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Effect of Elevated CO_2 on the Growth, Physiological Traits and Biological Yield of Three Genotypes of Wheat (*Triticum aestivum* L.)

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ABSTRACT

Because of economical relevance of wheat being a staple crop, it is important to understand how this crop will respond to the foreseen increase in atmospheric CO_2 conc. An experiment was conducted to know about the physiological and growth pattern of three genotypes PBW-373, PBW-343, PBW-502 of wheat (*Triticum aestivum* L.) under elevated CO_2 condition. Two chambers one with increased CO_2 and one with ambient CO_2 were employed. Crop was cultivated within the chamber under ambient (400 ppm) and enhanced CO_2 (800 ppm) conditions, from seedling to maturity. Compared to ambient CO_2, crop produced more biomass. The impact of EC on plant growth, reproductive structure, productivity and physiological parameters (photosynthetic rate, transpiration, stomatal conductance, morphology, leaf area and biomass) etc. were examined. The outcomes weren't one way. For one plant growth cycle, all the parameters were recorded. Photosynthetic rate, transpiration rate, stomatal conductance, and biomass all experienced significant increases among two genotypes out of three. Overall performance of PBW-343, PBW-373 was determined to be good in view of test weight under high CO_2 conditions. Genotypic variation was also documented. Both genotypes are known to be tolerant of high CO_2 conditions. Overall, it can be said that EC promotes plant growth and biomass, although further research is needed to determine how EC affects flowering. Increases in shoot length, root length, and the number of tillers in terms of their size and weight were caused by the high CO_2 concentration. The economic yield of wheat per plant significantly increases when exposed to high CO_2. In this work, we investigated the impact of current and projected CO_2 concentration on wheat crop growth, biomass, and yield.

***Key words**: Elevated CO_2, Photosynthetic rate, Stomatal conductance, Productivity, Physiological parameters, Reproductive growth, Biomass.*

Introduction

There is a significant discrepancy between the current CO_2 level, which is around 400 molCO_2mol^{-1}, and the preindustrial level, which was 280 mol CO_2 mol^{-1}, due to anthropogenic activities such as pollution and industrialization. According to future predictions, air temperatures will rise by 2.6–5.4°C before the end of the century (IPCC, 2007a; Dlugokencky and Tans, 2017) as well as the average global amounts of greenhouse gases (GHGs), including CO_2, CH_4, N_2, and ozone in the troposphere will increase. The combined land and ocean temperature has risen at an average rate of 0.14°F (0.08°C) per decade since 1880, according to NOAA's 2021 annual climate report. However, the average increase rate since 1981 has been more than twice as fast 0.32°F (0.18 °C) per decade. Global warming is mostly attributed to the increase in atmospheric (CO_2), which is expected to increase by 1.5 to 2 °C in the end of the 21st century (IPCC, 2021).

One of the well-documented global atmospheric trends over the past 50 years is the rising atmospheric carbon dioxide concentration (Prentice, 2001). Climate change will reduce the global area suitable for coffee by about 50 % across emission scenarios (Bunn, 2015). Agriculture and climate changes are both significant worldwide issues, and one has an impact on the other in one way or another. Unpredictable weather could be a factor in how climate change may affect the agriculture. To comprehend how climate change is affecting agriculture and to establish mitigation methods, local or regional research is more important (Kalra *et al*., 2008). The earth's temperature is expected to rise by 2-3 °C as a result of the atmospheric CO_2 concentration doubling, which might adversely impact agricultural production. The key impacts on agriculture are likely to be the favourable gains in crop yields and water usage efficiency while more recent empirical research suggests that the warming may only be 0.25 °C. In comparison to the ambient chamber, the total biomass increased by 65.4% and 39%, respectively, at 700 and 550 ppm CO_2 (Vanaja, 2007).

