ORAL 03

Comparison of Radiation Use Efficiency (RUE) and Leaf Gas-exchange Model with Napa Cabbage

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I. Introduction

For the impact assessment of agricultural production by climate change, simulation experiments with crop models under changed climate conditions are inevitable. There are lots of crop models which can simulate changes in agricultural system-soil-plant-atmosphere continuum. Most of crop models start to simulate basic physiological process-photosynthesis. Since Monteith and Moss (1977) observed that biomass accumulation by plants depends strongly on intercepted solar radiation, it was known that different crops show various linear relationships between accumulated biomass and cumulative intercepted solar radiation, which were known as the radiation use efficiency (RUE). Because RUE value combines whole individual process of photosynthesis of a crop, there is no need for detailed modelling of complex process (Soltani, 2012). It means RUE makes easy develop crop model. Farquhar *et al*. (1980) reported a significant photosynthesis model-FvCB model, which describe combined three biophysical processes of RuBP-limited, light-limited and sink-limited rates. They insist the key process is related of the gas-exchange mechanism on the leaf. This model can mimic the complex process, so it can consider more mechanistic or realistic. Kim and Lieth (2003) developed a coupled model of gas-exchange and energy balance with rose leaf. They can successfully apply a coupled approach to photosynthesis-stomatal conductance- transpiration modelling suggested originally by Collatz *et al*. (1991). There are few models developed to describe vegetable crops including napa cabbage. A napa cabbage, an ingredient of Kimchi, is one of important crops in South Korea, but its production is easily influenced by abnormal weather condition. We try to compare the performance of two approaches, RUE and gas-exchange models, with napa cabbage.

II. Materials and Methods

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Firstly a temperature-controlled experiment was conducted using soil-plant-atmosphere-research (SPAR) chambers. Six day/night temperature treatments were 14°C/9°C, 17/12, 20/15, 23/18, 26/21, 29/24. Plants grew about 60 days in SPAR chamber and collected and measured growth elements such as leaf number, leaf area and dry weight, every 7 day. RUE was estimated from cumulative intercepted-PAR and dry weights of plant samples. And we used a gamma function to correct RUE values by temperature. Leaf area index (LAIs) were estimated from leaf number, which was calculated rate function of leaf initiation related to temperature. Secondly, measurements of A-Ci curves were conducted with with napa cabbage leaves grown in SPAR chambers to get several parameters used in FvCB model. Averaged values of each parameter and LAIs from different SPAR chambers were used in gas-exchange model. We used the method suggested by Collatz *et al*. (1991), for scaling up from leaf-level to canopy-level in gas-exchange model. Both models were constructed using MS Excel Built-in coded by VBA programming language. Excel Built-in was originally made by Teh (2011), but used with some modification. For comparison of models data from independent experiment, conducted in Suwon, South Korea, were used. Simulations are conducted by daily bases in RUE model and hourly base in gas-exchange model.

III. Conclusion

The growth such as increasing leaf number, plant weight, of napa cabbage was successfully simulated by both of RUE and gas-exchange models. RUE model show reasonable simulation results in leaf number and fresh weight change (Fig. 1 and Fig. 2).

Fig. 1. Measured and simulated fresh weights of napa cabbage were compared. Radiation use efficiency (RUE) model is applied for growth simulation.

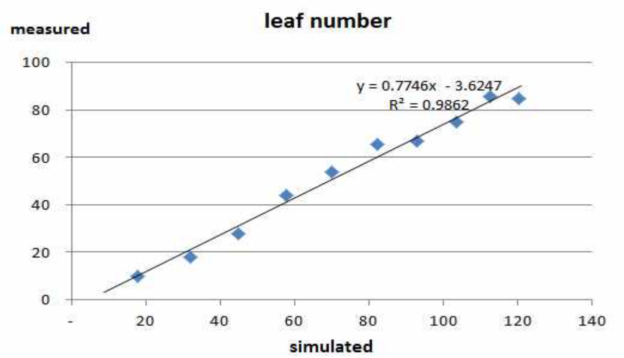

Fig. 2. The number of leaves by RUE model of napa cabbage is overestimated by 30% compared to measured data.

