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Effect of Elevated CO_2 on Growth and Yield Parameters of Groundnut Genotypes (*Arachis hypozeae* L.)

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***Abstract*:** Elevated carbon dioxide is known to impact crop growth and productivity. Groundnut is a very important edible oilseed crop raised mostly under rainfed situations worldwide. in the present study, five cultivars of groundnut (*Arachis hypogaea* L.) viz., TG 86, TG 84, TG 82, Mallika and Gangapuri were raised in three circular open top chambers at different elevated CO_2 levels as ambient condition (450 & 500ppm) and open atmospheric condition during *Kharif* 2019 at the research farm, College of Agriculture, Gwalior. to investigate the effect of elevated CO_2 on growth and yield parameters of groundnut *Arachis hypozeae* L. Groundnut grown in eCO_2 (500 ppm) exhibited significantly higher plant height with maximum number of branches/plants, number of nodules, 50% flowering & 50% maturity. the yield parameters also increased with increasing CO_2 concentration. minimum was recorded in open atmospheric condition. The experiment revealed that among different groundnut genotypes, TG 86 performed best and recorded the maximum yield of kernel, pod and haulm/plant which was statistically at par with TG 84.

***Keywords*:** Elevated, CO_2, OTC, Groundnut, Genotypes

The future climate change is projected to have increased concentration of CO_2 in the atmosphere. The concentration of tropospheric CO_2 has progressively increased from about 280 to 411 µmol/mol from the pre-industrial revolution to present and which is likely to reach 450-600 µmol/mol between 2030 and 2052, if it continues to increase at the current rate. in the recent years, the changing climate has declined the production of oilseeds by 13.7% and recorded negative growth rate of 14% over the corresponding season in the previous year. As it is well known that CO_2 is an important plant nutrient which could enhance crop growth and productivity (Erda et al 2005), however, its increasing levels could affect the majority of crop plants. The plants with C_3 photosynthetic pathway are highly sensitive to atmospheric CO_2 concentration thus it could limit ttheir performance to a great extent affecting crop productivity. Since legume crops can fix atmospheric nitrogen, they respond relatively more to a rise in CO_2 concentration. This ongoing global increase of atmospheric CO_2 could affect plant growth, yield, photosynthesis and below ground biomass. At present, understanding their effects on crops, and soil is crucial for predicting future plants response to maintain higher crop productivity of major crops like groundnut. Groundnut is C_3 legume crop, hence it is expected to be affected by the elevated CO_2 in the atmosphere in terms of its growth, physiological and yield parameters.

Results from Open top chambers (OTC), experiments indicated that elevated CO_2 concentrations resulted in higher biomass production in wheat, groundnut, sunflower, onion, tomato, coconut, cocoa, castor, sweet potato and arecanut. Significant yield response to elevated CO_2 has been reported in crops like rice (Shimono et al 2009), wheat (Ziska et al 2004), blackgram (Jyothilakshmi et al 2013), cowpea (Ahmed et al 1993), soybean (Ziska et al 2001), common bean (Bunce 2008) and also in several non-crop species (Ward and Kelly 2004). More than two decades of study on the effects of CO_2 enrichment have greatly improved our understanding on the above ground plant processes (Drake et al 1996; Baker 2004, Ainsworth 2008).

The genotypes of cultivated crops vary in their response to increased CO_2 concentrations. Thus, understanding their variability of the responses could help us to select specific cultivars with optimal performance (Vaidya et al 2014). Therefore, it becomes imperative to conduct studies which would improve our understanding on the impacts of elevated CO_2 on crop growth & yield, parameters under near-field conditions. The overall goal of the present investigation was to improve our knowledge of groundnut performance under high levels of CO_2.

MATERIAL AND METHODS

For the present experiment, three open top chambers were selected having the diameter of 7.4 m^2 with transparent PVC (polyvinyl chloride) sheet having 90% transmittance of light. To find out the effect of elevated CO_2 on growth and yield parameters of groundnut *Arachis hypozeae* L. Five

groundnut genotypes - TG 86, TG 84, TG 82, Mallika and Gangapuri were evaluated under open atmosphere condition, ambient CO_2 and elevated CO_2 concentration of (450 & 500 ppm) in selected open top chamber (OTCs). At the research farm, College of Agriculture, Gwalior during *kharif* 2019. The crop was grown inside the chambers as well as under the natural conditions. First open top chamber was maintained with elevated level of CO_2 at 450 ppm, second chamber with 500 ppm CO_2 and the third chamber without any external CO_2 supply served as an ambient chamber which was the control treatment for the present study.

RESULTS AND DISCUSSION

The growth and yield parameters of selected five groundnut genotypes showed positive response to elevated CO_2 (500 ppm) at different growth stages. The ANOVA and mean performance for growth and yield parameters were presented in Tables 1-2. Correlation between yield and yield attributes was presented in Figure 1-2.