There will be possibilities to improve productivity for some areas and crops, but overall, there is no question that net agriculture production will be negatively impacted by climate change (IPCC, 2007a). For the field study of crops in high CO_2 environments, open top chambers are the primary information source. A considerable amount of the potential increases in average crop yields owing to technical advancements, CO_2 fertilization, and other variables could be offset by climate trends since 1980, as demonstrated by Lobell *et al*., (2011). Due to anthropogenic activities i.e., pollution, industrialization, the current CO_2 level is approximately 400 μmol $CO_2 mol^{-1}$ and the preindustrial level was 280 μmol $CO_2 mol^{-1}$, and it is great difference. The global average concentrations of Greenhouse Gases (GHGs) suchasCO$_2$, CH_4, N_2O and tropospheric ozone. According to NOAA's 2021 annual climate report the combined land and ocean temperature has increased at an average rate of 0.14°F (0.08°C) per decade since 1880; however, the average rate of increase since 1981 has been more than twice as fast: 0.32°F (0.18 °C) per decade.

The amount of carbon dioxide and other greenhouse gases emitted over the next few decades will determine how much earth will warm in the future. Today, the burning of fossil fuels and the clearance of forests contribute about 11 billion metric tons of carbon every year, which is almost 40 billion metric tons of CO_2. The amount of carbon in the atmosphere exceeds what can be eliminated by natural processes, causing an annual increase in carbon dioxide (NOAA's Annual Climate Report for 2021). The cereal crop known as wheat (*Triticum aestivum*) is significant. It is essential to restore productivity development in the main wheat-producing regions of the world (CIMMYT). It is grown in a variety of conditions, and the increased atmospheric CO_2 is a severe issue that affects the yield. Burning biomass residue and fossil fuels are two sources of CO_2 in the atmosphere. Since cereal crops are more susceptible to environmental stress, research is needed to determine how elevated CO_2 levels affect wheat growth and development.

According to Xiong (2021), stress tolerance breeding is improving wheat's hardiness under rising temperatures. A new study reveals that increasingly unpredictable weather presents challenges for developing widely-adapted wheat lines. Such research is crucial for ensuring food security and creating wheat (*Triticum aestivum*) varieties that are more resistant to CO_2 and temperature stress. This investigation was carried out on three wheat genotypes (PBW-502, PBW-343, PBW-373) using open top chamber facility projected increased CO_2 (800 ppm) and ambient (400 ppm) in order to close such information gaps. Climate change has reportedly made it more difficult for breeders to identify lines that are adapted to abiotic stress, according to a CIMMYT publication from 2021. Additionally, they emphasize how climate change hinders the development of wheat breeding for yield and environmental adaptation. Future unpredictable weather conditions demonstrate how crucial it is to test wheat for climatic conditions in order to improve stress tolerance research for breeding. Wheat hardiness for high CO_2 is a crucial area for physiology and breeding for stress resistance in the future.

Materials and Methods

Study site and description of open top chamber (OTC)

The current experiment was carried out in the division of ecology and climate change of FRI (Dehradun), Uttarakhand, India (32°20'44.2172"N, 78°0'41.6185"E and 668 m.a.s.l.), in an open top chamber with enhanced CO_2 conditions. As per reports available from Singh *et al*., (2018) OTC are made of 80%-85% transmittance high quality multilayer polycarbonate sheet (3.0 m, width × 3.0 m, length × 4.0 m height). Commercial-grade CO_2 gas (100%) was injected into the chambers in the needed quantity. One OTC was used as the control chamber, which had 400 PPM of atmospheric CO_2. From seedling to harvest stage, growth cycle of *Triticum aestivum* was maintained with another OTC, (EC at 800 ppm). Sensors placed inside each compartment were used to measure the CO_2 levels. The appropriate chamber's solenoid valves were used to maintain the EC in each chamber.

Seed sowing and other practices

Seeds of all the threegenotypes of *Triticum aestivum* PBW-373, PBW-343 and PBW-502 were purchased from the Pant Nagar-based Govind Ballabh Pant University of Agricultural Sciences and Technology's Crop Research Centre. In plastic trays with soil, sand, and manure as the growing medium (2:1:1), seeds were planted (Fig. 1). Seedlings that were 15 days old were transplanted into pots and allowed to acclimate to pot conditions outside of OTC for 4 days. Seedlings were then placed in OTCs and given 4 days to acclimate to the environment. Finally, each OTC received the necessary amount of CO_2 gas. Plants received CO_2 treatment during their whole growth cycle (from germination to maturity). Throughout the life cycle, regular weeding and watering was done. 40 seeds of each of the three wheat varieties namely PBW-373, PBW-343, and PBW-502were seeded in six trays, two of which were placed in each of the two chambers, OTC 1 (ambient 400 ppm) and OTC 2 (800 ppm) as given in Fig. 2 and 3.

