V)\ NE$$

Where:

B = Volume of HCl used to neutralize NaOH in the beaker to the end point of the blank.

V = Volume of acid used to neutralize NaOH in the beaker to the end point.

N = Normality of the acid.

E = Equivalent weight (to express data as C, E=6, while as CO = E= 22).

By the end of experiment, soil sample from each treatment was collected, air-dried, sieved through 2 mm sieve then kept for some chemical properties determination.

*Statistical analysis:*

Statistical analysis was performed by using the SAS system **(SAS, 2005)**. Duncan's multiple range tests was used for means separation. Significance was assessed at $P < 0.05$.

## 3. Results and discussion

**Climatic condition:**

The air and soil temperature in the experimental site was shown in Figures (1 and 2). The mean monthly air temperature ranged from 13.45°C to 29.07°C and from 13. 93°C to 29.81°C, when soil temperature recorded from 14.03°C to 31.07°C and from 15.01°C to 32.03°C during the 2011/2012 and 2012/2013 wheat growing seasons, respectively. The mean monthly maximum air and soil temperatures during wheat growing season in 2011/2012 were slightly lower than that in 2012/2013. While, minimum air temperature in season 2011/2012 was slightly higher than that in 2012/2013, at all months except months of January. Moreover, soil minimum temperature was slightly higher at March, April and May in season 2012/2013 compare with season 2011/2012.

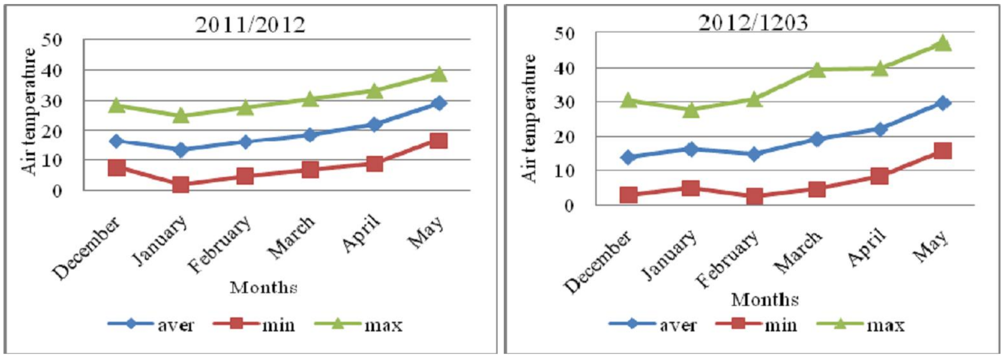

**Figure 1: Average air temperature during two growing wheat seasons.**

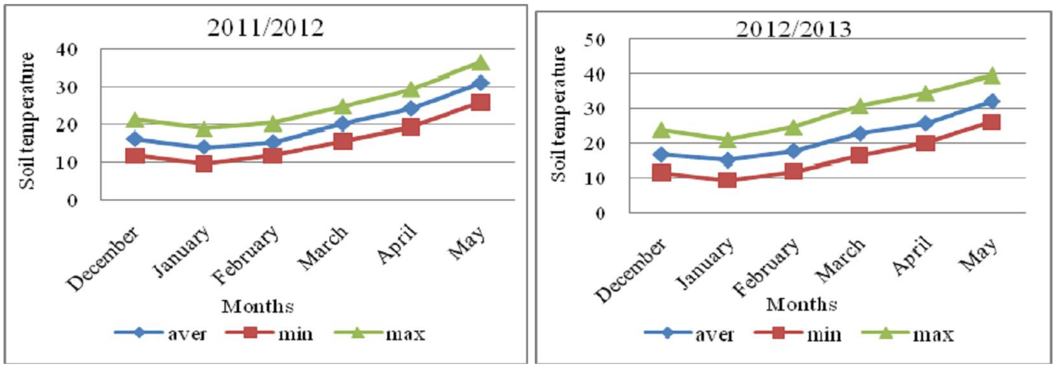

**Figure 2: Average soil temperature during two growing wheat seasons.**

**Soil properties:**

The soil properties (available nitrogen “AN”, soil organic matter “SOM” and soil pH) were influenced significantly by different types of fertilizer. Generally, organic fertilizer and bio-fertilizer treatments enhanced “AN” and “SOM”, while, reduced soil pH compared with chemical treatment.