Groundnut grown in eCO_2 (500 ppm) exhibited significantly higher plant height ((51.5 cm) with maximum number of branches (7.2) & number of nodules/plants (79.4, respectively) at 90 DAS. it was followed by eCO_2 concentration of 450 ppm. and the corresponding values were significantly lower plant height (47.7) number of branches (5.8) nodules/plant (75.0 respectively) was recorded in the open atmosphere condition at all growth stages. However, the genotypes TG 84 and TG 86 were found statistically at par with each other in term of plant height. The genotype Gangapuri (14.9cm) recorded comparatively shorter plant height at 30 DAS.

Significantly maximum number of branches & number of nodules /plants was recorded in TG 86 (6.9, 77.5), which was at par with TG 84 (6.8, 77.5), However, the genotype Gangapuri recorded the minimum number of branches/plant & number of nodules (5.7, 75.0 respectively) at 90 DAS. (Bhattacharya et al2000) reported a significant increase in plant height, leaf expansion in sweet potato and cowpea under eCO_2. Similar results were also reported by Vanaja et al (2007) and Srivastav et al (2001). carbon dioxide has direct fertilizing effect on plant growth. Groundnut, being a C_3 leguminous plant has found to show increased growth rates in eCO_2 (500 ppm) conditions. Crop respond positively to eCO_2 showed increase in photosynthetic rate, biomass (Stanciel et al 2002) increased plant height, root length, shoot length, stem length, leaf area and total biomass compared to the aCO_2 condition (Sreenivasulu et al 2015) Similarly, in some other crops like soyabean (Dongxiao et al 2013) and legume (Jennifer 2013) more plant height, leaf area, photosynthesis and total dry matter was noticed under eCO_2condition (Table 1).

Y**ield attributes:** The yield parameters also increased with increasing CO_2 concentration.Significantly, maximum number of pods /plant (34.8), pod weight/plant (19.7 gm), shelling (%) of groundnut (66.4%), 100-kernel weight (26.0 g) and SMK % (86.2%) were recorded with 500 ppm CO_2, the results indicated that increasing CO_2 concentrations up to 500 ppm recorded 16, 20.8, 16, 6.8 and 7.1% higher number of pods /plants, pod weight/plant, 100 kernel weight, shelling

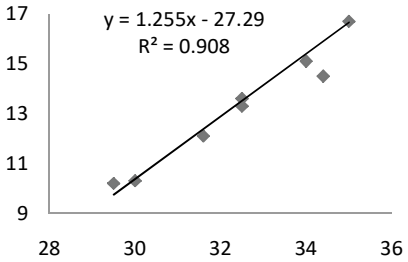
Table 1. The effect of elevated CO_2 on growth parameters of groundnut genotypes (*Arachis hypozeae* L)

Factor A (CO_2 levels)	Plant height (cm)			No. of branches /plant			No. of nodules /plant			50 % flowering	50 % maturity
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS		
Open atmosphere	15.6	37.7	47.7	3.6	5.2	5.8	48.6	78.6	75.0	25.8	108
Ambient CO_2	15.9	38.0	48.0	4.1	5.5	6.2	50.2	80.6	76.2	25.3	108
CO_2 Concentration 450 ppm	16.5	40.2	50.1	4.2	5.8	6.6	51.6	81.6	77.2	24.4	106
CO_2 Concentration 500 ppm	17.3	41.7	51.5	4.4	6.3	7.2	54.2	84.2	79.4	24.3	105
SEm±	0.11	0.45	0.48	0.11	0.13	0.16	0.28	0.37	0.59	0.17	0.46
CD (0.05)	0.35	1.38	1.48	0.33	0.42	0.50	0.86	1.15	1.81	0.53	1.41
Factor B (genotypes)											
TG 86	17.3	39.3	49.3	4.4	5.3	6.9	51.5	81.8	77.5	25.0	107
TG 84	17.5	39.8	49.6	4.4	6.3	6.8	51.3	81.3	77.5	24.8	106
TG 82	16.1	38.0	47.7	3.8	5.7	6.5	50.8	81.3	77.0	24.7	106
Mallika	15.9	41.5	51.5	4.0	5.7	6.4	51.3	80.8	77.8	25.0	107
Gangapuri	14.9	38.4	48.7	3.7	5.6	5.7	51.0	81.3	75.0	25.4	108
SEm±	0.13	0.50	0.54	0.12	0.15	0.18	0.31	0.42	0.66	0.19	0.51
CD (p=0.05)	0.40	1.55	1.66	0.37	0.46	0.56	0.96	1.29	2.02	0.59	1.58

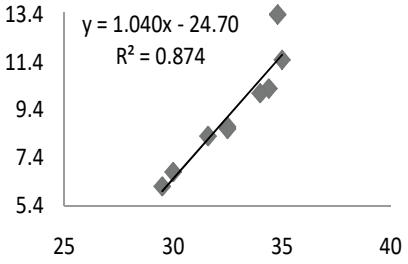
% and SMK%, respectively, over open atmosphere condition. However, the treatments of 500 ppm and 450 ppm CO_2 concentration were statistically similar for all these recorded parameters.