Fig. 1. Seed sowing in trays (all the three genotypes of Wheat)

Fig. 2. Wheat plants growing in OTC 2 (800 ppm)

Fig. 3. Open top chamber facility of different concentration of CO_2 in Forest Research Center, Dehradun

Growth parameters

The study was carried out for 5 months (November 2018 to April 2019) from germination to flowering stage. The parameters related to growth dynamics such as plant height (cm) at different days of interval, number of spikes, spike length, leaf diameter, fresh weight of plant, fresh weight of shoot, fresh weight of root, dry weights of root and shoot (g), height of spikes (cm) and grain weight, were considered.

Physiological parameters

All the physiological parameters like photosynthesis, transpiration, stomatal conductance, water use efficiency, chlorophyll estimation was observed under elevated CO_2 concentration (Fig. 4).

Fig. 4. Adaptive physiological responses of three genotypes of Wheat under ambient (400 ppm) and elevated (800 ppm) CO_2 concentrations

Measurement of adaptive physiological traits

The main physiological traits, i.e., rate of photosynthesis (ìmol CO_2 $m^{-2}s^{-1}$), transpiration (mmol H_2O $m^{-2}s^{-1}$), stomatal response (mol H_2O $m^{-2}s^{-1}$), and intercellular CO_2 concentration (ìmol CO_2 mol^{-1}), were measured during vegetative phase using (PPS) Portable Photosynthetic System (Model 6400 XT-LICOR, Incl USA. Between 9:30 am and 12:30 pm, when the sky was clear, physiological parameters were measured in the youngest and most fully exhausted flag leaves. Eight plants, with five replicates of each plant, yielded 40 observations for each parameter. The ratio of CO_2 photosynthetic rate (A) to transpiration (E) was used to calculate the instantaneous water use efficiency (A/E). The ratio of photosynthetic rate (A) to stomatal conductance (gs) was used to estimate intrinsic water use efficiency, whereas the ratio of photosynthetic rate (A) to intercellular CO_2 concentration (Ci) was used to estimate intrinsic carboxylation efficiency. Additionally, to determine the intrinsic mesophyll efficiency (Ci/gs), the ratio of intercellular CO_2 concentration (Ci) to stomatal conductance (gs) was computed (Warrier *et al*., 2013; Singh *et al*., 2016 and Singh *et al*., 2018).

Biomass estimation

For the purposes of the biomass study, the plants were uprooted, and the fresh weights of 10 plants from each replication were measured. The roots were then cleansed with distilled water to eliminate any soil that had adhered to the root hairs. According to Wu *et al*., (2013) and Singh *et al*., (2018), the fresh plant parts were weighed, oven dried at 65°C until a constant weight was attained, and then weighed once again.

Chlorophyll estimation

The amount of chlorophyll was calculated based on Hiscox and Israelstam's (1979) research. 50 mg of freshly chopped leaves were put to a test tube containing 10 ml of dimethyl sulphoxide (DMSO). After that, the tube containing the leaf fragments and DMSO was incubated in an oven at 65 °C for three hours. After 3 hours of incubation, the content was agitated once or twice, and the absorbance at 663 and 645 was measured using a spectrophotometer against a pure DMSO blank. The following formula was used to compute the amount of chlorophyll a, chlorophyll b, and total chlorophyll (mg^{-1} fresh weight of leaf) was estimated by using following formula.

Chl_a (mg/g) = {12.7(A663) 2.69 (A645)} x V/ (1000xW)

Chl_b (mg/g) = {22.9(A645) 4.68 (A663)} x V / (1000xW)

Chl total (mg/g) = {20.2(A645)+8.02(A663)}x V/ (1000 x W)

V= volume of solvent

W= Fresh weight of tissue extracted

Statistical analysis

All the experimental data were analysed byusing SPSS 16.0 software to carry out the multivariate general linear model to observe the existence of significant mean difference in response of physiological parameters, biomass, and carbon accumulation at different CO_2 levels. The critical difference at 5% level of probability wascalculated for testing the significance difference between twomeans.Two-way analysis of variance (ANOVA) was used to analyze the impact of cultivar and the four treatments. The statistically significance of data was compared based on their 95% confidence level ($p < 0.05$) (Gomez and Gomez, 1984).

