*Pak. J. Bot.*, 41(4): 1831-1836, 2009.

# EFFECT OF SHORT-TERM EXPOSURE TO TWO DIFFERENT CARBON DIOXIDE CONCENTRATIONS ON GROWTH AND SOME BIOCHEMICAL PARAMETERS OF EDIBLE BEANS (*VIGNA RADIATA* AND *VIGNA UNGUICULATA*)

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**Abstract**

Two weeks old seedling of *Vigna radiata* and *Vigna unguiculata* were exposed to 2% and 3% CO2 for 5 and 10 minutes in controlled environment chamber thrice a week for 4 weeks. The treatment had definite positive effect on Specific leaf area, total carbohydrate and total chlorophyll content promoted to increasing concentrations and duration of carbon dioxide exposure.

## Introduction

The atmosphere is composed of complex and dynamic natural gaseous system that is essential to support life on planet earth. $CO_2$ is one of the gas in our atmosphere, being uniformly distributed all over the earth's surface at a concentration of about 0.033% or 330 parts per million (Shakhashiri, 2008). In other report the $CO_2$ in earth's atmosphere is currently at a globally averaged concentration of 0.0385% or 385 parts per million and is increasing by about 2 ppm each year (Pidwirny, 2006). It is further estimated that in the next century the level of $CO_2$ is expected to increase to 700 ppm (Coviella & Trumble, 1999). $CO_2$ enters the atmosphere through the burning of solid fuels (coal), liquid fuels (gasoline), gaseous fuels (natural gas), deforestation and also chemical reactions undergoing in different factories. It is estimated that volcanoes release about 145-255 million tons of $CO_2$ into the atmosphere each year, rising atmospheric $CO_2$ concentration (Hsiao *et al.*, 1999). Increasing atmospheric concentrations of $CO_2$ affect the plants growth and intermediary metabolism. Climate scientists recognize $CO_2$ gas as major air pollutant, while they also recognize that $CO_2$ is essential for plant life undergoing photosynthesis. If the concentration of atmospheric $CO_2$ available to plants increases, plants may be able increase their rate of photosynthesis and thus grow more vigorously (Campbell *et al*, 1988; Bowes, 1991; Baker & Allen, 1994; Sarah *et al.*, 1999). Elevated $CO_2$ is the primary variable that influences growth, yield and increases aboveground biomass (Bender *et al.*, 1999). Short-term exposure (minutes to hours) of C3 plants is reported to elevate $CO_2$ intake and increase in the rate of net photosynthesis. In contrast, several studies have shown that long-term exposure (days to weeks) can result in a subsequent decline in net carbon assimilation (Evan *et al.*, 1985). The main objective in taking up this problem was to evaluate the effect of different concentration during exposure of 5 and 10 minutes duration of $CO_2$ on specific leaf area, total carbohydrate and total chlorophyll content of *Vigna radiata* and *Vigna unguiculata*, which are some of the parameters to determine betterment in growth.

## Material and Methods

Experiments were conducted on two different edible beans i.e., Cowpea (*Vigna unguiculata*) and Mung bean (*Vigna radiata*). The seeds were obtained from local Market. Healthy seeds of each species were selected and sterilized with 0.1% Mercuric

chloride solution for 5 minutes followed by rinsing with tap and distilled water. Seeds were sown in 8cm diameter plastic pots containing 300gm of sterilized soil. Plants were placed in sealed chamber and fumigated with two different concentrations of $CO_2$ (2% and 3%) for two different exposure periods (5minutes and 10 minutes) under artifical light condition and non-treated plants serve as control. There were there replicates for each treatment. The mixture of 2% $CO_2$ + 98% air and 3% $CO_2$ + 97% air cylinder were obtained from "The National Gas Limited Pakistan". Plants were regularly watered according to requirement throughout the experimental period.

Specific leaf area which is the ratio of leaf area to leaf dry mass was calculated by standardized method of Garnier *et al.,* 2001 by the using the formula given below:

$$\text{Specific leaf area} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Leaf dry mass (gm)}}$$

The leaf samples from both control and treated plants were collected in early hours of the morning and were kept in labeled sample bags. The plants samples were analyzed for following biochemical parameters.

Chlorophyll were extracted from the leaves and estimated by the method of Maclachlam & Zalik (1963)**.** Estimation of carbohydrate was done in plant extracts by Yemm & Willis (1954) method using Anthron reagent. Data were statistically analyzed by "SPSS" and "SIGMA PLOT" program was used for graphic presentation of the data.

## Results

The result obtained for the effect of different concentration of $CO_2$ and their exposure period on specific leaf area of *Vigna radiata* and *Vigna unguiculata* are present in Fig. 1. Significant (*$p<0.05$) increase in Specific Leaf Area was observed in treated samples throughout experimental period. In *Vigna radiata* higher increase was observed in 3% $CO_2$ at 10 minutes exposure. However in *Vigna unguiculata* maximum increase was found in 3% $CO_2$ at 5 minutes exposure.

