Net Ecosystem Exchange of Carbon Dioxide of an Apple Orchard in South Korea

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Abstract

- Carbon dioxide (CO_2) gases concentration in atmosphere has been growing since preindustrial times. By sequestering a large amount of atmospheric carbon (C), terrestrial ecosystems are thought to offer a mitigation strategy for reducing global warming . Woody agro-ecosystems such as fruit trees are among the least quantified and most uncertain elements in the terrestrial carbon cycle.
- In this study, CO_2 and energy fluxes were measured by the eddy covariance method on a 15-year old apple orchard of South Korea in 2006. Environmental parameters (net radiation, precipitation, etc.) were measured along with fluxes. The topography of the flux site is flat and homogeneous covered with apple trees. Micrometeorological fetch is more than 1km depending on the prevailing wind direction. Apple tree (*Malus domestica* Borkh., varitey Fuji) was 15 year old and the average pruned tree height was 4m.
- The results showed that during late June, the ability to sequestrate C was significant at an apple orchard ecosystem and it reached on the peak of -6.5 g C m^{-2} d^{-1}. We found that in the apple orchard, the daily average of net ecosystem exchange of CO_2 (NEE) and cumulative NEE on a yearly basis were -1.1 g C m^{-2} d^{-1} and -396.9 g C m^{-2}, respectively.
- These results reveal that there is high carbon sequestration in the apple orchard of South Korea, which is the same magnitude with respect to that of a natural forested ecosystem of the same biome rank (temperate-humid deciduous forest).

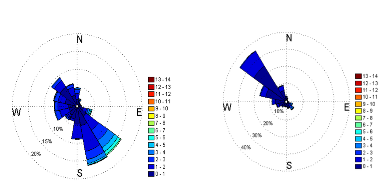
Eddy Covariance (EC) and Net Ecosystem Exchange (NEE)

- EC is a micrometeorological techniques to measure the exchange of water vapor and carbon dioxide between atmosphere and canopy.
- An open-path EC flux tower was installed for providing a direct, continuous measurement of the Net Ecosystem Exchange (NEE) of carbon, water and energy at the ecosystem level.
- Net ecosystem production (NEP), gross primary production (GPP), and ecosystem respiration (Re) were derived from NEE, and data gaps were filled using empirical models with meteorological variables such as radiation and soil temperature.

Fig.1. The photos of eddy covariance system installed at an apple orchard in Uiseong, South Korea

Study site

- ◆ Apple orchard
- ◆ Flux site : 36˚23´N, 128˚49´E, 210m a.s.l
- ◆ Topography : flat and homogeneous
- ◆ Micrometeorological fetch : more than 1 km
- ◆ Annual precipitation : 1,031.7mm
- ◆ Annual air temperature: 11.2 ℃
- ◆ Canopy height : 4m



