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Seasonal responses of maize growth and water use to elevated CO2 based on WTDPED experiments: evidences from multiple ecophysiological indicators

Ying Ma
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China (maying@igsnrr.ac.cn)

The increase in atmosphere carbon dioxide (CO_2) concentrations has been the most important environmental change experienced by agricultural systems. It is still uncertain whether grain yield of the global food crop of maize will remain unchanged under a future elevated CO_2 (eCO_2) environment. A water transformation dynamic processes experimental device (WTDPED) was developed using a chamber coupled with two weighing lysimeters and a groundwater supply system to explore the water-related yield responses of maize to eCO_2. Two experiments were conducted via the WTDPED under eCO_2 (700 ppm) and current CO_2 (400 ppm) concentrations. Seasonal changes in multiple ecophysiological indicators and related hydrological processes were compared between these two experiments. The results showed that the leaf nitrogen (N) content, chlorophyll content, net photosynthesis rate, and transpiration rate (T_r) consistently decreased during the seedling to filling stages but notably increased at the maturity stage due to eCO_2 ($P<0.05$). Nevertheless, the effects were not significant over the entire growing season or for other indicators, i.e., the leaf carbon (C) content, C/N ratio, and leaf area index ($P>0.05$). Significant decreases in crop height (mean of 15.9%, $P<0.05$) associated with notable increases in stem diameter (mean of 14.9%, $P<0.05$) were found throughout the growing season. Dry matter per corncob at the final harvest decreased slightly under eCO_2 (mean of 7.7 g, $P>0.05$). Soil moisture was not conserved by the decline of T_r ahead of the filling stage when soil evaporation was likely promoted by eCO_2 instead. The total evapotranspiration changed little (0.2%) over the entire growing season. Although the leaf water use efficiency increased significantly at every growth stage (mean of 27.3%, $P<0.05$), the grain yield, water productivity and irrigation water use efficiency were not improved noticeably by eCO_2. This study is critical to accurately predict future crop yield and hydrological changes under climate change.