Rice Research-Open Access

Chaturvedi AK, J Rice Res 2017, 5:4
DOI: 10.4172/2375-4338.1000e129

Editorial | Open Access

The Quest for Rice Productivity under Diurnally Changing Temperature Amplitude in Future CO_2 Enriched Climate

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Received date: December 14, 2017; **Accepted date:** December 17, 2017; **Published date:** December 18, 2017

Editorial

Climate change impact on agricultural crops is posing serious threat to global food security. Global climate change models predict increase in mean air temperature up to 2.6° and 4.8°C by 2065 and end of twenty-first century, respectively with doubling of current CO_2 concentration [1]. Despite of climate change constrains, predictions were made for increasing global food production by 70% to feed growing population by 2050 [2]. As a most important cereal crop, rice feeds more than 3 billion people and its contribution in total calorie intake in humans is >20%. It is majorly produced and consumed in Asia where it accounts for 40% to 80% of the calories in the diet [3]. Increase in global mean temperature [1] and unpredicted heat spikes at regional level [4] are catastrophic to rice yield and quality when coinciding with sensitive growth stages. In parallel, the sub-tropical and tropical rice-producing areas are anticipated to be more threatened by temperature increase [1]. Unprecedented increase in night-time and day-time temperature is documented for current and future climate. India is one of the key hotspots for warming in near future [5]. Increase in day-time temperature during sensitive reproductive stage could induce poor anther dehiscence, reduced pollen production, pollen germination and pollen tube growth resulting in higher spikelet sterility and poor seed set in rice [6-8]. Conversely, high night-time temperature from panicle initiation to physiological maturity adversely affected rice grain yield majorly due to reduction in nitrogen and non-structural carbohydrate translocation after anthesis, which results in poor grain filling [9-10]. Moreover, night-time temperature induced reduction in grain yield in rice was attributed to increased night respiration, reduced photosynthesis and total biomass [10,12].

A concomitant rise in atmospheric CO_2 concentration with increase in mean daily temperature due to rapid increase in night-time temperature (T_{min}) than day-time temperature (T_{max}) is narrowing the diurnal temperature amplitude under climate change. Interestingly, increase in T_{min} has been reported to be three times faster over increasing T_{max}. This is resulting in more frequent warmer nights and decreasing day/night differential (amplitude) in near and upcoming future [13]. Impact of increasing T_{min} and T_{max} is documented with yield penalty in rice. Conversely, elevated CO_2 (e[CO_2]) has been known to enhance rice productivity with stimulation in current photosynthesis and growth rate. However, role of e[CO_2] in combination to high day-time temperature has received attention and results suggest that high day-time temperature can offsets the e[CO_2] effects and grain quality may be further deteriorated [14-17]. Similarly role of e[CO_2] and high night-time temperature has received attention too [18]. Elevated [CO_2] with a narrowed temperature amplitude resulting from high day- and night-time temperature are inevitable combination of current and future climate and requires ample interest. There are few studies on the thermal amplitude in crops such as wheat [19], rice [20] and maize [21]. The importance of day/night differential has received considerable attention in relation to the growth and yield. It has been reported that plant growth would be favored by low night temperatures as this would reduce respiratory losses at a time when the supply of carbohydrate might become limiting. However, dry matter production for a wide range of crops grown under constant but optimal temperature is equal to and often greater than dry matter production by the same crops grown under differential day/night temperatures with the same mean value. Change in temperature amplitude from 10°C to 20°C has been reported to reduce growth. Further, the contribution of the amplitude of daily variation of 15°C (32.5/17.5°C) could increase carbon-use efficiency in mature leaves and roots of orange trees, leading to increased leaf area index and photosynthetic rates compared with 0°C (25/25°C) daily variation [22]. Differential impact of high day- and night-time temperature along with possible effect of varying amplitude has been advocated [23]. Differential mechanisms leading to high day and high night temperature stress-induced loss in yield and quality in rice has been reported recently [24]. Interestingly, there are no reports hitherto on rice response to temperature amplitude in combination to e[CO_2]. Hence, it is of utmost importance to analyze growth, carbon assimilation and source sink dynamics under varying temperature amplitude under e[CO_2]. The mechanistic understanding on that under future climate could address the unknown effect of temperature amplitude under enriched [CO_2] environment. Identification of traits affecting under varying temperature amplitude could be important key entry points for future studies and making inroads to rice resilience under future diurnally varying temperature amplitude under e[CO_2].

