Combined Effects of Elevated Temperature and CO_2 Concentration on Maize Growth

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1. Introduction

Phenological responses of crop on micrometeorological variation should be quantitatively expressed to predict the effect of climate change on crop production. The objective of the present study was to evaluate the combined effects of elevated air temperature and carbon dioxide (CO_2) on the growth of maize.

2. Materials and methods

The experiment was conducted for the second straight year in three closed growth chambers at Biotron Institute of Kyushu University (E130° 14', N33° 38'), Japan. Air temperature and CO_2 concentration in chambers were controlled as shown in Table 1. A set value of relative humidity was 70 % in all chambers. Sixteen Wagner pots with an area of 0.05 m^2 were placed in each chamber for measurements growth rate. Four more pots were placed in the chamber 3 to examine the effect of water stress (treatment termed STRESS). Mixture of Andosols and Masa (sandy soil) (1:1 volume) was put into each pot with 10 g of chemical fertilizer (N-P-K; 16%-16%-16%) as basal dressing. Three seeds of maize (*Pioneer G-98*) were sown in each pot on June 13, 2005, and seedlings were thinned to one plant five days after budding. For preventing soil surface evaporation, soil surface was covered with white plastic beads 10 days after sowing (DAS). Irrigation water was applied through a PVC tube of inner diameter 30 mm. Soil moisture of STRESS treatment was gradually decreased by watering less than THCH treatment since 59 DAS.

Crop height and the number of leaves were measured, and a pot was weighed every week. On 28, 42, 55 and 96 DAS, four plants were sampled from each treatment for measurements of dry matter weight (DMW) and leaf area. Air temperature and humidity were measured every 10 minutes using a humidity and temperature logger (Sensor HA9630, Logger HA3631, NIHON SHINTECH Co., Ltd.), and shortwave radiation, R_s, was measured every 3 minutes with a pyranometer (LI-200SB, LI-COR, inc.) in each chamber.

Table 1. Meteorological condition in chambers

Chamber (Treatment)	Air temperature (℃) day/night	CO_2 (ppm)
1(TLCL)	28/22	350
2(TLCH)	28/22	700

3. Results and discussion

The results in this experiment are discussed together with those in 2004.

Figure 1 shows the changes of the area of green leaves per a plant. There was no significant difference among treatments at the first and second samplings. The change in green leaf area changed depending on days after sowing rather than thermal time or short wave radiation during this period. At the third and last samplings, there were significant differences due to the effects of the growth environment. The change of the specific leaf area was well expressed with time from the sowing except for TLCL in 2005.

Dry matter weight (DMW) of total leaves, including green, yellow and dead leaves, was highest in TLCH and lowest in THCH at the maturity stage. The difference in DMW of total

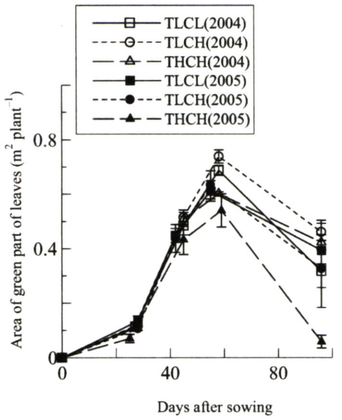

Fig. 1. Time courses of area of green leaves.

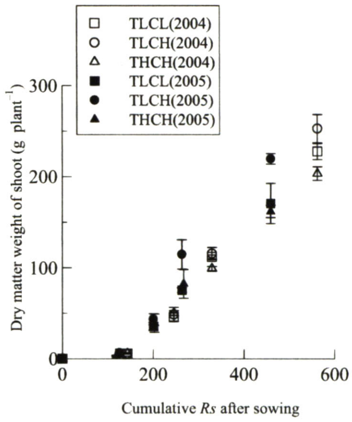

Fig. 2. Relationship between (dry matter weight of shoot and cumulative shortwave radiation.)

leaves due to treatment was smaller than other organs.

The change in dry matter weight of stem was highest in TLCH and lowest in TLCL at the maturity stage. DMW of stem was well expressed with a function of shortwave radiation cumulated from sowing except for TLCH at the third sampling. The change in dry matter weight of ear was lowest in THCH, and that in TLCH was almost equal with that in TLCL. DMW of ear was well expressed with a function of the cumulated shortwave radiation.

Figure 2 shows the relationships between dry matter weight of shoot (leaves + stem + ear) and cumulative shortwave radiation from sowing. The difference in DMW among treatments was clearly illustrated at the last sampling. DMW of shoot at the maturity stage was highest in TLCL and lowest in THCH. DMW in 2004 was larger than that in 2005 for all treatments. This difference was probably occurred because of the difference in total solar radiation during the growth period. The relationship for each treatment was expressed well than the relationship using the thermal time (Fig. 3).

4. Conclusions

The experiments for the combined effects of elevated air temperature and carbon dioxide (CO_2) on the growth in 2004 and 2005 reveal that:

- The rise in CO_2 concentration caused the increase in biomass of shoot especially in

that of stem from the comparison

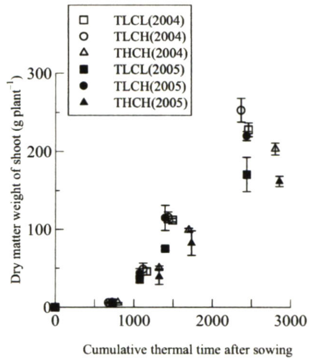

Fig. 3. Relationship between dry matter weight of shoot and cumulative thermal time.

treatments TLCL and TLCH.

- The increase in air temperature caused the reduction in biomass of shoot (leaf and ear).

The effect of elevated CO_2 concentration and air temperature on dry matter weight of shoot would be expressed well with a function of the cumulative shortwave radiation.

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