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Effect of CO_2 Enrichment on Physiological Parameters of Wheat and Associated Weed Species

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A B S T R A C T

The investigation was carried out to study the response of wheat and associated weed species against Elevated carbon dioxide. The weed species selected for the study were *Phalaris minor* and wild oat. The experiment was conducted under Ambient and Elevated CO_2 conditions. The physiological parameters including Relative stress injury, Chlorophyll 'a', Chlorophyll 'b' and total Chlorophyll were analyzed under the study. Results obtained from the investigation revealed that Elevated CO_2 significantly influenced the studied parameters. Similar trend of increment in all parameters was found in wheat as well as associated weed species in Elevated CO_2 environment in comparison to Ambient environment. The findings of the study confirm that Elevated CO_2 is helpful in enhancement of physiological activities of crop plants as well as weed species.

***Key words*:** Ambient, Elevated, Chlorophyll content, Crop, Environment, Climate

Food security is an important goal for the rest of the century. While there are a number of known roadblocks to achieving this goal, environmental constraints brought on by unprecedented human change pose a danger to key factors such as production, access, and quality. Among different environmental factors, CO_2 play major role in crop production. It is required for photosynthesis, which keeps plants alive and forms the foundation of the food chain. There is no substance more important for ecosystems, whether natural or man-made.

Wheat (*Triticum aestivum* L.) is the most important cereal crop for the majority of world's populations being staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally [1] and being cultivated over a wide range of climatic conditions. Wheat belongs to family *Poaceae* (*Gramineae*) which includes major crops plants such as wheat, barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.), rye (*Secale cereal* L.), maize (*Zea mays* L.) and rice (*Oryza sativa* L.).

Weeds are known to exhibit allelopathy by releasing water- soluble allelochemicals from leaves, stems, roots, rhizomes, flowers, fruits and seeds [2]. Weeds are a major problem in both crops grown under this system. Many weeds have been reported in association with wheat crop. Among them *Phalaris minor* and wild oat (*Avena ludoviciana*) are consistently prevalent at all sites in increasing trend. Changes in the *Phalaris minor* populations, biotypes, and the flora of weeds in wheat in the intensively cultivated rice-wheat cropping system of South Asia have been alarming. Reports of high populations (>500 plants/m^2) of *Phalaris minor* in wheat fields of Northern India and Pakistan, have led to partial or complete crop failure has been a matter of concern for the last ten years [3].

Plants are directly influenced by increasing CO_2 concentrations regardless of whether climatic changes occur. Almost all studies to date have found that increased CO_2 levels improve crop growth, alleviate various types of stress, and result in significant yield gains. Competitive shifts, on the other hand, may cause changes in the composition, structure, and function of natural plant communities because individual species respond differently. Carbon dioxide is one of the major contributors of greenhouse gases which can have a significant impact on plant metabolism. Although, there is broad agreement that higher atmospheric CO_2 levels stimulate photosynthesis in C_3 crop plants, yet, no such consensus exists on how rising CO_2 levels will affect the physiology of associated weeds, which provide a tough competition to the crop plants. So, the present study was conducted to assess the variations in physiological

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behavious of wheat crop with associated weeds *Phalaris minor* and *Avena ludoviciana* under high CO_2 environment.

MATERIALS AND METHODS

The proposed study was conducted in Free-Air Carbon dioxide Enrichment (FACE) at Directorate of Weed Research (DWR), Jabalpur, (Madhya Pradesh).

Detail of treatments

Crop	:	Wheat (*Triticum aestivum* L. em Thell.)
Weeds	:	*Phalaris minor* and *Avena ludoviciana*
Weed density	:	0, 15, 30 plant/m^2
CO_2 levels	:	Ambient (385 ± 5 ppm) Elevated (550 ± 50ppm)
Time of treatment	:	From emergence up to maturity of wheat
Observations	:	Plant height and Numbers of tillers at 30 and 60 days respectively

Two FACE rings (Ring A and Ring B) were adopted for the present experiment.

Data analysis

All observations were recorded at least three times. Obtained data was statistically analyzed with available programmes.