Increase in total carbohydrate content was observed in leaf of *Vigna radiata* and *Vigna unguiculata* in all treatment as compare to control (Fig. 2) and the result obtained was significant (***$p<0.001$). In all treatment increase in total carbohydrate content continued till the end of experiment. Higher increase in total carbohydrate content of both beans was observed in 3% $CO_2$ at 10 minutes exposure.

Different concentrations of $CO_2$ and their exposure period showed Significant (*$p<0.05$) changes in the chlorophyll content of *Vigna radiata* and *Vigna unguiculata* leaves (Fig. 3). In all treatment increase in chlorophyll content was observed and this increase in all the treatments was higher than control.

## Discussion

Stimulation of photosynthesis and plant growth is the direct effects of $CO_2$, which is beneficial for plants (Bazzaz, 1990; Jablonski *et al.,* 2002). Our result showed increase in specific leaf area in both plants species when grown in enriched $CO_2$ atmosphere. Yelle *et al.,* (1990) observed that two weeks exposure of Carbon dioxide (900µmol/m$^3$) 55% increase in leaf area and 33% increase in the specific leaf weight of tomato plants. Elevated $CO_2$ is reported to stimulate the growth and yield of plants (Deepak & Agrawal, 1999).

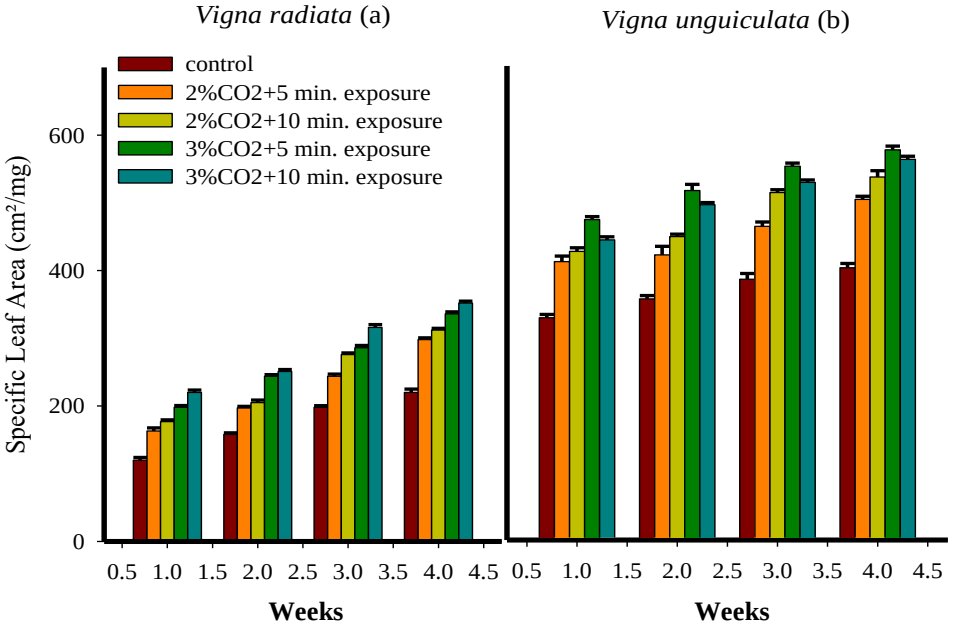


Fig. 1. Changes in the specific leaf area of *Vigna radiata* and *Vigna unguiculata* after fumigation with different concentration and exposure period of carbon dioxide ($CO_2$).

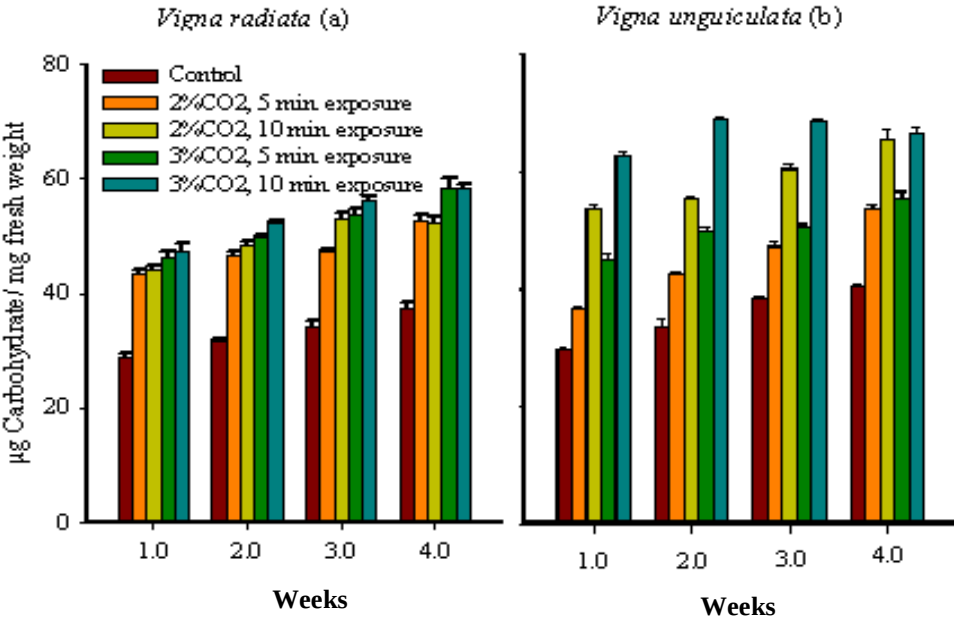


Fig. 2. Changes in the leaf total carbohydrate of *Vigna unguiculata* after fumigation with different concentration and exposure period of carbon dioxide ($CO_2$).

