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Variation of NEE and its affecting factors in a vineyard of arid region of northwest China

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HIGHLIGHTS

- Examined NEE variability and it was a carbon sinks.
- Diurnal variation of NEE was a "W" shape curve.
- Distinguish the main factors of the NEE.

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ABSTRACT

To understand the variation of net ecosystem CO_2 exchange (NEE) in orchard ecosystem and it's affecting factors, carbon flux was measured using eddy covariance system in a wine vineyard in arid northwest China during 2008–2010. Results show that vineyard NEE was positive value at the early growth stage, higher negative value at the mid-growth stage, and lower negative value at the later growth stage. Diurnal variation of NEE was "W" shaped curve in sunny day, but "U" shaped curve in cloudy day. Irrigation and pruning did not affect diurnal variation shape of NEE, however, irrigation reduced the difference between maximal and minimal value of NEE and pruning reduced the carbon sink capacity. The main factors affecting hourly NEE were canopy conductance (g_c) and net radiation (R_n). The hourly NEE increased with the increase of g_c or R_n when g_c was less than 0.02 $m \cdot s^{-1}$ or R_n was between 0 and 200 $W \cdot m^{-2}$. The main factors affecting both daily and seasonal NEE were g_c, air temperature (T_a), atmospheric CO_2 density, vapour pressure deficit (VPD) and soil moisture content.

1. Introduction

Farmland and orchard ecosystem are directly affected by human activities, but most scientists focus on the farmland ecosystem. With new farming and management measures, such as zero tillage, minimum tillage and crop rotation, farmland may increase carbon uptake capacity and change itself into a carbon sink (Schimel et al., 2001). Studies show that diurnal variation of net ecosystem CO_2 exchange (NEE) at the top of winter wheat canopy is a single peak curve (Lin et al., 2008). Diurnal variation of NEE in maize is also a single peak curve (Zhang et al., 2008). Seasonal variation of NEE in rice is a "V" shaped curve (Feng et al., 2008). Temperature has an obvious effect on the NEE of winter wheat in early spring, while nighttime NEE has an exponential relationship with ground temperature of 0–10 cm (Li et al., 2007). In addition, hourly variations of NEE had a significant correlation with net radiation (Guo et al., 2006).

However, there are few studies on the NEE of orchard ecosystem, especially in arid orchard ecosystem. Due to low rainfall, high temperature difference between day and night and adequate sunlight in Shiyang river basin in the arid region of northwest China, the region is suitable for growing wine grape and has a large area of it, but the variation of NEE and its influencing factors are not clear. Thus the objectives of this study were to investigate the variation of vineyard NEE and main factors affecting the variation of NEE at different time scales after monitoring the variation of carbon flux in vineyard using eddy covariance system for three years.

2. Materials and methods

2.1. Experimental outline

The experiment was conducted at Shiyanghe Experimental Station for Water-saving in Agriculture and Ecology of China

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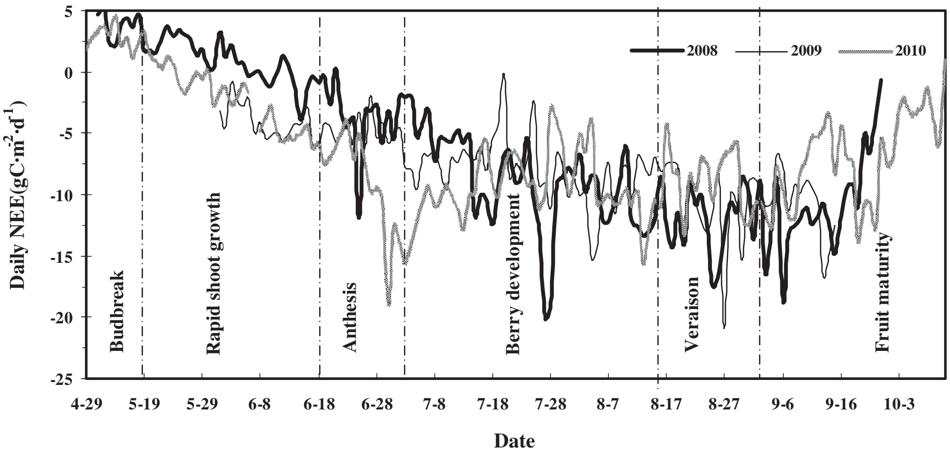

Fig. 1. Seasonal variation of vineyard NEE. NEE is net CO_2 exchange.