RESULTS AND DISCUSSION

Climate change has had a significant impact on terrestrial ecosystem structure and function, carbon and water balance, and crop productivity [4-5]. The present experiment was carried out to analyze the response of wheat and associated weeds i.e., *P. minor* and wild oat under ambient as well as elevated carbon dioxide environments. At various levels, many studies have shown biological responses to CO_2 enrichment and associated interactions with environmental change [6-7].

Table 1 Effect of CO_2 enrichment on relative stress injury at 30 DAS and 60 DAS in wheat and weed species [*Phalaris minor* and *Avena ludoviciana*]. Values presented are mean ± SE based on three independent determinations

Relative stress injury (RSI) %						
Time	30 DAS			60DAS		
Treatment	Wheet	*P. minor*	Wild Oat	Wheet	*P. minor*	Wild Oat
Ambient	11.47±1.00	16.82±1.45	12.98±1.01	15.47±1.02	17.82±1.46	15.98±1.25
Elevated (Ring A)	17.63±0.48	17.65±1.62	16.44±0.48	19.63±0.45	19.65±1.63	19.44±0.47
Elevated (Ring B)	19.23±0.39	20.02±2.56	17.02±0.39	21.23±0.40	21.02±2.57	19.02±0.42

Comparative analysis of Relative stress injury (RSI) in wheat at 30 DAS revealed increment under elevated CO_2 in both Ring A and Ring B. RSI in Ambient condition was 11.47±1.00, however under Elevated condition in Ring A it was 17.63±0.48 and in Ring B 19.23±0.39. Similar trend was followed by both of the weed species i.e., *P. minor* and wild oat (Table 1). For *P. minor* the RSI under Ambient condition was 16.82±1.45 and in Elevated conditions it was 17.65±1.62 (Ring A) and 20.02±2.56 (Ring B). Similar to this, wild oat had 12.98±1.01 RSI under Ambient condition and 16.44±0.48 in Ring A and 17.02±0.39 in Ring B under Elevated environment at 30 DAS. When compared to the control, the relative stress injury rose significantly in all treatments. The similar results have been reported earlier in crop plants under normal and stressed conditions [8]. At 60 DAS wheat, *P. minor* and *Avena ludoviciana* presented similar increase in RSI% from ambient to elevated conditions.

Chlorophyll ‘a’ content was measured for plants of wheat as well as both weed species (*Phalaris minor* and *Avena ludoviciana*) under ambient and elevated carbon dioxide environments. At 30 DAS wheat had 114.48±2.83 Chlorophyll ‘a’ under Ambient carbon dioxide environment. However, under elevated carbon dioxide environments it was 131.08±3.33 and 133.63±10.42 for Ring A and Ring B respectively. *P. minor* showed 109.81±8.66 Chlorophyll ‘a’ under ambient, 116.85±4.73 and 114.63±8.23 under Elevated environments in Ring A and Ring B respectively at 30 DAS. Wild oat presented similar increment and it had 117.79±4.04 chlorophyll ‘a’ under ambient condition while, 126.47±5.93 and 132.06±9.62 in Ring A and Ring B under elevated environments at 30 DAS (Table 2).

Table 2 Effect of CO_2 enrichment on chlorophyll ‘a’ at 30 DAS and 60 DAS in wheat and weed species [*Phalaris minor* and *Avena ludoviciana*]. Values presented are mean ± SE based on three independent determinations

Chlorophyll 'a'						
Time	30 DAS			60DAS		
Treatment	Wheat	*P. minor*	Wild Oat	Wheat	*P. minor*	Wild Oat
Ambient	114.48±2.83	109.81±8.66	117.79±4.04	124.48±2.83	109.81±8.41	117.79±4.02
Elevated (Ring A)	131.08±3.33	116.85±4.73	126.47±5.93	139.08±3.36	119.85±4.53	136.47±5.60
Elevated (Ring B)	133.63±10.42	114.63±8.23	132.06±9.62	143.63±9.56	125.63±8.23	135.06±9.12

At 60 DAS the mean value of chlorophyll ‘a’ for wheat under ambient condition was 124.48±2.83. In Ring A it was 139.08±3.36 and in Ring B it was 143.63±9.56 under elevated environment. For *P. minor* the mean value was 109.81±8.41 under Ambient environment while it was 119.85±4.53 and 125.63±8.23 for Ring A and Ring B respectively under elevated conditions. Wild oat also presented similar trend as wheat and *P. minor*.