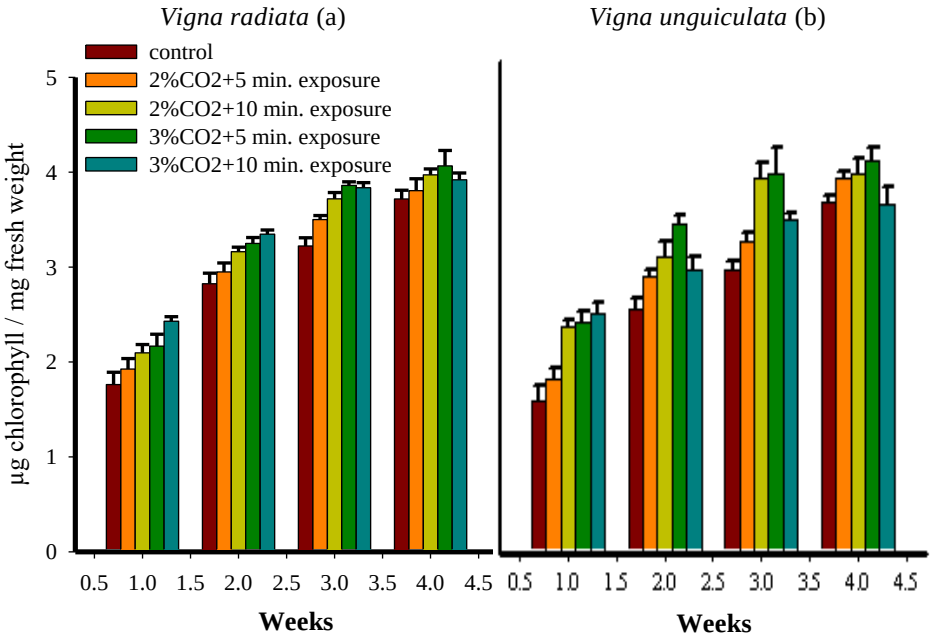


Fig. 3. Changes in total chlorophyll of *Vigna radiata* and *Vigna unguiculata* after fumigation with different concentration and exposure period of carbon dioxide ($CO_2$).

Increase in total carbohydrate content of leaf is also shown in present investigation. Short term exposure of elevated levels of $CO_2$ is reported to stimulate net photosynthetic rate in C3 plants because the existing $CO_2$ concentration in the atmosphere is insufficient for its supply to them Rubisco (ribulose-1, 5-bisphosphate carboxylase/oxygenase) Drake *et al.*, (1997). An increase in the availability of $CO_2$ increases carboxylation and decreases the oxygenase activity of Rubisco (which catalyzes either the carboxylation or the oxygenation of ribulose-1, 5-bisphosphate with carbon dioxide or oxygen), hence reducing the $CO_2$ loss through photorespiration. Therefore, a net increase in photosynthesis occurs due to procession of additional $CO_2$ (Bowes, 1991; VU *et al.*, 1997). An increase in net photosynthesis in elevated $CO_2$ is anticipated regardless of whether Rubisco activity or regeneration of ribulose-1, 5-bisphosphate (RubP) is limiting assimilation, and regardless of whether light is saturating or limiting (Drake *et al*., 1997). Increased carbon uptake resulting from this initial stimulation of photosynthesis is reported to alter the balance of supply and capacity to use carbohydrates, with the result that non-structural carbohydrate concentrations invariably increase within leaves grown at elevated $CO_2$ (Drake *et al*.1997).

Increase in the chlorophyll content is evident with fumigation of the elevated levels of $CO_2$. Chlorophyll is the central part of the energy manifestation of every green plant system and therefore, any significant alteration in its levels is likely to cause a marked effect on the entire metabolism of plants. According to Sgherri *et al*., (1998) alfalfa plants grown in an open-top chamber, under an atmospheric $CO_2$ concentration of 600 ppm displayed greater leaf chlorophyll concentrations than those observed in plants grown at 340 ppm $CO_2$ concentration.

Likewise, exposure of an orchid to a super-elevated $CO_2$ concentration of 10,000 ppm resulted in a 64% increase in its leaf chlorophyll concentration relative to that measured in leaves of plants grown at ambient $CO_2$, thus permitting greater light harvesting during the process of photosynthesis. Greater utilization of sunlight in $CO_2$ enriched plantlets resulted in 20-fold higher starch contents as compared to control, No damage or disruption of chloroplasts was evident because of high starch accumulation in leaves of $CO_2$ enriched plants (Gouk *et al*., 1999).

## Conclusion

It will suggest the short-term exposure to elevated level of Carbon dioxide is improves the growth and yield of crop plants. *Vigna radiata* and *Vigna unguiculata* both respond strongly to elevated levels of carbon dioxide.

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(Received for publication 18 April 2009)