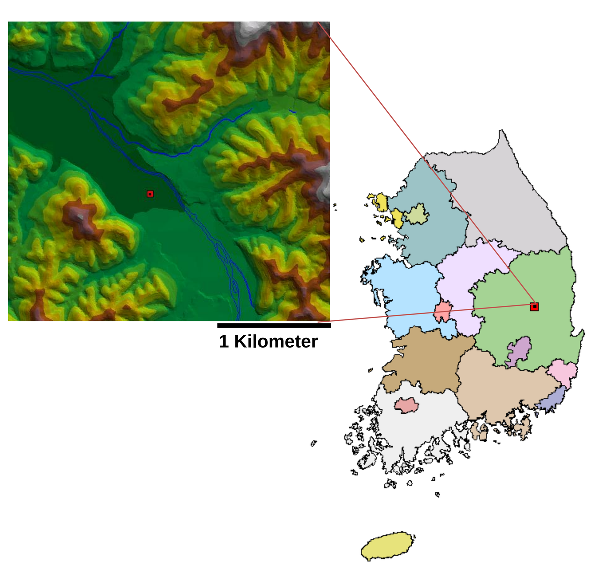


Fig. 2. The wind direction and wind speed

Measurement variables

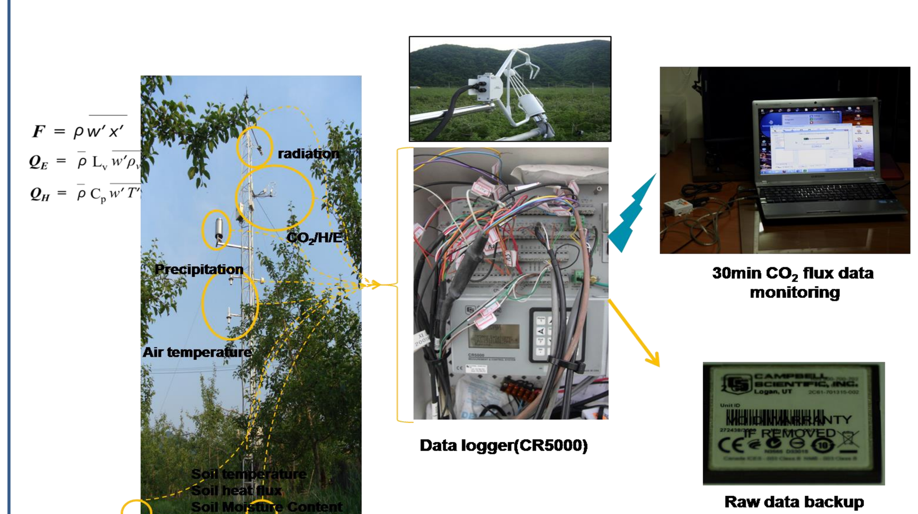


Table 1. Measurement variables and height(depth)

Instruments	Quantity	Measurement variables	Measurement height (depth)
CSAT3	1	Fluctuations of wind speed and air temperature	7m
LI-7500	1	CO_2 and H_2O density	7m
CNR1	1	Incoming/outgoing short- and long-wave radiation, Net radiation	9m
HMP45C	2	Air temperature and relative humidity	4m, 5m
HPF1	2	Soil heat flux	0.3m
TCAV	**2**	Soil temperature	0.3m
CS615	2	Soil water content	0.3m

Leaf area index (LAI)

