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Climate Change and Flowering in Plants

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Temperature is a major determinant of the timing and duration of key developmental phases like flowering, while CO_2 is a major determinant of plant growth. The data on historical flowering date of more than 400 plant species and deciduous trees at decadal time scale over a few centuries provides convincing evidence that flowering times have advanced by 4-6 days per single degree centigrade increase on an average

Introduction

Climate change is alteration in the geometric distribution of weather patterns and when that change lasts for an extended period of time (i.e. decades to millions of years). The Intergovernmental Panel on Climate Change Reports (IPCC, 2014) documents evidence of increasing temperature and carbon-dioxide concentrations (CO_2) along with other green house gases leading to a higher frequency of extreme climate events such as heat waves, drought events, etc. The global average combined land and ocean surface temperature and CO_2 data as calculated shows increase by 0.65 to 0.87 °C and 40% (400 ppm) over the period 1880 to 2015, respectively (IPCC, 2014; NASA, 2016; NOAA, 2016). Current projection is that the concentrations of CO_2 will continue to rise to as much as 500-1000 ppm by the year 2100. According to Inter governmental Panel Climate Change (IPCC, 2013; IPCC, 2014) the expected changes in temperature over the next 30-50 years are predicted to be in the range of 2-3 °C. However, temperature is a major determinant of the timing and duration of key developmental phases like flowering (Jagadish and Bahuguna, 2016), while CO_2 is a major determinant of plant growth (Craufurd and Wheeler, 2009).

Climate Change and Phenology of Plant

Phenology is the study of the timing of recurrent biological events, such as bud break, flushing, flowering, fruit development etc. and is closely regulated by climate and seasonal changes. Phenology variation among species is one of the important mechanisms for maintaining species co-existence in diverse plant communities (Cleland *et al.*, 2007). The phenological events like the shifts in the timing of biological process provide some of the most powerful evidence that ecosystems are being influenced by global environmental change along with interactions with other cues, such as photoperiod. Hence, climate change is likely to have significant impacts on plant developmental processes especially flowering.

Climate Change and Flowering Time

The plant reproductive success is determined by flowering time which marks visible transition from the vegetative to reproductive phase. It determines the duration from emergence to flowering and the reproductive competency of a plant. The timing of flowering parses relative to

the occurrence of abiotic and biotic constraints and is critical for successful seed-set and propagation. It may affect individual species "fitness" in relation to competition with other species. The synchrony of pollination with insects in ecosystems is affected with change in flowering time and hence, the distribution of species may be affected. All the above functions could be affected by climate change and at the same time flowering time is one of the major factors getting affected due to changing climate (Jagadish *et al.*, 2016).

The data on historical flowering date of more than 400 plant species and deciduous trees at decadal time scale over a few centuries provides convincing evidence that flowering times have advanced by 4-6 days per single degree centigrade increase on an average (Table 1). Temperature affects flowering time by influencing both the rate of development directly as well as vernalization (Craufurd and Wheeler, 2009). Higher concentration of CO_2 favors higher photosynthate (sugars and starch) accumulation in plants. A sugar signaling metabolite trehalose-6- Phosphate (T6P) showed a strong correlation with vegetative and shoot-apical meristem tissue. T6P has been reported to relay on tissue carbohydrate availability and act as key signal for floral induction (Wahl *et al*., 2013). Flowering time in 40 published studies involving both cultivated crops and other plant species exposed to elevated carbon-dioxide e[CO_2] (from 350 to 1000 ppm) showed that in 28 cases flowering time was earlier (average 8.6 days) and in 12 cases flowering was delayed (average 5.2 days) (Jagadish *et al.*, 2016) (Table 1).

