GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

www.scienceandnature.org

Short Communication

EFFECT OF ELEVATED CARBON DIOXIDE (eCO2) ON GROWTH AND DEVELOPMENT OF DIFFERENT RICE CULTIVARS IN ODISHA

B. P. Rosalin*, Surendranath Pasupalak, Anupama Baliarsingh
Department of Agricultural Meteorology, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar – 751 003
*Corresponding email: rosalin.rosy08@gmail.com

ABSTRACT
Rice is the most important cereal crop in India including state of Odisha. The climate change and elevated carbondioxide have fertilization effect in increasing biomass and yield. Hence ,a controlled environment pot experiment in Bhubaneswar on rice ,grown in kharif, 2012 to find out the effect of eCO_2 (476 ppm) on growth ,development and yield of seven rice cultivars of three maturity groups in comparison to ambient OTC and open field. Elevated CO_2 increased plant height ,tiller number, leaf area and dry matter production The favourable effect of eCO_2 was found on plant height and tiller number during vegetative stage (active tillering),leaf area in reproductive stage (Panicle initiation) and dry matter at maturity. The increases due to eCO_2 were 14.8 cm more in plant height ,189 cm^2 per hill more leaf area ,two more tillers per hill and 3.1 g per hill more dry matter compared to open field. In contrast the relative growth rate and net assimilation rate were higher in ambient OTC than in eCO_2 OTC and open field.Net photosynthetic rate was almost same under three environmental conditions. In case of appearance of developmental stages, panicle initiation and flowering stages were accelerated by 3 days under eCO_2 and ambient OTC compared with open field. But maturity stage came one day later under eCO_2 than open field condition.

KEY WORDS: Carbon dioxide, growth, development, rice cultivar

INTRODUCTION

Rice, with an annual production of 0.6 bt, is most important cereal crop for feeding world population (IRRI, 2002). More than half of the world population (about 63%) in Asia depends on rice as their staple food. In India rice is the most important cereal crop with area 44.8 m ha and production 91.8m t, which is 21% of the global rice production next to China (FAO, 2006-07). Odisha a major rice growing state having rice grown area 4.4 m ha. CO_2 is one of the key inputs required for photosynthesis, biomass production and yield formation in all agricultural crops. The energy production from fossil fuels has increased atmospheric CO_2 concentration from about 280µmol per mole to 370 µmol mol $^{-1}$since 1750 and may reach 550 µmol mol $^{-1}$ by middle of 21st century (McCarthy *et al*., 2001). The direct effect of increased CO_2 concentration is expected to enhance the growth and yield of many C3 agricultural crops including rice (Kimball *et al*., 2007).So to meet the future rice demand due to increased population, it is therefore essential to produce rice more efficiently under elevated CO_2. According to laboratory experiment, rice grown at a higher CO_2 level has more vegetative growth than rice grown at an ambient level of CO_2 and open field (DaMatta *et al*., 2009).However, Razzaque *et al*. (2011) reported that growth and yield responses of rice to eCO_2 differed with genotype. The high yield varieties generally responded less than local varieties. When appearance of developmental stages were considered, earlier flowering in response to increased CO_2 was reported in most crop species including rice , but delayed and unchanging flowering time at eCO_2 have also been reported. There is no reliable criteria for rice cultivators and eCO_2 studies are less in India and never so in Odisha as a rice growing state so we have undertaken an pot experiment in Open Top Chamber(OTC) at Central Research Farm, Bhubaneswar during Kharif season of 2012 to study growth and and development of seven kharif rice cultivators to eCO2 besides characterizing the physical environment under eCO^2 in open Top Chamber (OTC) as compared to ambient OTC and open field and to determine the effect of eCO_2 on leaf nitrogen content.

MATERIALS & METHODS

The experiment conducted in OTCs in Central research Station of the OUAT BBSR during kharif, 2012-13.Top soil 0 to 30 cm depth from commercially cultivated rice plot of 5 year as used to fill pots. Physiochemical analysis of composite soil found to be loam, sandy, acidic soil available in N and available K_2O with low organic carbon. It was medium in available of P_2O_5 content. The place is warm and moist climate with hot humid summer and a short mild winter. Area in Bhubaneswar is situated at 20° 15'N and 85°'52 E 65 km west of Bay of Bengal. Climate falls in

moist hot group with average rain fall code for the place is $D_1E_3(B_1A_2B_1)C_1D_1E_2$(lenka,1976).The monsoon usually sets on 10th June and recede by 15th October having rain fall 1240mm. The pot experiment conducted in seven varieties Mandakini (95-100 days), Jyotirmayee (95days), Khandagiri (95 days), Tejaswani (130 days), Hiranmayee (130days), Ramchandi (150-155 days) and Swarna (140 days).