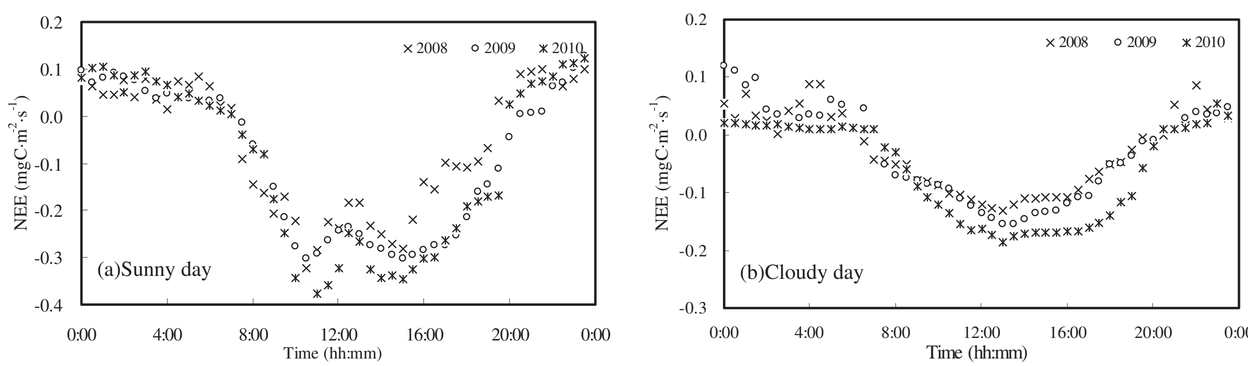

Fig. 2. Diurnal variation of vineyard NEE in sunny and cloudy days. Sunny days are 15 June 2008, 23 June 2009 and 20 June 2010, cloudy days are 3 July 2008, 27 June 2009 and 10 July 2010. NEE is net CO_2 exchange.

Agricultural University (37°51′N, 102°51′E, altitude 1585 m), located in Wuwei, Gansu Province of northwest China during 2008–2010. The site has high sunlight hours with a mean annual sunshine duration over 3000 h, mean annual temperature of 8 °C, frost-free days of 150 d and annual accumulated temperature (>0 °C) of 3550 °C. The region is limited in water resources with a mean annual precipitation of 164.4 mm and groundwater table of about 40–50 m. The experiment field is 1650 m long (south–north direction) and 1400 m wide (east–west direction). The experimental soil is irrigated desert soil (Siltigic-Orthic Anthrosols) and soil texture is sandy loam, with a mean dry bulk density of 1.45 g cm^{-3}, mean porosity of 52% and mean volumetric water content at field capacity of 0.35 cm^3 cm^{-3}. The experimental grapevines (Vitis vinifera L.cv Merlot) were planted in 1999 in east-west direction, with row spacing of 2.7 m and plant spacing of 1.0 m. The vineyard was furrow-irrigated 5 or 6 times during whole growth stage, with total irrigation of 300 mm each year.

2.2. Eddy covariance measurements

Eddy covariance system was located in the central south of the vineyard, 2.2 m above canopy, fetch length was from 300 to 1000 m. The eddy covariance sensor array included a CSAT3 three-dimensional sonic anemometer (Gill Instruments, UK), open-path H_2O & CO_2 analyzer (Li-Cor Inr., USA, Model LI-7500), HMP45C temperature and humidity sensor (Cambell Scientific, USA), NR-

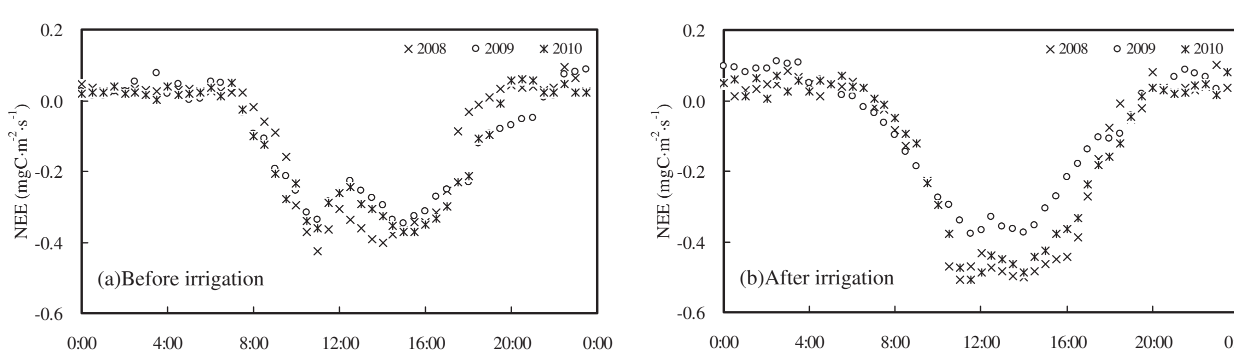

Fig. 3. Diurnal variation of vineyard NEE before and after irrigation. Irrigation days are 2 June 2008, 5 June 2009 and 10 June 2010. NEE is net CO_2 exchange.