Results

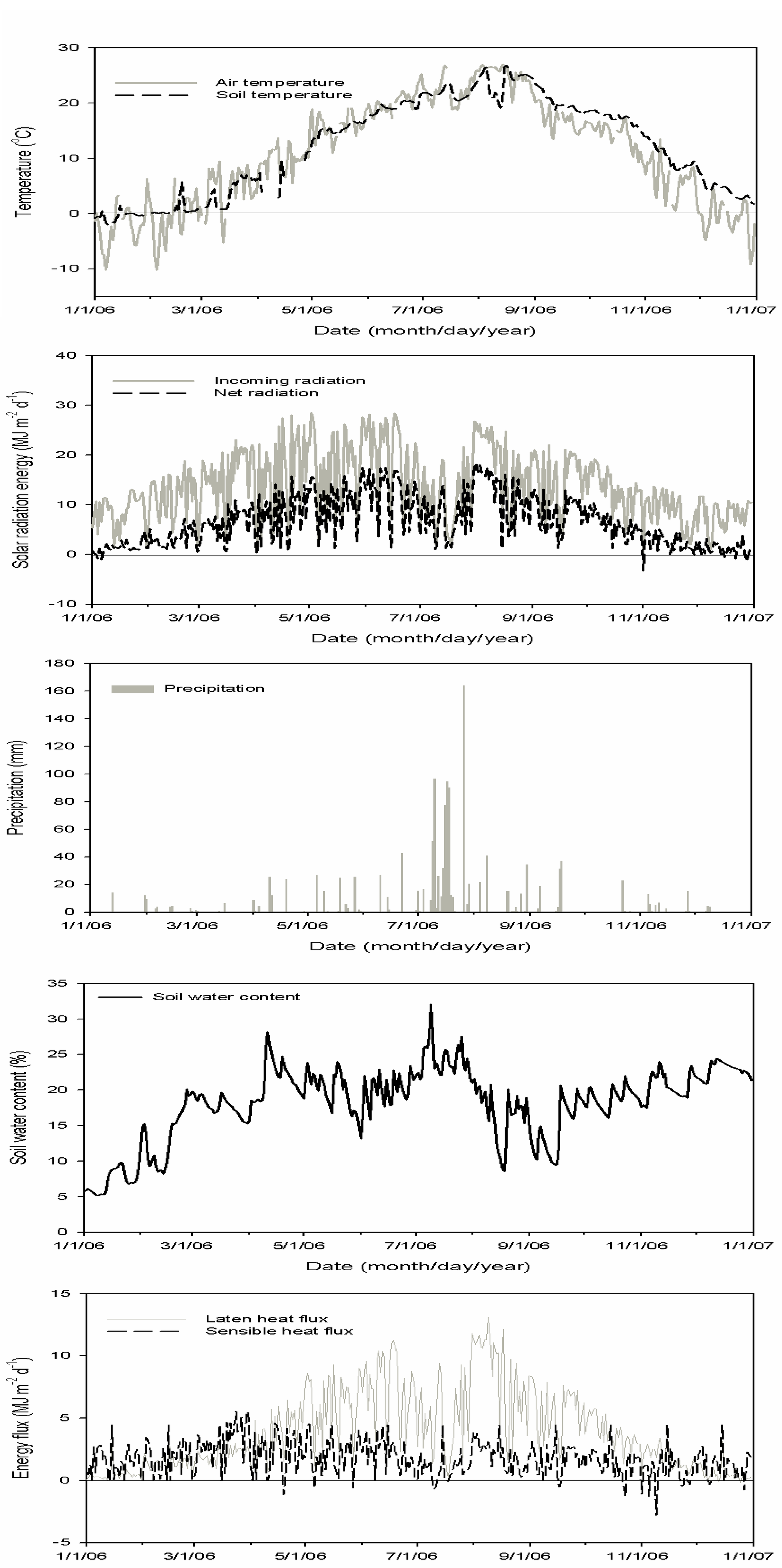


Fig. 3. Seasonal variations of meteorological variables (air temperature, etc.) at the Uiseong apple orchard in 2006

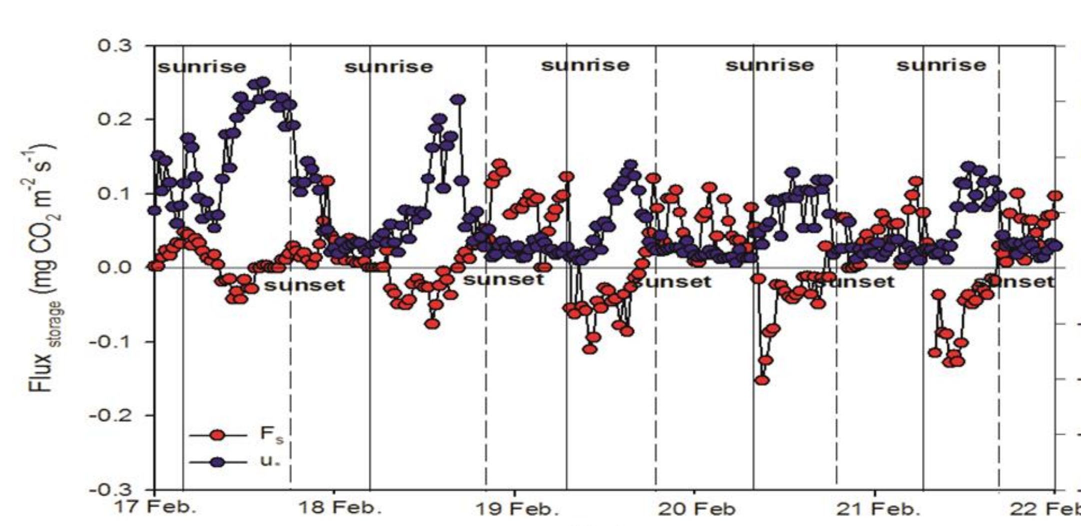


Fig. 4. Diurnal patterns of change in CO_2 storage (Fs), friction velocity (u*) from 17 Feb. to 22 Feb. 2006. Sunrise time is shown by the solid vertical lines, and sunset time by the dashed vertical lines. F_s increased gradually after sunset, reached the daily maximum storage just before sunrise, and then turned to release of CO_2 immediately after sunrise.

