Assessing the interactive effects of elevated ozone and carbon dioxide on behavioural changes of pollinators in Indian mustard

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Abstract

The pollutant load is increasing exponentially in the atmosphere due to human activities. Among the air pollutants, the tropospheric ozone (secondary pollutant and strong oxidant) has negative effects on living organisms and its concentration has been increasing at an alarming rate in the recent past. On the other hand, elevated carbon dioxide has positive effects on plant production and has global warming as one of the greenhouse gases. As per the 5th assessment report of the Intergovernmental Panel on Climate Change (IPCC), tropospheric ozone concentration projects an increase of about 20-25% by 2050 across the globe. Atmospheric CO_2 concentrations (385 ppm) have increased by at least 35%, since the start of the Industrial Revolution and are forecasted to reach 540–970 ppm by the year 2100. Both the elevated ozone and carbon dioxide were impacting the pollinators' foraging rate, speed and diversity in different mechanisms. Hence, our study focussed on the impact of tropospheric ozone and elevated carbon dioxide on the pollinators' behaviour (foraging rate, speed, mustard flower colour intensity and diversity indices) in Indian mustard for two seasons. In India, mustard ranks 3rd position in oilseed production and 3rd by sharing about 11% of the global rapeseed-mustard production was significantly affected by both elevated ozone (65±10 ppb) and carbon dioxide (550±10 ppm). The colour intensity of flowers declined significantly in eO_3, which affected the foraging rate of pollinators in elevated O_3, CO_2 and interaction. This also resulted in decreased diversity indices (Shannon-Weiner diversity index, Simpson Dominance index, Evenness, Margalef index and Dominance index). An increase in the foraging rate of pollinators was observed under eCO_2 in *Apis florea* (54 seconds/flower) and Hoverfly (38 seconds/flower). The negative effects of tropospheric ozone are ameliorated by increased carbon dioxide levels, which offsets the foraging rate of *Apis florea* (25 seconds/flower) and Hoverfly (28 seconds/flower). The highest diversity indices were highest in ambient conditions and lowest under elevated treatments.

Keywords: *Elevated ozone, elevated CO_2, pollinators, foraging rate, Apis florea*