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Canopy and leaf architecture of rice exposed to elevated CO2 and air temperatures

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Objectives

The objectives were to know how increasing atmospheric CO2concentration ([CO2]) and air temperatures (Ta) will affect canopy and leaf architecture of rice, and the resultant structure, will affect crop production processes.

Materials and methods

Controlled-environment chamber and experiment design: In 2005, rice crops (cv. Dongjinbyeo) were grown in six temperature gradient chambers (TGCs) at Chonnam National University, Gwangju (126°92' E, 35°31' N), Korea. Over the season, three of six TGCs were fumigated with [CO2] of 59211ppmV. The remaining three TGCs were maintained at natural ambient [CO2]. There were three temperature (Ta) subplots in the range from local ambient Ta (av.25.8oC) to ambient +3oC in each TGC. The experiment was a split-plot design with the whole plots arranged in randomized complete blocks (3 replications). Two levels (ambient and elevated) of [CO2] were whole-plot treatment and three levels of temperature were the split-plot treatment.

Plant culture: Germinated seeds were sown on 6 May. Seedlings were transplanted into paddies inside TGCs on 4 June, with a hill (3 seedlings/hill) spacing of 15cm and a row spacing of 30cm. Fertilizers were applied at the rate of 11, 4.5 and 5.7g m-2 for N, P2O5 and K2O, respectively. Other crop managements were similar to those used by local farmers.

Measurements and plant sampling: At full heading [79 days after transplanting (DAT)], a typical hill from each of the subplots were sampled with a block of soil (30x15x15cm) and placed in naturally erect posture, and then divided into several layers with height of 15cm from the ground level. Plant parts from each layer were separated into stem, living leaf, dead leaf and panicle, and then leaf area and dry matter (DM) determined separately. Six SPAD readings on flag leaves were taken at three positions (at by 1/4, 1/2 and 2/3 of the blade length from the leaf tip), and were averaged. At 87 DAT, flag leaves on each of two hills from each of the subplots were collected, and its length, width and area were determined. Based on these data, specific leaf area (SLA) and weight (SLW) were calculated.

Results and discussion

Elevated [CO2] reduced significantly flag leaf length by 16% but not width, resulting in a corresponding reduction (16%) in leaf area when measured at full heading (Fig.1). Air temperatures did not affect the magnitude of these changes with elevated [CO2], though, regardless of [CO2] conditions, the leaf size of rice increased as temperature rises. This result indicates that with elevated [CO2] increased green leaf area index (GLAI) at early stages of crop development, which found in previous studies, will probably due to increased leaf number per plant with increasing tiller appearance, rather than increased size of individual leaves. For specific leaf weight (SLW), a similar response was observed with respect to [CO2] and air temperatures (Fig. 2). This was contrast with the response at early stages of crop development when SLW slightly increased with elevated [CO2]. The response of SPAD value, which is an indicator of leaf quality, to [CO2] and air temperatures was also similar to that of SLW. Elevated [CO2] decreased canopy height of rice, while air temperature did not alter it. Over all Ta regimes, total DM was significantly increased with elevated [CO2], showing the greatest increase in the lowest layer in the canopy when panicle DM excluded (Fig. 3). In both ambient and elevated [CO2], although most of the panicles was distributed in the canopy layer over 75cm, panicles positioned at the layer less than 75cm were greater in elevated [CO2] compared to ambient [CO2]. Across all layers, cumulative GLAI was decreased with elevated [CO2], averaging of about 15% over all Ta regimes (Fig. 4). In both ambient and elevated [CO2], the portion of GLAI positioned at higher canopy layer was significantly increased as air temperature rises. These results suggest that elevated [CO2] alone or together with global warming has a potential to alter canopy and leaf architecture of rice, which in turn, may change an efficiency of light acceptance for canopy photosynthesis and other crop production processes.