Illustrated data in (Table. 3) obtained that the highest values of “AN” and “SOM” were recorded with Compost tea + EM treatment, when, the lowest values with chemical treatment.

In addition, data in (Table. 3) reflected that the chemical treatment increased soil pH more than other treatments, except K-Humate and K-Humate + EM treatments. The Compost tea + EM treatment gave the high reduction value of soil pH, while, control, K-Humate and K-Humate + EM treatments gave highest values without any significant value between them. Those results were recorded during two growing seasons.

The result is supported by **Ullah *et al.*, 2008** who reported that the organic matter content and availability of N in soil has been increased by organic fertilizer application. On the other hand, soil pH was increased with chemical application than organic application. **Yadav *et al.*, 2002** and **wells *et al.*, 2000**, mentioned that the chemical properties of soil were influenced by different sources of soil nutrients (organic and chemical). Soil pH varied significantly with the treatments, it decreased with organic manures application and application of chemical + organic but increased with only chemical fertilizer application. Moreover, soil organic matter was decreased by chemical fertilizer application, but was increased with all types of organic manure application and that was recorded the highest with combined application. Whereas, **Bouajila and Sanaa, 2011** reported that, add of compost or manure acted significantly on soil characteristics, especially the fertility and its productive capacity. Moreover, authors reported that improve soil organic level, resulting in a higher organic carbon content which contributes to diminish climatic heating.

Also, **Constantin *et al.*, 2010** found a positive relationship between C and N inputs via cover crop biomass and soil C and N contents on three different soil types. Field experiments showed that plots with annual inputs of animal manure hold more soil C and N than plots receiving mineral fertilizers only **(Christensen and Johnston, 1997)**. Hence, there are cumulative effects of cropping systems with abundant organic inputs on soil total N contents that could influence levels of plant-available N and thus yields of cereal crops. In contrast, residual effects of N added with mineral fertilizers are negligible **(Petersen *et al.*, 2010)**.

The result might be due to improvement of other physical and chemical properties for organic manure application compared to the chemical fertilizer application.

**Table (3): Effect of different types of fertilization on soil properties available nitrogen, soil organic matter and soil pH during 2011/2012 and 2012/2013seasons.**

| Treatments | First season | | | Second season | | |
|---|---|---|---|---|---|---|
| | AN | SOM | pH | AN | SOM | pH |
| NPK | 51.81 D | 1.683 C | 7.927 A | 51.58 D | 1.660 C | 7.900 A |
| Compost tea | 54.22 CD | 2.090 B | 7.780 C | 54.03 CD | 2.077 B | 7.753 C |
| K-Humate | 57.36 C | 2.000 B | 7.923 A | 57.16 C | 1.990 B | 7.893 A |
| EM | 57.57 C | 2.016 B | 7.847 B | 57.35 C | 2.007 B | 7.817 B |
| Compost tea + EM | 69.44 A | 2.460 A | 7.723 D | 69.24 A | 2.437 A | 7.697 D |
| K-Humate + EM | 64.92 B | 2.063 B | 7.927 A | 64.73 B | 2.053 B | 7.897 A |

**Yield and yield components:**

Data presented in (Table. 4) indicated that various studied treatments had a significant effect ($P < 0.05$) on straw, grain yield, biological yield, total content of nitrogen in grain (TCNG) and grain protein content (GPC). The greatest values of yield and its components were observed with applied compost tea + EM treatment. Meanwhile, the lowest values of tested parameters were recorded with added EM treatment. This results obtained at 2011/2012 and 2012/2013 seasons. These results are in a harmony with those reported by **(Atta Allah and Mohamed, 2003; Sarwar, 2005; Yassen *et al.*, 2006; Javaid and Shah, 2010; Youssef, 2011)**.

