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ASSESSING GREENHOUSE GAS EXCHANGE OF AGRICULTURAL CROPS BY FLUX MEASUREMENTS IN THRACE PART OF TURKEY

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ABSTRACT

Agriculture plays an important role in the global greenhouse gas (GHG) budget and its cycle. CO_2 is one of the most important greenhouse gases, and plants release CO_2 into the atmosphere by respiration and sink it by photosynthesis from the atmosphere. In addition, soil has an essential role in this exchange. Unfortunately, studies on the measurement of greenhouse gases above agricultural crops in internationally accepted methods are not sufficient, especially in developing countries. Thus, it is a clear need to determine carbon exchange of agricultural crops and activities (sink and emission) by taking into consideration of the specific conditions such as climate, crop variety, soil etc. Eddy Covariance (EC) is one of the widely used micrometeorological methods in the world for flux measurement studies. Developments in measurement and analysis by instruments have allowed this method to be applied more by researchers for the studies on GHG exchange. In this research, carbon exchanges (sink and emission) of watermelon grown in Atatürk Soil, Water and Agricultural Meteorology Research Institute located in the Thrace part of Turkey, was measured using the Eddy Covariance method. Finally, estimated gas exchange above crops will be presented.

Keywords: *Carbon, greenhouse gas, micrometeorology, agricultural meteorology, flux.*

INTRODUCTION

Greenhouse gas (GHG) exchange between earth and the atmosphere becomes important with relation to industrial revolution because GHG cause global warming and climate change. Deforestation, forest fire, drought, land use changes and usage of fossil fuels for different purposes result increases in GHG concentration in the atmosphere. In the terrestrial ecosystem, agriculture has one of the key components of global GHG's budget by means of capturing CO_2 from the atmosphere. Therefore, agricultural and forest areas have critical roles by sinking of carbon for the national global GHG's budget. CO_2 from the atmosphere is captured by photosynthesis, emitted by respiration and stored by sink (Net ecosystem exchange) within the plant organs. There are however few studies on this topic for the agricultural crops when compared to the studies on forests. In most of the developing countries; such as Turkey, carbon budget of agriculture is calculated according to IPCC values. For this reason, representativeness of the calculated carbon budget should be assessed by comparison with measured data and actual emission and sink coefficients.

The purpose of this study is to assess the results of the experimental GHG flux studies, were done in the Thrace part of Turkey, on CO_2 and H_2O above crop (watermelon) using eddy covariance (EC) flux approach. The measurements were carried out from 2012 to 2013. Experimental studies were conducted in the selected fields (KRK) of Atatürk Soil Water and Agricultural Meteorology Research Directorate in the Kırklareli city, Turkey.

MATERIAL AND METHODS

The flux studies had been carried out between 14 May and 9 October 2012 in watermelon planted field in KRK (41.73 ° K, 27.21 ° D) which is shown in Figure 1. The experiment area is about 2 ha. An EC measurement system (3D sonic anemometer, open type gas analyzer) and an agricultural meteorology research station were established in the study area. Figure 2 shows EC and agricultural meteorology measurement stations established in KRK. At the EC station, the 3D components of wind speed by 3D sonic anemometer and the CO_2 gas concentration by open path infrared gas analyzer, were measured. In the agricultural meteorological station, the global solar radiation, the net radiation and photosynthetic active radiation were measured at 2 m, wind speeds at 0.5, 1, 2, 5 and 10 m and wind direction at 2 m, soil temperatures at 2, 5, 10 and 20 cm.

Figure 1. Watermelon planted area in KRK.

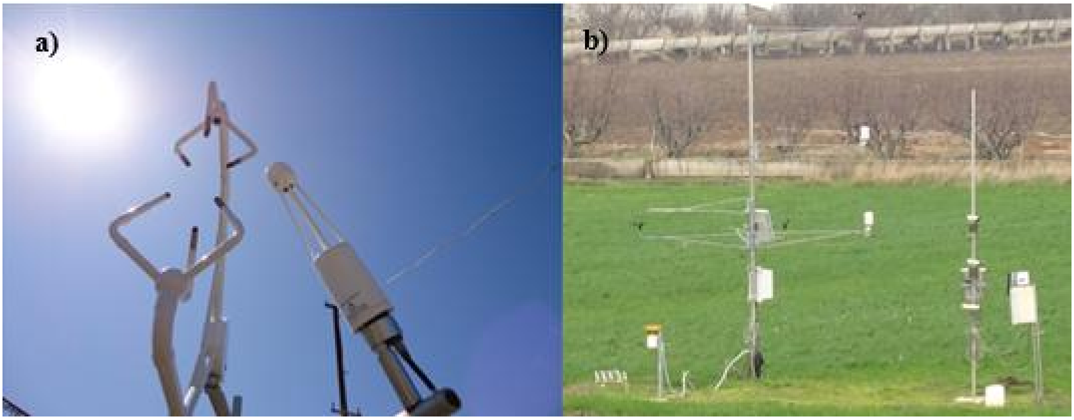


Figure 2. a) EC b) Agricultural meteorological station (Şaylan et al. 2012)