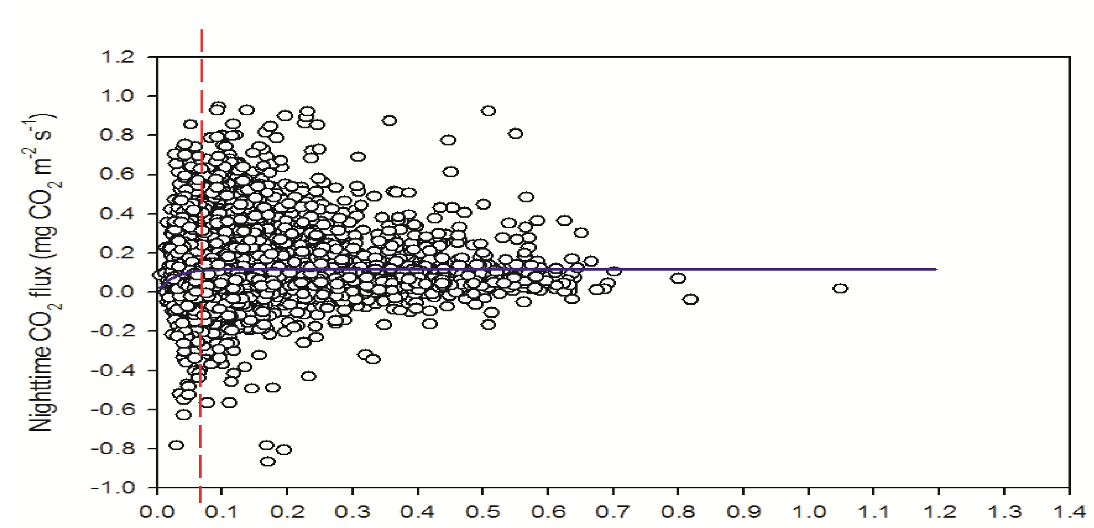


Fig. 5. Determination of the threshold friction velocity (u*) from 1 Jan. to 31 Dec. 2006. The solid line represents a smoothed function fitted to the data. The dashed line represents the threshold below which the flux is lower. The u* threshold for the site is 0.8 m s^{-1}.