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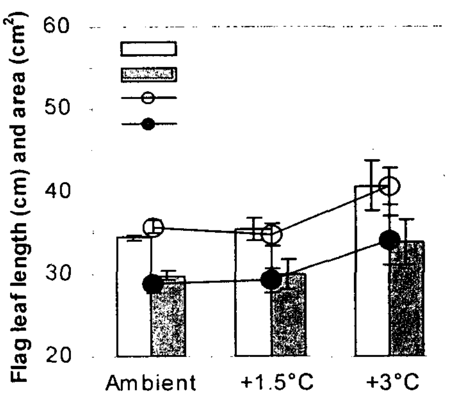

Fig. 1. Flag leaf length and area of rice grown under different [CO2] and air temperatures (Anova results for leaf length, CO2: *, temp.: *, CO2 x temp.: ns, and for leaf area, CO2: *, temp.: *, CO2 x temp.: ns)

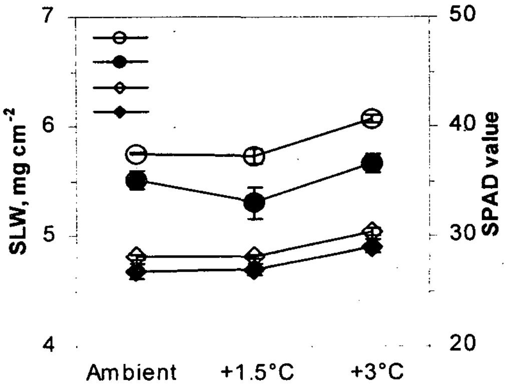

Fig. 2. SLW and SPAD value of flag leaf of rice grown under different [CO2] and air temperatures (Anova results for SLW, CO2: *, temp.: *, CO2 x temp.: ns, and for SPAD value, CO2: *, temp.: **, CO2 x temp.: ns)

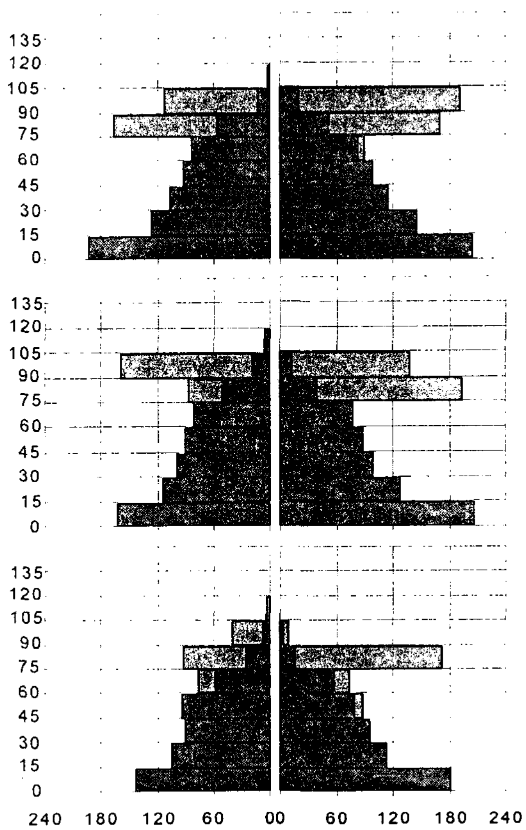

Fig. 3 DM in several canopy layers of rice grown under different [CO2] and air temperatures (■ : shoot DM, ▨: panicle DM).

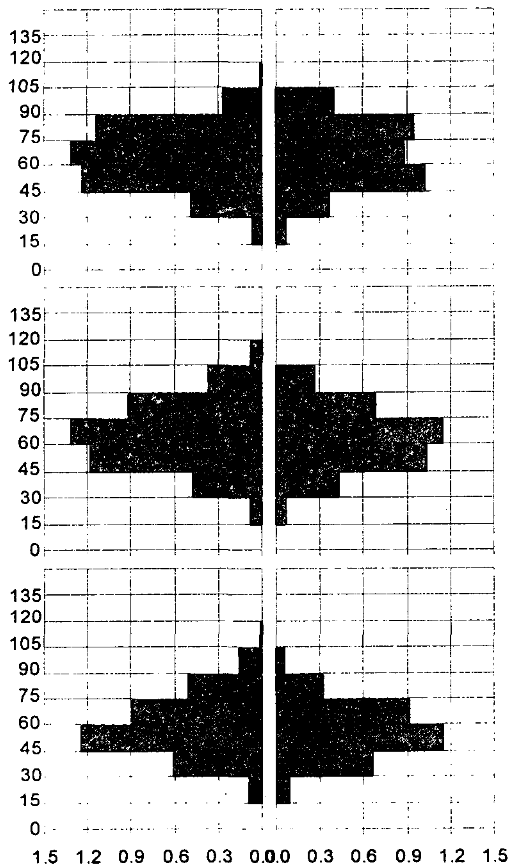

Fig. 4 GLAI of several canopy layers of rice grown under different [CO2] and air temperatures.