Table 1: Flowering time variation (days) under elevated CO_2 and warming temperature

Plant species	Days (Delay (+) or Advancement (-) in flowering time)		Duration of Study	References
	e[CO_2]	Warming		
Spring wheat	−1 to −3	−7 to −18	1985-2009	Marc and Gifford, 1984; Olesen *et al*., 2012
Winter wheat	-	−4 to −14	1985-2009	Olesen *et al*., 2012
Sunflower	−1 to −3	-	NA	Marc and Gifford, 1984
Soybean	−2 to +11	-	NA; 2013	Heinemann *et al*., 2006; Bunce, 2015
Pigeon pea	+8 to +9	-	2012-2013	Sreeharsha *et al*., 2015
Rice	−7	-5	NA	Seneweera *et al*., 1994
405 flowering plant species, UK	-	−2 to −13	1753-2003	Amano *et al*., 2010
Grass land nectar plants	−8 to +2	-	NA	Rusterholz and Erhardt, 1998

Conclusion

The available data on climate change over the past century indicates that the earth is warming up and changes in important biological events such as plant phenology have been constantly reported in many parts of the world. Experimental and modeling approaches have sought to identify the mechanisms causing these shifts, as well as to make predictions regarding the consequences.

References

Amano T, Smithers RJ, Sparks TH and Sutherland WJ. 2010. A 250-year index of first flowering dates and its response to temperature changes. *Proc. R. Soc. Biol. Sci.* 277: 2451-2457.

Bunce JA. 2015. Elevated carbon dioxide effects on reproductive phenology and seed yield among soybean cultivars. *Crop Sci.* 55: 339-343.

Cleland EE, Chuine I, Menzel A, Mooney HA, Schwartz MD. 2007. Shifting plant phenology in response to global change. *Trends Ecol. Evolution* 22(7): 357-365.

Craufurd PQ and Wheeler TR. 2009. Climate change and the flowering time of annual crops. J. Exp. Bot. 60: 2529-2539.

Heinemann AB, Maia AHN, Dourado-Neto D, Ingram KT and Hoogenboom G. 2006. Soybean (*Glycinemax* (L) Merr) growth and development response to CO2 enrichment under different temperatures regimes. *Eur. J. Agron.* 24: 52-61.

IPCC [Intergovernmental Panel on Climate Change] 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC [Intergovernmental Panel on Climate Change] 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, 151 pp.

Jagadish SVK, Bahuguna RN, Djanaguiraman M, Gamuyao R, Prasad PVV and Craufurd PQ. 2016. Implications of High Temperature and Elevated CO2 on Flowering Time in Plants. Front. Plant Sci.7: 913.

Marc J and Gifford RM. 1984. Floral initiation in wheat, sunflower and sorghum under carbon dioxide enrichment. *Can. J. Bot.* 62: 9-14.

NASA [National Aeronautics and Space Administration]. 2016. Arctic Sea Ice Minimum [on line]. Available: http://climate.nasa.gov/evidence/.

NOAA [National Oceanic and Atmospheric Administration]. 2016. CO2 concentration at Mauna Loa observatory [on line]. Available: https://scripps.ucsd.edu/programs/keelingcurve.

Olesen JE, Børgesen CD, Elsgaard L, Palosuo T, Rötter RP, Skjelvåg AO. 2012. Changes in time of sowing, flowering and maturity of cereals in Europe under climate change. *Food Addit. Contam. A.* 29: 1527-1542.

Rusterholz HP and Erhardt A. 1998. Effects of elevated CO_2 on flowering phenology and nectar production of nectar plants important for butterflies of calcareous grasslands. *Oecologia* 113: 341-349.

Seneweera S, Blakeney A, Milham P, Basra AS, Barlow EWR and Conroy J. 1994. Influence of elevated CO2 and phosphorus nutrition on the growth and yield of a short-duration rice (*Oryza sativa* L. cv. Jarrah). *Aus. J. Plant Physiol.* 21:281-292.

Sreeharsha RV, Sekhar KM and Reddy AR. 2015. Delayed flowering is associated with lack of photosynthetic acclimation in pigeon pea (*Cajanus cajan* L.) grown under elevated CO_2. *Plant Sci.* 231: 82-93.

Wahl V, Ponnu J, Schlereth A, Arrivault S, Langenecker T and Franke A. 2013. Regulation of flowering by trehalose-6-phosphate signaling in *Arabidopsis thaliana*. *Science* 339: 704-707.