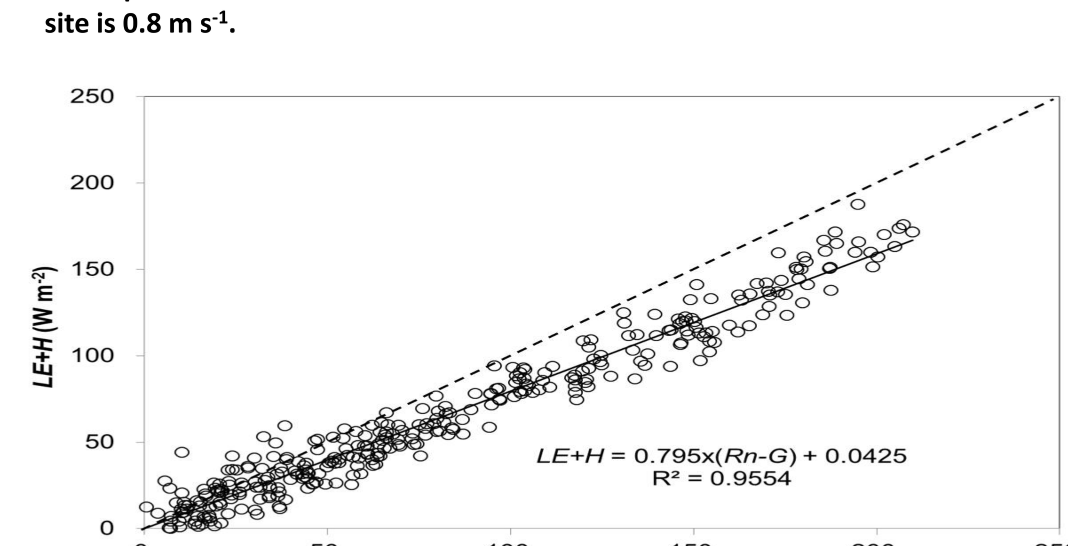


Fig. 6. Regression relationship between half hourly energy flux [latent heat flux (LE) and sensible heat flux(H)] and energy balance [net radiation (R_n) and soil heat flux (G)]. The dashed line indicated the 1:1 line.

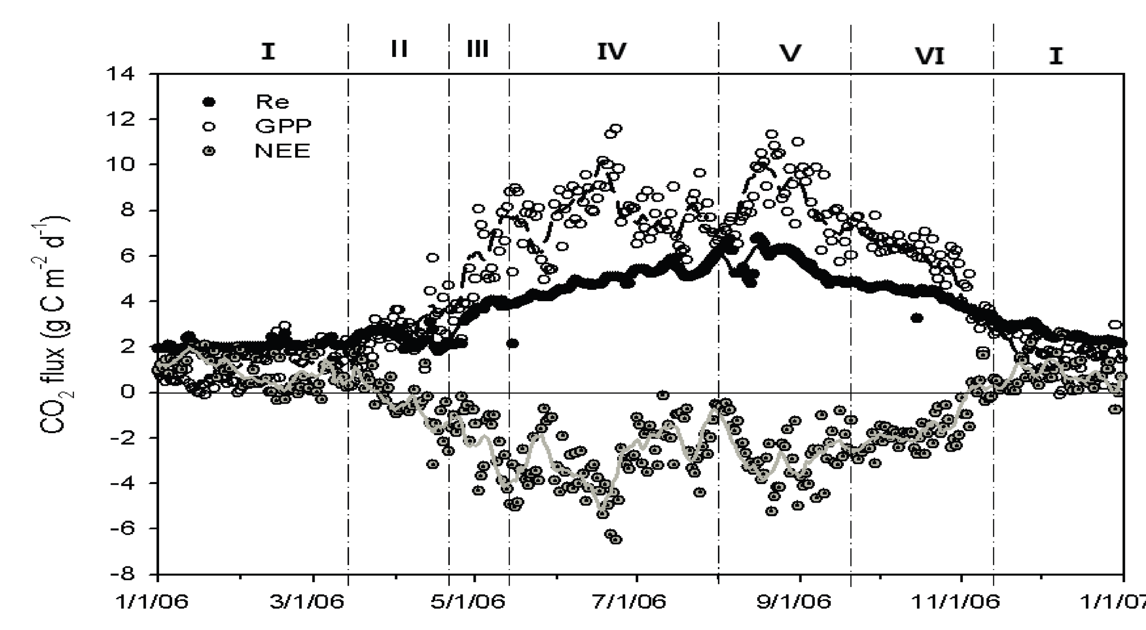


Fig . 7. Seasonal variation in daily gross primary production (GPP), ecosystem respiration (Re) and net ecosystem exchange of CO_2 (NEE) at the Uiseong apple orchard in 2006. The roman characters represent the developmental stage of apple tree. Ⅰ, Ⅱ, Ⅲ, Ⅳ, Ⅴ, and Ⅵ denote dormancy, bud burst & foliation, flowering, growth & enlargement, maturity, and harvest period, respectively.