Results and Discussion

Adaptive physiological responses to the elevated co_2 condition

The parameters for the physiological response to CO_2 indicated a significant difference between the control (400 ppm) and high (800 ppm) CO_2 values (Table 1).

Photosynthetic rate

The highest photosynthetic rate in variety PBW-343 was determined to be at 800 ppm CO_2, which is (5.63 mol $CO_2 m^{-2} s^{-1}$), when compared to ambient CO_2 levels with raised 800 ppm. In ambient (400 ppm) CO_2 conditions, it was discovered that the photosynthetic rate of the same variety (PBW-343) was approximately lower (4.98 mol $CO_2 m^{-2} s^{-1}$). Wheat's photosynthetic rates were found to be positively impacted by CO_2 levels; however there were clear variances across the various wheat kinds. Under both CO_2 concentrations (400 ppm and 800 ppm), variety PBW-502 demonstrated its maximum photosynthetic rate. At an EC of 400, the variety PBW-373's photosynthetic rate increased from 3.06 mol CO_2 $m^{-2} s^{-1}$ to 4.88 mol $CO_2 m^{-2} s^{-1}$.

Water use efficiency

At a time interval of 80 days, the water use efficiency of all three varieties, PBW-502(1165.2), PBW-343(1269.4), and PBW-373(1124.1) rose in an elevated state (800 ppm), but the water use efficiency of all three varieties decreased in an ambient CO_2 condition (400 ppm), including PBW-502(438.2), PBW-343(439.9), and PBW-373(486.3).

Transpiration rate

Additionally, it was noted that elevated CO_2 concentrations caused greater water loss from the leaf surface through transpiration. At intervals of 80 days, all three genotypes PBW-502(9.17), PB-343(8.65), and PBW-373(10.28) saw an increase in transpiration rate under elevated CO_2 (800 ppm), while all three varieties PBW-502(4.56), PBW-343(5.49), and PBW-373(2.58) had a drop in transpiration rate under ambient conditions (400 ppm).

Stomatal conductance

Under EC (800 ppm), but not for ambient (400 ppm), stomatal opening and closure were observed to be significantly stimulated in terms of stomatal conductance. For the cultivars PBW-502, PBW-343, and PBW-373, stomatal conductance was determined to be 0.29, 0.25, and 0.35 mol H_2O $m^{-2} s^{-1}$, each under 400 ppm. For all three kinds, stomatal conductance increased under EC conditions by 0.37, 0.29, and 0.39 mol H_2O $m^{-2} s^{-1}$ compared to ambient.

Intercellular CO_2 concentration

Intercellular CO_2 concentrations for the cultivars PBW-502, PBW-343, and PBW-373 were found to be 425.14, 395.38, and 399.45, respectively, in EC condition (800 ppm). For all three for the cultivars PBW-502, PBW-343, and PBW-373 it reduced by 369.40, 349.43, and 360.09 under ambient conditions (400 ppm).

Leaf temperature

The varieties PBW-502, PBW-343, and PBW-373 had respective leaf temperatures of 28.72°C, 29.33 °C, and 32.27 °C under ambient conditions; however, increasing the CO_2 concentration also caused an increase in leaf temperature, with values of 32.03°C (PBW-502), 33.13 °C (PBW-343) and 33.09 °C (PBW-373) being recorded under 800 ppm. Furthermorea tendency of higher leaf temperature was observed efficiently under 800 ppm in comparison to the ambient condition.

In genotype PBW-343 photosynthetic rate was found to be lowered (47%) under the elevated CO_2 conditions, but in genotype PBW-502 photosynthetic rate was found to be increased (54%) at elevated CO_2 (800 ppm) as compared to ambient (400 ppm). Similarly in the genotype PBW-373, 34% more photosynthetic activity was found under high CO_2 levels. Stomatal conductance was 50% higher in genotype PBW-502 under elevated CO_2 (800 ppm) than at ambient (400 ppm). While genotype PBW-343 shows no discernible variation under low or high CO_2 conditions. Under high CO_2 compared to ambient conditions, genotype PBW-373 exhibited a 40% increase in stomatal conductance.