References

1. Alexander L, Simon Bindoff NL (2013) Working Group I Contribution to the IPCC Fifth Assessment Report Climate Change 2013: The Physical Science Basis Summary for Policymakers. OPCC.
2. Alexandratos N, Bruinsma J (2012) World agriculture towards 2030/2050: the 2012 revision (No. 12-03, p. 4). Rome, FAO: ESA Working paper.
3. Mahajan G, Sekhon NK, Singh N, Kaur R, Sidhu AS (2010) Yield and Nitrogen-Use Efficiency of Aromatic Rice Cultivars in Response to Nitrogen Fertilizer. J New Seeds 11: 356-368.
4. Battisti DS, Naylor RL (2009) Historical warnings of future food insecurity with unprecedented seasonal heat. Science 323: 240-244.
5. Rao BB, Chowdary PS, Sandeep VM, Rao VUM, Venkateswarlu B (2014) Rising minimum temperature trends over India in recent decades: implications for agricultural production. Global and Planetary Change 117: 1-8.
6. Prasad PVV, Boote KJ, Allen LH, Sheehy JE, Thomas JMG (2006) Species, ecotype and cultivar differences in spikelet fertility and harvest index of rice in response to high temperature stress. Field Crop Res 95: 398-411.

7. Jagadish SVK, Craufurd PQ, Wheeler TR (2007) High temperature stress and spikelet fertility in rice (Oryza sativa L.). J Exp Bot 58: 1627-1635.
8. Jagadish SVK, Muthurajan R, Oane R, Wheeler TR, Heuer S, et al. (2010) Physiological and proteomic approaches to address heat tolerance during anthesis in rice (Oryza sativa L.). J Exp Bot 61: 143-56.
9. Shi W, Yin X, Struik PC, Xie F, Schmidt RC, et al. (2016) Grain yield and quality responses of tropical hybrid rice to high night-time temperature. Field Crops Res 190: 18-25.
10. Bahuguna RN, Celymar AS, Wanju S, Jagadish KSV (2017) Post-flowering night respiration and altered sink activity account for high night temperature-induced grain yield and quality loss in rice (Oryza sativa L.). Physiol Plant 159: 59-73.
11. Mohammed AR, Tarpley L (2009) High night time temperatures affect rice productivity through altered pollen germination and spikelet fertility. Agric Forest Meteorol 149: 999-1008.
12. Mohammed R, Cothren JT, Tarpley L (2013). High night temperature and abscisic acid affect rice productivity through altered photosynthesis, respiration and spikelet fertility. Crop Sci 53: 2603-2612.
13. Alexander LV, Zhang X, Peterson TC, Caesar J, Gleason B, et al. (2006) Global observed changes in daily climate extremes of temperature and precipitation. J Geophys Res: Atmosph, 111(D5).
14. Cai C, Yin X, He S, Jiang W, Si C, et al. (2016) Responses of wheat and rice to factorial combinations of ambient and elevated CO2 and temperature in FACE experiments. Global Change Biol 22: 856-874.
15. Wang J, Wang C, Chen N, Xiong Z, Wolfe D, et al. (2015) Response of rice production to elevated [CO2] and its interaction with rising temperature or nitrogen supply: a meta-analysis. Climatic Change 130: 529-543.
16. Chaturvedi AK, Bahuguna RN, Pal M, Shah D, Maurya S, et al. (2017) Elevated CO2 and heat stress interactions affect grain yield, quality and mineral nutrient composition in rice under field conditions. Field Crops Res 206: 149-57.
17. Chaturvedi AK, Bahuguna RN, Shah D, Pal M, Jagadish SK (2017) High temperature stress during flowering and grain filling offsets beneficial impact of elevated CO_2 on assimilate partitioning and sink-strength in rice. Scientific Reports 7:8227.
18. Cheng W, Sakai H, Yagi K, Hasegawa T (2009) Interactions of elevated [CO2] and night temperature on rice growth and yield. Agri Forest Meteorol 149: 51-58.
19. Slafer GA, Rawson HM (1995) Rates and cardinal temperatures for processes of development in wheat: effects of temperature and thermal amplitude. Funct Plant Biol 22: 913-926.
20. Yin X, Kropff MJ, Goudriaan JAN (1996) Differential effects of day and night temperature on development to flowering in rice. Annals Bot 77: 203-213.
21. Sunoj VJ, Shroyer KJ, Jagadish SK, Prasad PV (2016) Diurnal temperature amplitude alters physiological and growth response of maize (Zea mays L.) during the vegetative stage. Environ Exp Bot 130: 113-121.
22. Bueno ACR, Prudente DA, Machado EC, Ribeiro RV (2012) Daily temperature amplitude affects the vegetative growth and carbon metabolism of orange trees in a rootstock-dependent manner. J Plant Growth Regul 31: 309-319.
23. Bahuguna RN, Jagadish KS (2015) Temperature regulation of plant phenological development. Environ Exp Bot 111: 83-90.
24. Shi W, Xinyou Y, Struik PC, Solis C, Fangming X, et al. (2017) High day- and night-time temperatures affect grain growth dynamics in contrasting rice genotypes. J Exp Bot 68: 5233-5245.