Such satisfactory result might be due to the prevailing bio-fertilizer supplemented organic fertilizer improved soil properties, especially organic matter and N content. The application of bio-fertilizer in combination with organic or mineral fertilizers increased the efficiency of both organic and mineral N fertilizer, but apply the bio-fertilizer alone was ineffective in increasing yield. Thus, bio-fertilizers could be used as value-added soil amendments by supplementing organic and low chemical fertilizer rates for improving soil fertility and sustaining crop productivity **(Abbasia and Yousra, 2012)**. Also, other authors mentioned the same results bio-fertilizer is enhancing soil biological activity, which improved nutrient mobilization from organic and chemical sources. Also, the bio-fertilizer plays a significant role in regulating the dynamics of organic matter decomposition and the availability of plant nutrients and increasing nitrogen fixer. In this case, **Radwan and Hussein, 1996; Sharief *et al.*, 1998; Elsayed *et al.*, 2005; El-Garhi *et al.*, 2007; Badr *et al.*, 2009; Bahrani *et al.*, 2010; Abd El-Lattief, 2012** found positive effect on yield and yield attributes of wheat when inoculated with bio-fertilizer. Controlled field trials in Iran, **Khavazi *et al.*, 2005**, found that yield improvements of more than 20% have been observed for wheat as a result of application of bio-fertilizer inoculums.

**Table (4): Effect of different types of fertilization on yield (straw, grain and biological yield) and its components (total content of nitrogen in grain and grain protein content) during 2011/2012 and 2012/2013seasons.**

| Treatments | First season | | | | |
|---|---|---|---|---|---|
| | Straw yield Ton/fed | Grain yield Ton/fed | Biological yield gm/m$^2$ | TCNG % | GPC % |
| NPK | 5.687 B | 3.910 B | 2271 B | 2.423 BC | 15.15 B |
| Compost tea | 5.803 B | 2.987 E | 2082 BC | 2.507 AB | 15.67 AB |
| K-Humate | 5.123 BC | 3.700 C | 2077 C | 2.570 A | 16.06 A |
| EM | 4.947 C | 2.897 E | 1842 D | 2.310 C | 14.44 C |
| Compost tea + EM | 6.543 A | 4.347 A | 2571 A | 2.600 A | 16.25 A |
| K-Humate + EM | 5.793 B | 3.377 D | 2162 BC | 2.441 B | 15.25 B |
| | Second season | | | | |
| NPK | 5.400 AB | 3.718 B | 2171 B | 2.407 B | 15.04 BC |
| Compost tea | 5.509 AB | 2.824 E | 1984 B | 2.487 AB | 15.54 AB |
| K-Humate | 4.829 B | 3.507 C | 1985 B | 2.560 A | 16.00 A |
| EM | 4.661 B | 2.703 E | 1753 C | 2.290 C | 14.31 C |
| Compost tea + EM | 6.231 A | 4.158 A | 2474 A | 2.577 A | 16.10 A |
| K-Humate + EM | 5.499 AB | 3.194 D | 2070 B | 2.407 B | 15.04 BC |

**Soil $CO_2$ emission:**

Soil $CO_2$ flux was fitted with applied organic and bio-fertilizations treatment. The results indicated that soil $CO_2$ emission was reduced with application of compost tea + EM treatment through determined period (60, 90, 120 and 150 days from sowing date), while, lowest emission after 30 days from sowing date was observed in the chemical treatment. While, the soil $CO_2$ emission was increased with added K-Humate + EM treatment at measurements period from 60 to 150 days from sowing date and with compost tea treatment after 30 days from sowing date (Table. 5). This results are recorded in both growing season 2011/2012 and 2012/2013.

These results may be due to the influence of compost tea plus EM treatment on the soil properties (available nitrogen, soil organic matter and pH), Table (3), which lead to increase the "AN" and "SOM" and reduced soil pH. Some authors obtained that the application of farmyard manure induced a rapid increase in $CO_2$ emissions from the soil than $CO_2$ emissions from the soil that fertilized with mineral N **(Jäger *et al.*, 2011)**.

Increasing N fertilizer application decreased soil $CO_2$ emissions **(Wilson and Al-Kaisi, 2008)**. **Kowalenko *et al.* (1978)** and **Fogg (1988)** found increased N fertilization depressed soil $CO_2$ emissions. The effects of N deposition on soil $CO_2$ emissions have also been studied **(Micks *et al.*, 2004; Bowden *et al.*, 2004; Burton *et al.*, 2004)**. These studies reported results similar to Kowalenko *et al.*, 1978 and **Fogg (1988)**. The reason for the depression of soil $CO_2$ emissions due to N fertilization is relatively unclear. Previous studies have suggested that the depression occurred because increased N reduced enzymatic activity **(Fogg, 1988; Bowden *et al.*, 2004; Burton *et al.*, 2004)**, decreased pH **(Aerts and de Caluwe, 1999)**, or decreased microbial biomass **(Soderstrom *et al.*, 1983)**.