From present study it was found that overall, all the physiological parameters (photosynthetic rate, biomass, transpiration, etc.) were positively affected by elevated CO_2, the results are also similar to other researchers Singh *et al.*, (2018) and Sharma (2019). But different varieties showed different response in ambient and elevated CO_2 condition. Overall variety PBW-343 is more CO_2 resistant rather than PBW-502 and PBW-373. Increase in CO_2 concentration causes a rapid development of leaf area, which increases the availability of transpiring surface subsequently enhancing transpiration rate (Morison and Gifford, 1984 and Sharma, 2019). Physiological characters of all the three genotypes from control to EC (400 to 800 ppm) are presented in Table 1.

Growth and yield parameters affected by elevated CO_2

The results related to growth and yield parameters are given in Table 2. The fresh weight and dry weight of leaves shoot and root of all three genotypes found to be enhanced under an elevated CO_2

condition (800 ppm). The plants produced maximum biomass under high CO_2 condition. Maximum plant height (14.06 cm) was attained by genotype PBW-343 in EC condition and minimum (11.95 cm) was attained by PBW-373 at ambient CO_2 condition (400 ppm), overall maximum plant height was recorded in EC condition in comparison to the ambient CO_2 condition (400 ppm). It means elevated CO_2 have positive effects on plant height in Wheat. In case of fresh weight of the whole plant, overall maximum biomass was attained by variety PBW-343 (16.61 gm) under elevated CO_2 condition as compared to ambient (400 ppm) which is 7.18 g in PBW-502. Overall, 60.59 %, 54.48 % and 56.83 % increase in the total biomass of all the three varieties respectively, PBW-502, PBW-343 and PBW-373 was recorded. The plants became taller and produced maximum biomass under elevated CO_2 conc. It was also observed that rising of, atmospheric CO_2 could significantly stimulated the leaf photosynthesis and above-ground dry weight biomass production in C_3 plant species, *Xanthium strumarium* (Ziska, 2001).

Plant Biomass

Plant biomass was studied as both fresh weight of above ground and below ground part. There was a significant increase (68%) in plant fresh weight, under elevated CO_2 condition; Average fresh weight of a wheat was reported (13.14 gm) under elevated CO_2, while it is (7.8 gm) under ambient condition. Variety PBW-343 produced maximum fresh weight and dry weight under elevated CO_2 (800 ppm), which is followed by variety PBW-373. High atmospheric CO_2 conc. affected the plant biomass in the present work. These results are quite similar to the finding of Hu *et al*. (2021) which also reported that high atmospheric CO_2 promoted various physiological and growth responses such as water and nutrient uptake, tillering, leaf photosynthesis, floret differentiation and grain filling, which leads to increased plant growth and grain yield.

Dry root weight

There was found an increase of 11.2 % in root dry weight (1.25g) under elevated CO_2 (800 ppm) in comparison to (1.11 g) ambient (400 ppm). Maximum root dry weight was attained by variety PBW-373 and PBW-502 under elevated CO_2 condition. There was 53 % more root fresh weight in elevated CO_2 condition. In case of root dry weight 87 % more root dry weight was observed under elevated CO_2 condition but maximum root dry weight was in PBW-502 (2.56 g). The results were similar with Singh *et al*., 2018.

Leaf diameter

It was observed that leaf diameter increased under elevated conditions. A total of 13% more leaf diameter attained 800 ppm, maximum leaf diameter was attained by PBW-343 and PBW-373 under elevated CO_2 condition and minimum in PBW-373 under ambient condition.

Chlorophyll content

There was found a significant difference (13.8%) increase in chlorophyll content in under elevated CO_2. All the variety showed difference in ambient and elevated CO_2. It means elevated CO_2 have some positive effect on chlorophyll content in the plant. The corresponding results were reported by Singh *et al*. (2018). Among the varieties PBW-343 and PBW-373 attained maximum chlorophyll content under elevated CO_2, this may be reason for more biomass under elevated CO_2 (800 ppm) condition. These

Table 1. Effect of two levels of CO_2 conc. ambient (400ppm) and elevated (800 ppm) on the physiological characters of all the three genotypes (PBW-502, PBW-343, PBW-373) of Wheat