Thanks to the advancement in technology and the development of measuring devices, 3D wind speed and gas flows have been measured in very short time intervals (Burba, 2013). The EC method, in which the fluxes of the interested gas (CO_2, CH_4, H_2O etc.) related to the covariance between the concentration and vertical wind speed in [illegible] eddies, has been popular since the 90's. Nowadays, EC is the most widely used m[illegible]od in flux studies.

Equation 1 shows how [illegible] CO_2 flow is calculated according to the EC method:

$$F_c = \rho \text{[illegible]} \quad (1)$$

where F_c is CO_2 flux (μmol m^{-2} s^{-1}), w′ is deviation of av[illegible]age wind speed (m s^{-1}), c′ is deviation of average CO2 concentration, and [illegible]c′ is covariance of the deviations (Foken, 2008).

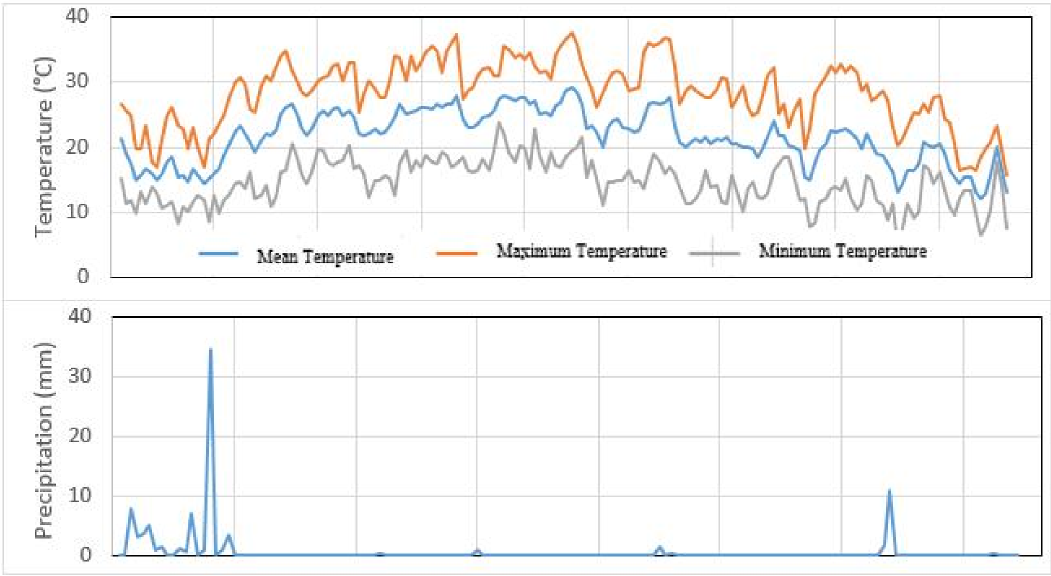
The main output of the EC method is Net Ecosystem Exchange (NEE). Negative values of NEE refers the net carbon accumulation of the crop. The NEE obtained as a result of the measurements and calculations is fragmented into the Ecosystem Respiration (R_{eco}) values representing the amount of carbon that the plants give to the atmosphere as a result of respiration, and Gross Primary Production (GPP) that shows total carbon production of plants. The relation of these three variables is given in Equation 2:

$$R_{eco} - \mathrm{NEE} = \mathrm{GPP} \quad (2)$$

The direct and high resolution of flux measurement capability of EC method has made this method the most widely used in flux studies despite the cost of installation and difficulties in data analysis.