Furthermore, several studies described a similar positive correlation of soil pH-value and soil $CO_2$ efflux **(Andersson and Nilsson, 2001; Ellis *et al.*, 1998; Hall *et al.*, 1998; Sitaula *et al.*, 1995)**. **Baath (1996) and Högberg *et al.* (2003)** demonstrated the direct positive effect on soil emission with soil pH tolerance of the bacterial community. A biological activity of soil microorganisms is permitted between a soil pH of a minimum of 3 and a maximum of {7 to 8} **(Scheffer and Schachtschabel, 2002)**. In addition, inside the mentioned values and otherwise constant conditions observed a nearly linear increase of soil $CO_2$ emission. Variation of the soil pH-value of the soil and between the single measurement points at each site showed a positive correlation with the $CO_2$ efflux. During simultaneous measurements with higher soil pH exhibited higher $CO_2$ fluxes **(Reth *et al.*, 2005)**.

Meanwhile, soil $CO_2$ efflux influenced by other factors like, the root respiration **(Janssens *et al.*, 1998; Kutsch *et al.*, 2001; Law *et al.*, 1999)** and comprises total soil $CO_2$ efflux, and plants continuously excrete exudates into the soil.

On other hand, due to application of bio-fertilizers the soil pH (KCl solution) raised $CO_2$ emission **(Kutyova *et al.*, 2002; Durinina *et al*, 2001)**.

**Table (5): Effect of different types of fertilizers application on soil $CO_2$ emission ($CO_2$–C Kg/fed) during 2011/2012 and 2012/2013seasons.**

| Treatments | First season | | | | | |
|---|---|---|---|---|---|---|
| | 30 | 60 | 90 | 120 | 150 | Accumulative |
| NPK | 1.233 B | 1.856 A | 1.856 CD | 2.002 AB | 1.941 C | 8.890 C |
| Compost tea | 1.747 A | 1.914 A | 1.910 ABC | 1.944 B | 1.897 D | 9.412 B |
| K-Humate | 1.344 B | 1.871 A | 1.865 BCD | 1.940 B | 1.935 C | 8.956 C |
| EM | 1.655 A | 1.900 A | 1.915 AB | 2.057 A | 2.017 B | 9.544 AB |
| Compost tea + EM | 1.573 A | 1.768 B | 1.830 D | 1.936 B | 1.885 D | 8.992 C |
| K-Humate + EM | 1.714 A | 1.934 A | 1.932 A | 2.073 A | 2.043 A | 9.694 A |
| | Second season | | | | | |
| NPK | 1.239 C | 1.868 AB | 1.884 BC | 2.016 AB | 1.957 C | 8.965 C |
| Compost tea | 1.756 A | 1.924 A | 1.939 AB | 1.955 B | 1.910 D | 9.483 B |
| K-Humate | 1.353 BC | 1.880 A | 1.893 BC | 1.951 B | 1.947 C | 9.024 C |
| EM | 1.663 A | 1.909 A | 1.943 AB | 2.069 A | 2.030 B | 9.615 AB |
| Compost tea + EM | 1.580 AB | 1.779 B | 1.857 C | 1.949 B | 1.900 D | 9.065 C |
| K-Humate + EM | 1.727 A | 1.953 A | 1.959 A | 2.084 A | 2.054 A | 9.777 A |

**Total accumulative $CO_2$ emission from soil:**

Data in Table (5) noted that applied K-Humate + EM treatment gave the highest values of total accumulative soil $CO_2$ emission. While, the lowest values of total accumulative soil $CO_2$ emission were recorded with application of NPK, K-Humate and compost tea + EM treatments, respectively, without any significant differences between both treatments.

In addition, obtained results from regression analyses confirmed that no significant effect on total accumulative $CO_2$ emission on wheat yield and yield components. These results are confirmed in both growing seasons 2011/2012 and 2012/2013.

**Time effect on $Co_2$ emission measurements:**

The amount of carbon dioxide emission from soil was different on particular period of measurements. The lowest rate of $CO_2$ emission evolution was observed on 30 days after sowing date. With the passage of time carbon dioxide emission increased, the highest rate of $CO_2$ was recorded after 120 and followed by 150 days from sowing date without any significant differences between them (Table. 6). The mentioned trend was not harmony with **Włodarczyk, 2000, Rogalski *et al.*, 2008**, whom reported that $CO_2$ emission decreased substantially after one day.