Eight OTC in two row having 3.3m distance in between in East-West direction of circular shape was made up of weather resistant heavy duty UV filtered polycarbonate sheets (100% transmission), 4 m height along with diameter .From a height of 3.5 m CO2 was supplied to OTCs through micro pipeline from 47 L gas cylinder containing 22 kg CO2 at 8 bar pressure in the control room located near OTCs. The temperature and relative humidity sensors inside the OTCs were direct capacitance type (Ambetronics Company). Digital panel output display was there with software analysis. Air temperature measured at 1.2 height by thermometer shielded from direct solar radiation. The gate of first row of OTC s was faced towards south and other towards north. The pot experiment was conducted in seven variety in Open field, OTCs with ambient CO_2(380ppm) conc. and elevated CO_2(476 ppm) concentration. Seasonal weather in open field was having 20 rainy day with 252.8mm rainfall. Mean maximum temp at 2pm was 30.8° centigrade and minimum at 7 am was 19.1° C .The mean maximum temp in Open field ,OTCs with ambient CO_2(380ppm) conc and elevated CO_2(476 ppm) conc was 30.8 °C,31.3 ° C,33.3° C respectively. However the CO_2 content in ambient OTC (341.9ppm) was close to outside air (355.3ppm) but it was found eCO_2 OTC had 24.8% CO_2 higher than outside. Pot filling, Transplanting, Cultural operation and harvesting was done as per normal procedure as done as per normal procedure. One hill was destructively sampled from each combination at active tillering panicle initiation, flowering and maturity stage. Plant height measured by meter ruler, Tiller number counted at different developmental stage namely tillering, PI, flowering and maturity. Leaf area of sample measured by leaf area meter at PI, flowering and a maturity stage. The observed value for growth, developmental stage, yield components were subjected to standard statistical analysis (Gomez and Gomez, 1984).

RESULTS

The increase in temp under eCO_2 was higher 2.3 ºC during whole cropping period. The increased temp was as high as 5.4° C during flowering in medium maturity cultivars and 2.6-3 ºC during PI to flowering stage in late maturity cultivar. Across three environment, the cultivars differed in plant height in open field condition at panicle initiation and flowering stage. The cultivar mandakini was taller (106.2 cm) and differed from Khandagiri, Tejaswani and Swarna at PI stage and from Khandagiri and Jyottirmayee at flowering stage. Under eCO_2 the plant height was more (avg 78.3cm) than under open field condition (avg 53.7 cm).The tiller number was higher in Mandakini(8) , Jyotirmayee(8) than in Tejaswani(5) under open field condition. All other variety did not differ in tiller number when compared to Jyotirmayee. Under ambient OTC, varieties did not differ in tiller number per hill at any of stages. Elevated CO_2 produced higher number of tillers per hill (9) than open field (7) and ambient OTC (8) conditions. Among varieties Swarna, Tejaswani and Hiranmayee produced more leaf area per hill (1138cm^2) than Khandagiri, Mandakini, Jyotirmayee and Ramchandi. The dry matter production was higher under eCO_2 (19.3g) than under ambient OTC and open field (both 16.9g) conditions at PI stage. But at the flowering stage the dry matter production was higher under eCO_2 condition (23.7g $hill^{-1}$) than open field(20.6 g $hill^{-1}$) condition and almost same under ambient OTC(22.2g) condition. Environment effect was not significant at maturity stage. Growth rate was higher under ambient OTC (0.40gd^{-1}) than open field condition (0.31gd^{-1}) at flowering to maturity stage when compared among the three environmental conditions. Ambient CO_2 caused higher RGR from PI to flowering to maturity. From PI to flowering RGR was lower under eCO_2 condition (0.012$gg^{-1}d^{-1}$) than ambient OTC condition (0.015$gg^{-1}d^{-1}$) and from flowering to maturity open field condition had lower RGR (0.011$gg^{-1}d^{-1}$) than ambient OTC(0.014$gg^{-1}d^{-1}$).Net assimilation rate almost same among three environmental condition. Rate of net photosynthetic rate higher in cultivator Mandakini. Under eCO_2, the cultivar Jyotirmayee had higher respiration rate (-2.55µmol $m^{-2}s^{-1}$).Under open field condition, the respiration rate was higher (-0.65µmol $m^{-2}s^{-1}$**)** than eCO_2 condition in vegetative stage when compared among the three environments. Across three environment, the cultivar Jyotirmayee had higher productive panicle numbers per hill (10) than the cultivars Khandagiri (6) and Ramchandi (7).All other cultivar did not differ in productive panicle number.