RESULTS AND DISCUSSION

The maximum, minimum and average temperatures, precipitation, relative humidity (RH), wind speed, global and net radiation averages obtained from measurements made at the meteorological station are shown in Figure 3. In this period including watermelon growing, the daily mean air temperature is 22.7 °C, the average maximum air temperature is 37.6 °C measured on August 8, 2012 and the minimum air temperature is 8.28 °C measured on May 24, 2012. The air temperature generally remained below about 2 °C over the 50-year average temperature recorded by Turkish State Meteorological Service during the development period (Aslan, 2014). The first month of the growing period was quite rainy. A total of 88.2 mm of precipitation during the whole period as 71.4 mm of it fell between 14 May 2012 and 2 June 2012. From the planting of the crop until July 31, 2012 which was the first harvest date, 18 rainy days past and 73 mm of precipitation were observed (precipitation over 0.1 mm was considered). The May which is a rainy month in the City of Kırklareli has caused the relative humidity to be generally high during this month. The daily average relative humidity during the growing period was 61.41%. The maximum and minimum relative humidity values were measured on May 29, 2012, with 96.3%, and on August 28, 2012, with 33.62%. Global and net radiation showed similar changes in the same period. Due to the rainy weather and cloudiness during May, very low values were observed for both variables. Global and net radiation increased during June and began to decline from July. During this period, the lowest daily average global and net radiation values were measured on May 29, 2012 as 71.09 Wm^{-2}, 4.61 $W\ m^{-2}$, respectively. The maximum global radiation and net radiation values were measured on June 18, 2012 with 373.2 $W\ m^{-2}$ and June 17, 2012 with 176.7 $W\ m^{-2}$, respectively. The average global radiation and net radiation values were determined as 274.11 $W\ m^{-2}$, 126.5 $W\ m^{-2}$, respectively. Daily average, maximum and minimum wind speeds were determined as 1.74, 7.36 and 0.46 $m\ s^{-1}$ respectively while the average wind speed was 1.74 ms^{-1}.