**Table (6): time effect on soil $Co_2$ emission ($CO_2$ – C Kg/fed) during 2011/2012 and 2012/2013 seasons.**

| Times | First season | Second season |
|---|---|---|
| 30 | 1.543 C | 1.553 C |
| 60 | 1.874 B | 1.886 B |
| 90 | 1.884 B | 1.912 B |
| 120 | 1.952 A | 2.004 A |
| 150 | 1.952 A | 1.967 A |

**Relationships between soil $CO_2$ emission and air or soil temperature:**

According to stepwise regression procedure indicated that, the average air temperature, minimum air temperature, maximum air temperature and average soil temperature, respectively, had significant exponential relationship regression during the entire measuring period of $CO_2$ emission. While maximum and minimum soil temperatures were not obtained any significant regression with $CO_2$ respiration in both growing seasons (Figures 3 and 4). On other hand, average soil temperature through period of $CO_2$ emission varied from 14.03 to 24.23°C and 16.58 to 25.6°C, respectively in 2011/2102 and 2012/2013. The relatively higher average soil temperature appeared in the months of growing season from February to April than other months. In months from December to April, soil temperature was always above 10°C in both seasons.

Similar trend was observed with minimum air temperature arranged between 2 to 8.87°C and 2.43°C – 8.35°C, respectively in 2011/2102 and 2012/2013, and started for increasing from February to April months in first season and March to April months in second season. Minimum air temperature decreased was relatively low 10°C through all $CO_2$ emission months in two seasons.

Maximum air temperature recorded from 24.9 to 33.02 and 27.76 to 39.87°C, respectively in 2011/2102 and 2012/2013. Maximum air temperature started rising from February to April in two growing seasons. Maximum air temperature increased above 30°C through all $CO_2$ emission months except December to February months in first season and January month in second season.

Average air temperature was ranged from 13.45 to 22.07 and 13.93 to 22.07°C, in 2011/2102 and 2012/2013. Increasing average air temperature was started from February to April months. Average air temperature was always above 10°C through both seasons.

Our results showed that $CO_2$ flux was equally related with both air temperature (average, minimum and maximum) and average soil temperature at the time of $CO_2$ flux measurement.