Treatments	Photosynthetic Rate (µmol CO_2 m^{-2} s^{-1})	Water Use Efficiency	Transpiration Rate (mmol H_2O m^{-2} s^{-1})	Stomatal Conductance (mol H_2O $m^{-2}s^{-1}$)	Intercellular CO_2	Leaf Temp.(^{0}C)
T1V1	3.56	438.2	9.17	0.290	425.14	28.72
T1V2	4.98	439.9	8.65	0.253	395.38	29.33
T1V3	3.06	486.3	10.28	0.354	399.45	32.27
T2V1	4.00	1165.2	4.56	0.377	369.40	32.03
T2V2	5.63	1226.4	5.49	0.294	349.43	33.13
T2V3	4.88	1124.1	2.58	0.398	360.09	33.09
SE	0.815	125.12	24	0.012	24	1.79
CD	NS	NS	NS	0.034	NS	5.2

findings are accordance with (Zhang *et al.,* 2022), in compared to the control, the leaf chlorophyll content under elevated CO_2 and warming in three cultivars had an average increase of 10% and 15%, respectivelyin 3 varieties of wheat. It was found that chlorophyll content showed an increase from ambient to elevated condition from 2.32 (PBW-502), 2.68 (PBW-343) and 2.86 (PBW-373) under 400 ppm to 2.47 (PBW-502), 3.21 (PBW-343) and 3.17 (PBW-373) under 800 ppm. So there was found a significant increment.

Yield attributes

Spike length was maximum in ambient as compare to elevated CO_2, average spike length (3.08 cm) was observed in ambient 400 ppm while (2.19 cm) in 800 ppm. In case of grain weight it was more in 400ppm as compare to 800 ppm.

Grain weight/spike

There is a non-significant difference in grain weight/spikes, it may be due to some negative effect on flowering. High leaf area leads to higher biomass (fresh weight and dry weight) accumulation upon elevated CO_2 treatment, this may be due to the high rate of photosynthesis and water use efficiency under elevated CO_2 condition. Improvement in leaf area and LAI was recorded (Rangaswamy *et al.*, 2021), at both elevated levels of CO_2. There was significantly higher total leaf area at 50% flowering in tomato. Additional examination of 81 tests with controlled CO_2 concentrations revealed that with a doubling of atmospheric CO_2 concentration, yields will likely rise by 33%. A further 46 observations were retrieved and averaged on the impact of CO_2 enrichment on transpiration. When paired with the yield increase, these findings showed that a doubling of CO_2 concentration might cut transpiration by 34%, which suggests that water use efficiency may double.

Our findings are corroborated with the findings of Singh *et al*. (2016) and who also reported an increase in crop height by the exposure to increasing CO_2concentration. High leaf area leads to higher biomass (fresh weight and dry weight) accumulation upon elevated CO_2 treatment, this may be due to the high rate of photosynthesis and water use efficiency under elevated CO_2 condition. Improvement in leaf area and LAI was recorded (Rangaswamy *et al*., 2021), at both elevated levels of CO_2. There was significantly higher total leaf area at 50% flowering in tomato.

Wang *et al*., (2013) worked on 59 experimental data pertaining to photosynthesis of wheat crops grown across the world under EC (450-800 ppm) and recorded an increase of 33% in comparison to the ambient conditions. The observations made here are in conformity with their findings. In the present observation, it was found that increase in photosynthesis under elevated CO_2 condition (800 ppm) as

Table 2. Effect of ambient and elevated CO_2 on growth of three genotypes (PBW-502, PBW-343, PBW-373) of Wheat (*Triticum aestivum*)