Though the structure of RUE model is simpler than that of gas-exchange model, it is not easy to get accurate RUE values of napa cabbage. RUE values also affected by air temperature, so correction process is needed. Gas-exchange model was constructed using data of measured A-Ci curves at leaf level using LI-6400. This gas-exchange model simulates hourly changes in photosynthesis and growth process (Fig. 3). Because gas-exchange model can simulate other physiological process such as respiration, stomatal conductance, leaf temperature, it can be used a good tool to investigate and fill the knowledge gaps in plant physiology. This model is more mechanistic and has a potential to be used as a tool of yield forecasting in napa cabbage production (Fig. 4). But the other processes of water and nutrition movement in soil, environmental stress and damage should be combined for more realistic prediction of growth in the field situation.

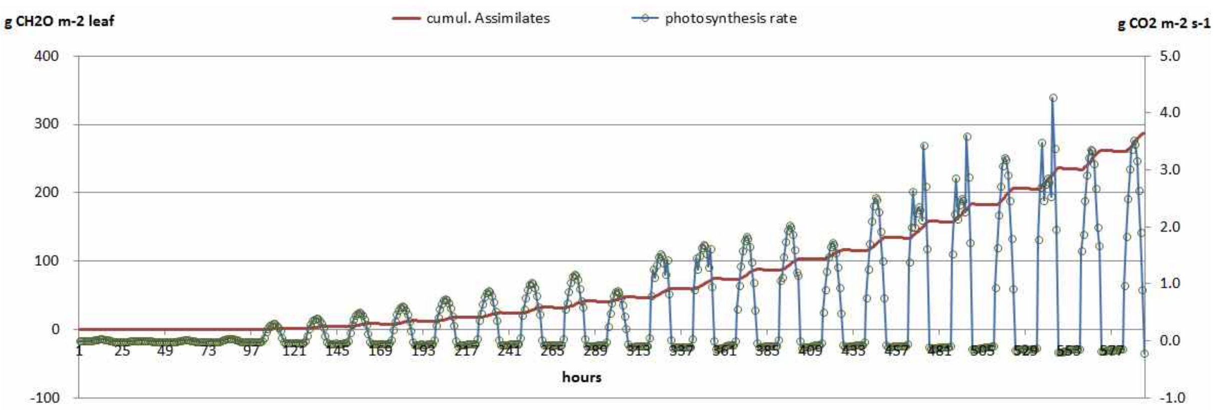

Fig. 3. The changes in photosynthesis and assimilation process can be simulated by gas-exchange model of napa cabbage. Those process are simulated every hour units. Plant respiration can be showed using this model.

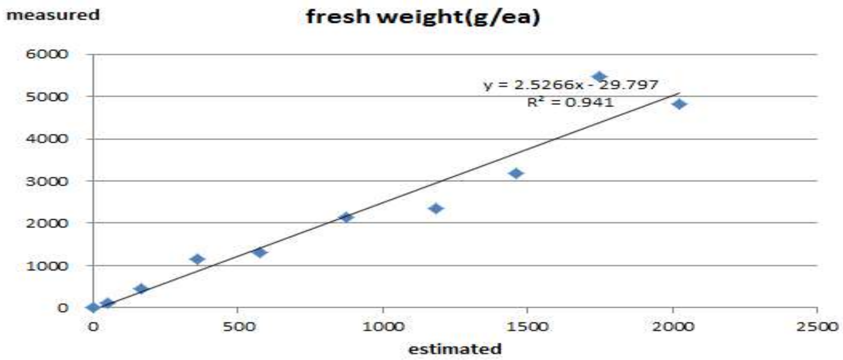

Fig. 4. The gas-exchange model of napa cabbage shows the potential of accurate simulation of plant growth though fresh weight data show underestimated results compare to measured data.

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