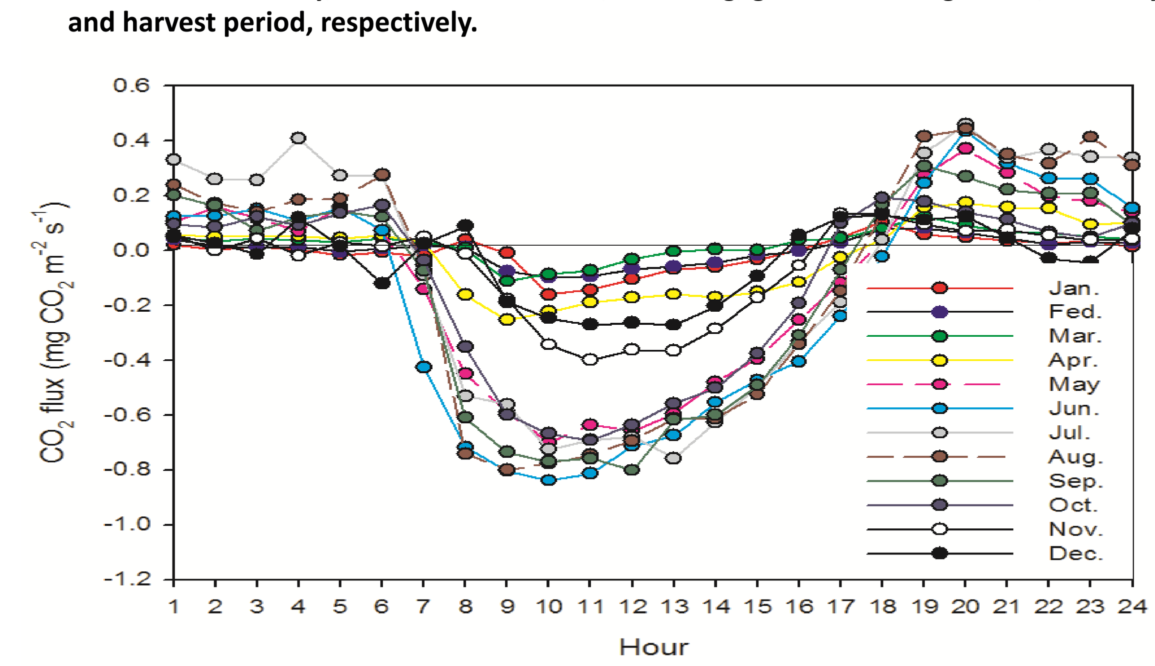


Fig . 8. Monthly diurnal variations of net ecosystem exchange of CO_2 (NEE) at the Uiseong apple orchard in 2006.

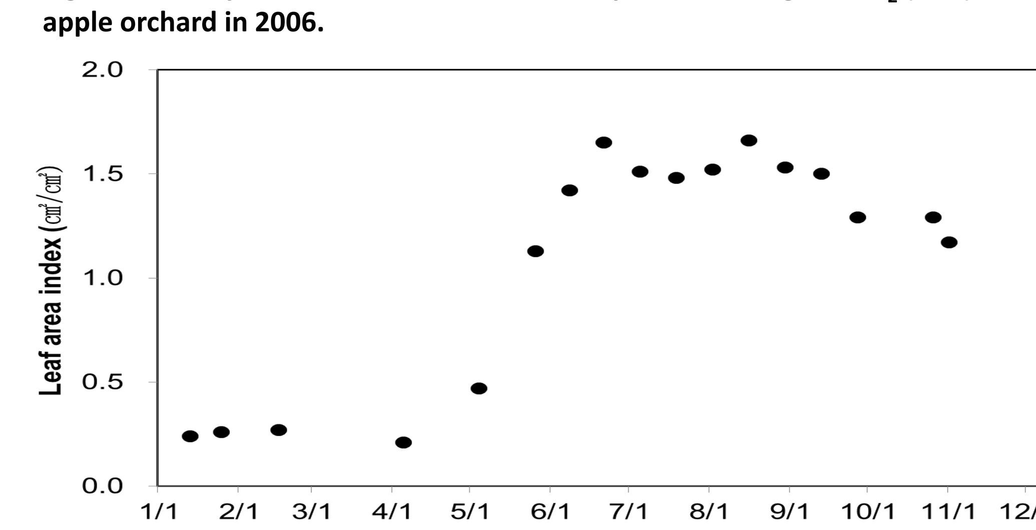


Fig. 9. Seasonal variations of leaf area index at the Uiseong apple orchard in 2006.

◈ Acknowledgement

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