Growth Parameters	Under ambient condition CO_2 (400 ppm)			Under elevated CO_2 (800 ppm)			SE	CD
Variety/Treatment	PBW-502 T1V1	PBW-343 T1V2	PBW-373 T1V3	PBW-502 T2V1	PBW-343 T2V2	PBW-373 T2V3		
Plant Height (cm)(At maturity)	12.53	12.98	11.95	13.24	14.06	13.25	1.19	NS
Fresh Weight (Plant) at maturity (g)	7.18	9.05	7.73	11.85	16.61	13.60	1.28	NS
Dry weight Shoot (g) 40 DAS	5.46	5.42	7.02	7.99	12.42	12.7	1.25	3.82
70 DAS	0.24	0.42	0.42	0.98	0.48	0.36	3.57	NS
Dry weight Root (g) 40 DAS	0.29	0.58	0.64	0.83	0.85	0.74	0.43	1.32
70 DAS	0.02	0.12	0.15	2.56	0.13	0.19	0.73	NS
Chlorophyll Content (mg/g)	2.32	2.69	2.86	2.47	3.21	3.17	0.65	NS
Spike length (cm) 100DAS	1.95	2.51	2.13	3.29	3.07	3.04	19	NS
No of spikelet's	13.5	11.5	13.5	28.7	29.7	28.1	2.83	8.63
Leaf Diameter (cm)	0.75	0.84	0.72	0.85	0.91	0.92	1.49	NS
Grain Weight (g) test	35.3	36.2	33.5	27.85	36.25	38.25		NS

V1= Variety 1, V2= Variety 2 and V3= Variety 3
T1 (Treatment 1) = Ambient CO_2 conc.
T2 (Treatment 2) = Elevated CO_2 conc.

compare to ambient (400 ppm). Root dry weight, Chlorophyll content, no. of spikelet's and grain yield was is found maximum in elevated CO_2condition as compare to ambient CO_2. Best growth parameters were seen in variety PBW-343. There was found a significant difference in chlorophyll content in all the variety in both the case ambient and elevated CO_2, it means elevated CO_2 have some positive effect on chlorophyll content in the plant. The corresponding results were reported by (Blandino *et al*., 2020; Chavan *et al*., 2019; Hatfield *et al*., 2019; Korres *et al*., 2016; Li *et al*., 2020; Singh *et al*. (2018); Tcherkez *et al*., 2020; Wang *et al*., 2021 and Yadav *et al*., 2019. Besides above, the carbon allocation to leaves, stem, and root parts was also enhanced under an elevated CO_2 condition. The plants become taller and produce maximum biomass under elevated CO_2 condition. It was also observed that rising of atmospheric CO_2 could significantly stimulate leaf photosynthesis and above-ground dry weight biomass production of a C_3 species, *Xanthium strumarium* (Ziska, 2001). Similar results were reported for biomass and photosynthesis for *Cirsiumarvense L*. (Ziska 2002). The biomass production and water use efficiency of the plants exposed to elevated CO_2 condition too increased. The corresponding results were reported by (Barnes *et al*., 1995; Kannojiya *et al*., 2019; Lamichaney *et al*., 2021; Prakash *et al*., 2022; Pandey *et al*., 2017; Singh *et al*., 2018. Enhanced CO_2 level can lead to positive effects more in C_3 plants compared to C_4 plants (Mishra *et al*., 2013; Rawat and Melkania., 2015; Pleijel and Hogy, 2015).

According to the present study and earlier research, exposure to 800 ppm CO_2has an impact on a plant's growth, development, and yield. Plant biomass (fresh weight and dry weight) and yield (grain weight/spike), which are all impacted by the CO_2, are typically caused by a greater availability of photosynthates, all growth related metrics are responding favourably, but a non significant effect on yield was observed (Broberg *et al*., 2019) future research on the effects of CO_2 on flowering and grain production per hectare is necessary. Many growth and physiological parameters are significantly affected by varietal differences; variety PBW-343 has demonstrated greater resilience to CO_2, while variety PBW-502 has detrimental effects of CO_2 on both morphology and physiological functions.

Conclusion

The results of the current study show that the *Triticum aestivum* is capable of adapting to changing climatic conditions, particularly those associated with increased atmospheric CO_2 concentration. The physiological processes, particularly the photosynthetic rate, transpiration rate, stomatal conductance, water use efficiency and, may be improved under such elevated CO_2 concentration conditions, promoting plant growth and ultimately increasing biomass production, particularly the root biomass in *Triticum aestivum*. This plant may therefore be among the most significant cereal crops that will be more suited to reducing climate change in the future. Three genotypes of wheat, PBW-502, PBW-343, and PBW-734, were employed in the current study. There are genotypic differences between these genotypes in terms of growth and physiological traits. Therefore, in the future, we can choose genotypes that are CO_2 tolerant and beneficial for the future physiological breeding programme. To recommend more CO_2 resistant varieties for the upcoming future of climate change, additional screening tools for more variety are therefore needed at a significant level.

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