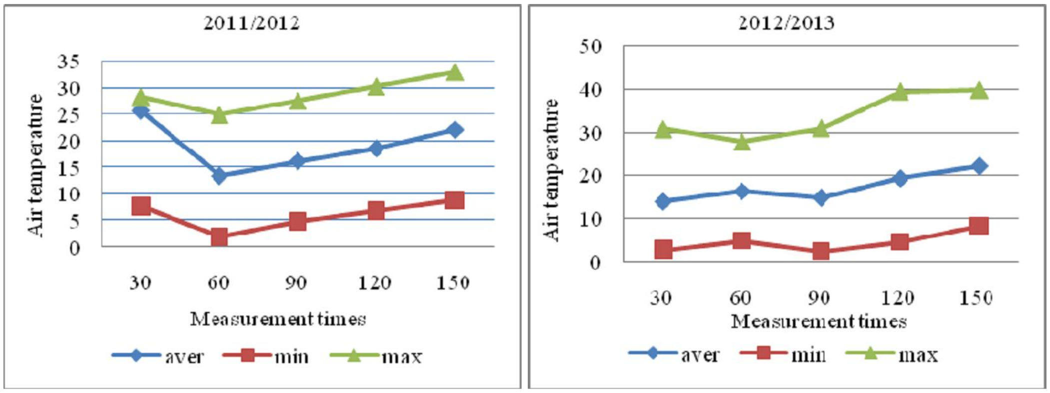

**Figure 3: Average air temperature through measurements period of $CO_2$ during two growing wheat seasons.**

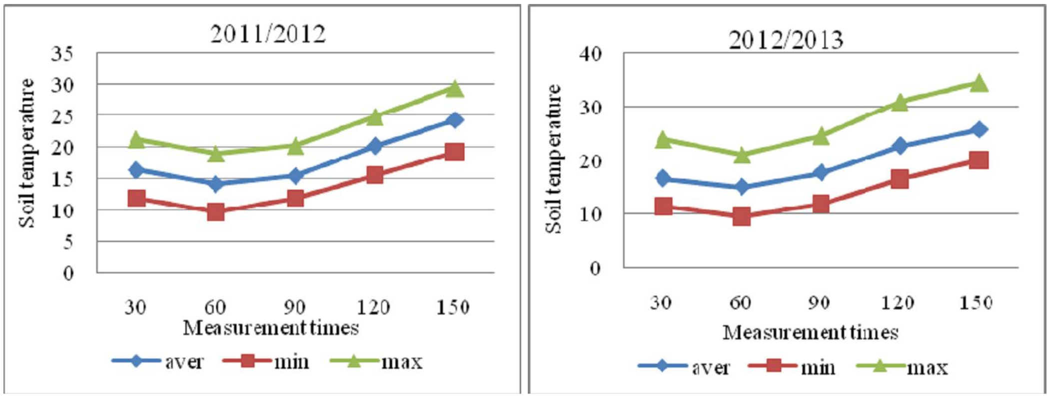

**Figure 4: Average soil temperature through measurements period of $CO_2$ during two growing wheat seasons.**

This could be attributed to the air temperature (average, minimum and maximum) were more correlated with $CO_2$ flux than soil temperature (maximum and minimum) **(Parkin and Kaspar, 2003)**, air temperature influence soil temperature, which in turn, directly influence $CO_2$ flux from the soil surface **(Bajracharya *et al.*, 2000a, b; Curtin *et al.*, 2000; Parkin and Kaspar, 2003)**. **Parkin and Kaspar (2003)** reported that soil surface $CO_2$ flux was better related with air temperature than with soil temperature because of plant residue at the soil surface. $CO_2$ flux was equally related with both soil temperature and daily average air temperature at the time of $CO_2$ flux measurement. The $CO_2$ flux was linearly related with soil temperature and daily average air temperature at the time of $CO_2$ measurement **(Sainju *et al.*, 2008)**. Moreover, Soil warming can enhance the soil microbial activities and root growth sharply **(Zheng *et al.*, 2009)**. This leads to an active decomposition of soil organic C and enhancement of plant-derived $CO_2$ release from root respiration (Fang *et al.*, 2009).

**Prediction of soil $CO_2$ emission:**

Furthermore, the most effective climatic factors could be used to predict amount of soil $CO_2$ emission ($R^2 = 0.629$, $P < .0001$) was selected (Average air temperature (*TAV*), minimum air temperature ($T_{AMin}$), maximum air temperature (*TAMax*) and average soil temperature (*TSV*), respectively). Prediction equation for $CO_2$ emission from soil was concluded according to the mentioned statistical analysis and presented as follow:

$$Y = 0.713 + 0.26\,T_{AV} + 0.23\,T_{AMin} - 0.1\,T_{AMax} + 0.06\,T_{SV}$$

Where is: Y= soil $CO_2$ emission.

## 4. Conclusions

This study demonstrated how different types of fertilization affected on soil $CO_2$ emission ($CO_2$–C Kg/fed) from cultivated wheat yield. Statsical analysis showed that the soil properties were effect by the type of fertilizer. The "AN" and "SOM" represented the positive response for organic and bio-fertilizer compared with chemical fertilizer. In the same time, soil pH increased by applied chemical treatment more than other treatments except K-Humate and K-Humate + EM treatments. Moreover, the greatest values of yield (straw, grain yield, biological yield) and its components (total content of nitrogen in grain "TCNG" and grain protein content "GPC") were observed when applied compost tea + EM treatment. Meanwhile, the lowest values of tested parameters were recorded with added EM treatment. Soil $CO_2$ emission was reduced with compost tea + EM treatment through determents period (60, 90, 120 and 150 days from sowing date), when, lowest emission after 30 days from sowing was observed in the chemical treatment. While, the soil $CO_2$ respiration was increased with added K-Humate + EM treatment at measurements period from 60 to 150 days after sowing date and with compost tea treatment after 30 days after sowing date. In addition, the lowest rate of $CO_2$ evolution was observed on 30 days after sowing date. With the passage of time carbon dioxide emission increased, the highest rate of $CO_2$ was recorded after 120 days from sowing date. The climatic factors as well as (average air temperature, minimum air temperature, maximum air temperature and average soil temperature) had significant exponential relationship regression during the entire measuring period of $CO_2$ emission. This statistical regression method can be used to predict soil $CO_2$ emission where soil $CO_2$ respiration is primarily dependent on climatic factors.

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