DISCUSSION

Dry matter production in the present experiment was higher under eCO_2 than under open field .The results are inline of findings of several coworkers that total dry matter per stem was greater under eCO_2 (Kim *etal*., 2001; Sakai *et al*, 2001 Yang *et al.,* 2009).In fact, the most visible effect of eCO_2 which was established is that eCO_2 promotes vegetative growth .In the present study eCO_2 produced more leaf area at PI and flowering stages. The results were similar with previous studies shown that total leaf area at PI and flowering stage. The results were similar with previous studies shown that total leaf area was substantially increased by CO_2 enrichment (Wong *et al.,* 1992, Roger *et al.,* 1996, Makino *et al.,* 1997), De Costa *et al.,* 2003). However there was a small decrease in the dry matter under eCO_2 at harvest. The reduction in crop dry matter was because of accelerated leaf senescence and death of plant parts during final crop maturity stage as evidenced from the much reduced leaf at maturity. Kim *et al*. (2001) also observed enhanced leaf senescence in CO_2 enriched plots and attributed this to lower nitrogen availability after panicle initiation. Similar result of lower leaf nitrogen content under eCO_2 than open field condition also observed in the present study. Net photosynthetic rate (Pn) was almost the same for

three environmental conditions at all stages of crop, although the rate varied among the stages from 22.24µmol $m^{-1}s^{-1}$to 19.04µmol $m^{-2}s^{-1}$. The results of this experiment for Pn rate did not agree with the results of the other workers that the canopy Pn significantly increased under eCO_2 but its enhancement rate decreased through the growing season (Sakai *et al*., 2001). Similar Pn rate contributed to almost the same net assimilation rate and relative growth rate under all the three environmental conditions. Thus the role of increased leaf area was not found on the Net assimilation rate could be explained from the multiplicative effect of leaf area on Net assimilation rate with lesser contribution of leaf area in this regard. The increased dry matter accumulation in early maturity cultivars was attributed to the higher leaf area and higher Pn rate of the cultivars than the late maturity cultivars. Relatively more Pn rate caused higher Net assimilation rate in early maturity cultivars. But decreased dry matter in medium maturity cultivars at PI stage could not be explained.

CONCLUSION

The elevated Carbon dioxide increased plant height, tiller number, leaf area and dry matter production at various stages of maturity in rice. In contrast the relative growth rate ,mean growth rate and net assimilation rate were higher in ambient OTC than in eCO_2 OTC and open field without any change in the net photosynthetic rate.

ACKNOWLEDGEMENT

The Authors are very much grateful to the Dean College of Agriculture, Bhubaneswar and Head of the Department of Agrometerology for providing necessary facilities and guidance in completing the research work with in stipulated period of time.

REFERENCES

DaMatta, F.M., Adriana, G., Bruna, A., Marcos, and S, Buckeridge, E. (2009) Impacts of climate changes on crop physiology and food reality. *Journal of Food Research*, **34**:1-10.

De Costa WAJM , Weerakon WMW, Herath, H.M.L.K. and Abeywardena, R.M.I. (2003) Response of growth and yield of rice (Oryza sativa) to Elevated atmospheric Carbon Dioxide in the sub humid zone of Srilanka. *Journal of Agronomy and Crop science*, **189**:83-95.

Gomez, K.A. and Gomez, A.A.(1984) *Ststistical procedures for agricultural research. A Willey inter science publication*, New York, pp.76-83.

Kim, H. Y. Lieffering, M.,Miura, S., Kobayashi, K. and Okada, M. (2001) Growth and nitrogen uptake of CO2-enriched rice under field condition. *New Phytologist***,** **150**:223-229.

Kimball, B.A., Idso, S.B.. Jhonson, S. and Rilling, M. T. (2007) Seventeen years of carbondioxide enrichment of sour orange trees: Final results .*Global change biology*, **13**:2171-83.

Lenka, D. (1976) Classification of rain fall zones and drought prone area (In) water requirement of crops in Orissa. Publisher Directorate of Agriculture, Govt of Odisha, pp.4-5.

Razzaque, M.A., Haque, M.M., Khaliq, Q.A., Soliman, A.R.M. and Hamid, A. (2011) Effect of CO2 and Nitrogen levels on yield and yield attributes of rice cultivars. *Bangladesh Journal of Agricultural Research*, **36(2):**213-221.

Roger, G.S., Milham, P.J., Gillings, M. and Conroy, J. (1996) Sink strength may be the key to growth and nitrogen responses in N-deficient wheat at elevated CO2.*Australian journal of Plant physiology*, **23**:253-264.

Makino, A., Harada, M., Sato, T., Nakano, H. and Mae, T. (1997) Growth and N allocation in Rice Plant under CO2 enrichment. *Plant Physiology*, **115**:199-203.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and Whiteseeds K.S. (2001) Climate change 2001. Impacts, Adaptation and Vulnerability.3rd Assessment Report of the Intergovernmental Panel for climate change. Cambridge University Press, Cambridge.

Sakai, H., Yagi, K., Kobayashi, K. and Kawashima, S. (2001) Rice Carbon Balance under Elevated CO2.*New Phytologist*, **150**:241-249.

Yang, L., Liu, H., Wang, Y., Zhu, J., Huang, J., Liu, G., Dong, G. and Wang, Y. (2009) Yield formation of CO_2 – enriched inter-sub specific hybrid rice cultivar Liangyoupeijiu under fully open –air filled conditions in a warm sub –tropical climate .*Agriculture, Ecosystem & Environment*, **129(1):**193-200.

Wong, S.C., Kriedemann, P.E. and Farquhar, G.D. (1992) CO_2 X nitrogen interaction on seedling growth of four species of eucalyptus. *Australian journal of Botany*, **40**:457-472.