Regarding the mean value of chlorophyll ‘b’ at 30 DAS wheat had 31.44±2.03, 33.64±3.01 and 35.49±3.12 under ambient as well as elevated CO_2 conditions. In the similar way *P. minor* and wild oat also presented an increment in the mean value of chlorophyll ‘b’ (Table 3). The trend of increase in the mean value of chlorophyll ‘b’ was continuous at 60 DAS. In wheat it was 39.44±2.83 under ambient environment while 43.64±3.33 in Ring A and 45.49±3.41 in Ring B. *P. minor* had 25.22±1.66 chlorophyll ‘b’ in Ambient and 28.23±2.73 in Ring A while 29.82±2.23 in Ring B under elevated carbon dioxide environment. In the similar way wild oat showed 34.21±4.04 in Ambient

condition, 36.10±2.93 in Ring A and 37.64±2.62 in Ring B under elevated conditions at 60 DAS.

Table 3 Effect of CO_2 enrichment on chlorophyll 'b' at 30 DAS at 30 DAS and plant height at 60 DAS in wheat and weed species [*Phalaris minor* and *Avena ludoviciana*). Values presented are mean ± SE based on three independent determinations

Chlorophyll 'b'						
Time	30 DAS			60 DAS		
Treatment	Wheat	*P. minor*	Wild Oat	Wheat	*P. minor*	Wild Oat
Ambient	31.44±2.03	22.22±1.66	29.21±2.04	39.44±2.83	25.22±1.66	34.21±4.04
Elevated (Ring A)	33.64±3.01	24.23±2.933	32.10±2.73	43.64±3.33	28.23±2.73	36.10±2.93
Elevated (Ring B)	35.49±3.12	26.82±2.23	30.64±2.62	45.49±3.41	29.82±2.23	37.64±2.62

Table 4 Effect of CO_2 enrichment on total chlorophyll content at 30 DAS at 30 DAS and plant height at 60 DAS in wheat and weed species [*Phalaris minor* and *Avena ludoviciana* (L.). Values presented are mean ± SE based on three independent determinations

Total chlorophyll						
Time	30 DAS			60 DAS		
Treatment	Wheet	*P. minor*	Wild Oat	Wheet	*P. minor*	Wild Oat
Ambient	165.93±1.83	137.011±8.66	153.04±4.04	185.93±2.83	148.01±8.62	163.043±4.04
Elevated (Ring A)	176.73±2.33	168.58±4.73	172.42±2.93	196.73±3.33	168.58±4.73	172.42±5.93
Elevated (Ring B)	174.12±10.41	152.7±4.23	187.46±9.62	199.12±10.42	172.70±8.23	197.46±7.32

Total chlorophyll content was also analyzed for wheat, *P. minor* and wild oat under ambient as well as elevated carbon dioxide environments. The mean values for total chlorophyll content in wheat at 30 days after sowing (DAS) under ambient environment was 165.93±1.83. However, under elevated environment in Ring A it was 176.73±2.33 and in Ring B 174.12±10.41. These results showed an increase in the total chlorophyll content under elevated carbon dioxide environments. Similarly, [9] reported enhancement in total chlorophyll content in rice crop under elevated carbon dioxide environment in comparison to ambient environment. At 30 DAS under ambient condition, *Phalaris minor* had the mean value of total chlorophyll content 137.011±8.66 while under elevated conditions in Ring A it was 168.58±4.73 and in Ring B 152.7±4.23. The similar trend was followed by wild oat also as it had total chlorophyll content in ambient situation 153.04±4.04 while 172.42±2.93 and 187.46±9.62 in Ring A and Ring B respectively under elevated situations.

CONCLUSION

The present study demonstrated the optimistic effect of elevated CO_2 on physiological parameters in wheat as well as associated weed species i.e., *Phalaris minor* and wild oat. However, the findings alarm the farming community about weed control in coming days due to prediction of elevated CO_2.

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