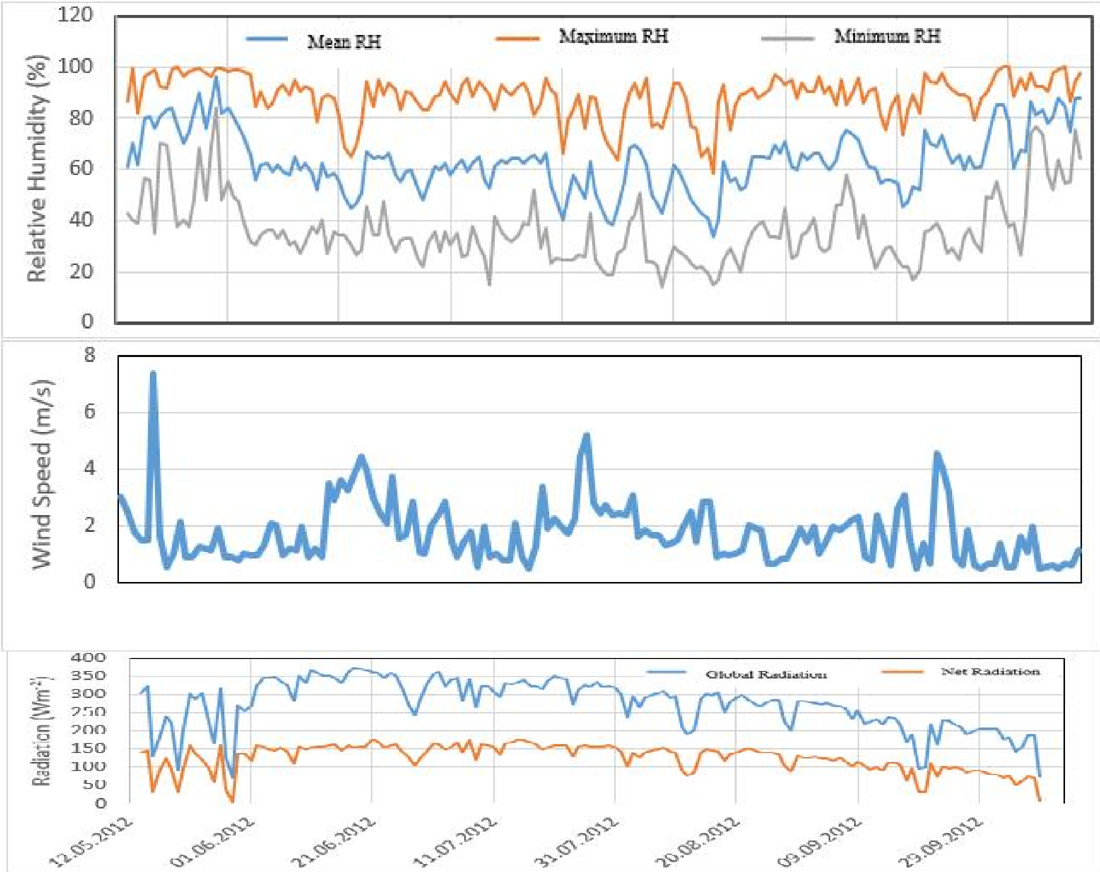


Figure 3. Variation of meteorological parameters during growing period

The variation of the daily values of NEE, GPP and R_{eco} during the growing period is shown in Figure 4. As a result of the measurements and analyzes, cumulated GPP was found as 1160.2 g C m $^{-2}$ (4246.3 g CO_2 m $^{-2}$), while R_{eco} was 846.35 g C m^{-2} (3097.6 g CO_2 m^{-2}) and NEE was -299.03 g C m^{-2} (-1094.45 g CO_2 m^{-2}). The negative value of NEE shows that the crops act as sink in the carbon budget. The daily mean GPP, NEE and R_{eco} values were 8.99, -2.31 and 6.56 g C m^{-2}, respectively. Daily maximum and minimum GPP were determined as 17.64 and 1.27 g C m^{-2} respectively during the growing period of watermelon. The maximum daily amount of carbon released by watermelon respiration was 10.08 g C m^{-2}, whereas the minimum was found as 2.91 g C m^{-2}. The maximum amount of carbon storage from the atmosphere was measured as -9.09 g C m^{-2}. The daily average emission value of watermelon was determined as 6.56 g C m^{-2} (24 g CO_2 m^{-2}) and the sink value was 2.31 g C m^{-2} (8.45 g CO_2 m^{-2})

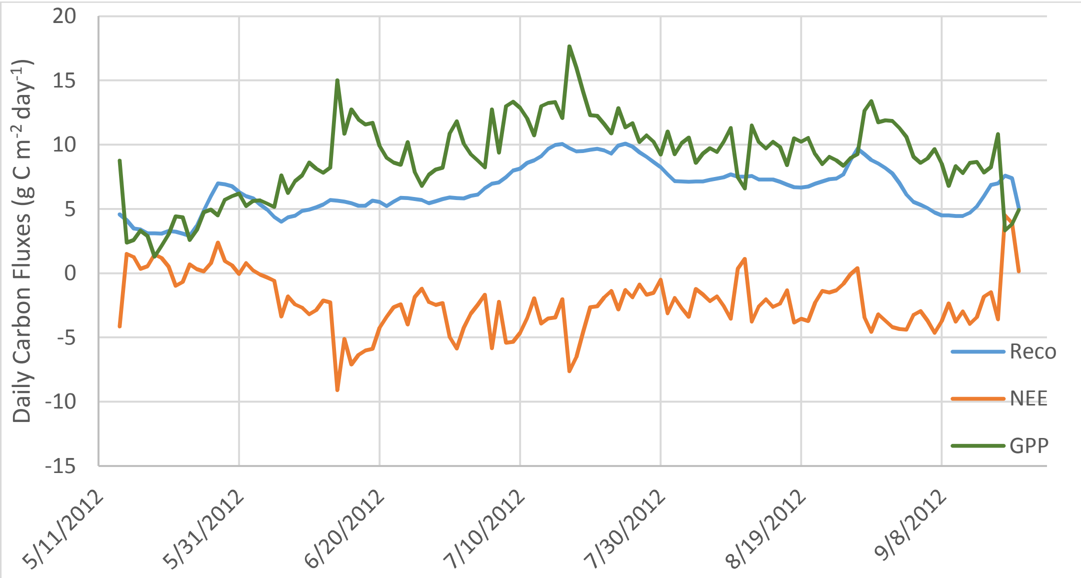


Figure 3. Variation of NEE, GPP and R_{eco} during growing period

CONCLUSIONS

The measurement and analysis results cannot be compared with any study, because this study is the first one in the world including watermelon crop. Coefficients obtained from the developed countries are used in the assessment of the carbon budget of the countries. With the spread of similar studies, it will be possible to determine the national carbon budget by determining the coefficients representing the climate and ecosystem conditions of individual countries.

The carbon fluxes of the crop is under the influence of many meteorological variables. In order to represent the fluxes accurately, it is important to examine the linear or nonlinear relationships between NEE, GPP and R_{eco} and also meteorological variables. The mathematical models using the obtained relations and values by this kind of studies may be able to determine carbon fluxes correctly. However, it is necessary to measure carbon exchange over crops using micrometeorological methods for having actual data, although it is costly and inconvenient.

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