As for different genotypes, TG 86 recorded the maximum number of pods /plants, (35.0), pod weight/plant (18.8g), 100-kernel weight (27.3 g), Shelling (%) (68.2) and SMK (%) (87.8) of groundnut. However, it was found statistically similar with TG 84 and the minimum values for these observations were observed in Gangapuri.

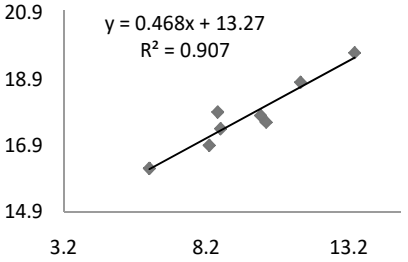
Yield: The pod, kernel, haulm yields were significantly influenced with increasing eCO_2 concentrations among different genotypes of groundnut. The treatment with 500 ppm eCO_2 concentrations resulted in significantly highest kernel yield/plant (13.41 g), haulm yield (54.3 g), pod yield/plant (18.1 g) However, the yield values remained



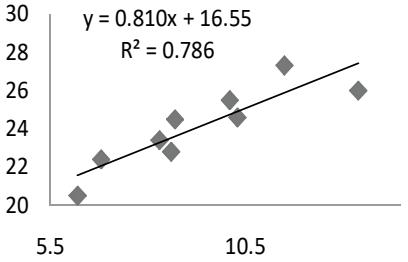
No. of pod/plant vs pod yield /plant



No. of pod/plant vs kernel yield/plant



Kernel yield/plant vs pod weight /plant



Kernel yield/plant vs 100 -kernel weight

Table 2. The effect of elevated CO_2 on yield & yield attributes of groundnut genotypes (*Arachis hypozeae* L)

Factor A (CO_2 levels)	Yield attributes					Haulm yield/plant (gm)	Pod yield/plant (gm)
	No. of pods / plant	Pod weight / plant (gm)	100-kernel weight (gm)	Shelling (%)	Sound mature kernel (%)		
Open atmosphere	30.0	16.3	22.4	62.2	80.5	34.6	10.3
Ambient CO_2	31.6	16.9	23.4	64.6	82.8	37.0	12.1
CO_2 Concentration 450 ppm	34.4	17.6	24.6	65.2	84.0	42.5	14.5
CO_2 Concentration 500 ppm	34.8	19.7	26.0	66.4	86.2	54.3	18.1
SEm±	0.48	0.35	0.27	0.88	0.45	1.71	0.58
CD (p=0.05)	1.49	1.08	0.82	2.72	1.38	5.27	1.80
Factor B (genotypes)							
TG 86	35.0	18.8	27.3	68.2	87.8	50.8	16.7
TG 84	34.0	17.8	25.5	66.5	86.1	46.7	15.1
TG 82	32.5	17.4	24.5	63.8	84.1	42.5	13.6
Mallika	32.5	17.9	22.8	63.8	84.4	40.4	13.3
Gangapuri	29.5	16.2	20.5	60.9	74.5	30.2	10.2
SEm±	0.54	0.39	0.30	0.99	0.50	1.91	0.65
CD (p=0.05)	1.66	1.21	0.92	3.04	1.54	5.89	2.01

statistically similar with the value recorded with elevated CO_2 concentrations of 450 ppm. The percentage increase in yield values was 98.3, 56.4 and 75.7 higher as compared to open atmosphere condition. Higher yield attributes with different CO_2 levels are responsible for increased yields which could also be explained by positive correlation between yield attributes with yield of groundnut (Fig. 1, 2). Similarly, the genotype TG 86 recorded 85, 68.2, 63.8 higher kernel, haulm, pod and respectively, in comparison to gangapuri. Significantly, highest kernel yield (11.46 g), pod yield (16.7 gm), haulm yield (50.8 g) was obtained in TG 86 which was followed by TG 84 (Table 2).

The eCO_2 levels of 500 ppm had highest above-ground biomass production which suggests greater availability of metabolites for growth and development of reproductive structures (sink), which ultimately led to realization of higher yield/plant The elevated CO_2 concentration levels resulted in the highest yield attributes of groundnut genotypee as reflected by the highest values of pod/plant, pod weight/plant, test weight and pod yield. The yield attributes and pod and haulm yield had shown linear increment along with CO_2 enrichmentt. The better yield attributes and increased pod yield obtained in this study agrees with the findings of Chen and Sung (1990) and Hardy and Havelka (1977). Ackerson et al (1984) attributed the high seed yields obtained for soybeans under CO_2 enrichment to more pods and seeds per plant.

CONCLUSION

It was concluded that, the elevated CO_2 concentration 500 ppm improved all the growth and yield parameters in the selected genotype (TG 86) of groundnut. This is due to improved photosynthesis as groundnut being a C_3 crop responded positively to enhanced CO_2 levels. However, a variability of response among these genotypes was noticed for different traits which could be used in selection or development of varieties to fit into future climatic conditions. Thus, it is evident that the mechanism of enhanced CO_2 action varies for different potentials of genotype.

REFERENCES

Ackerson RC, Havelka UD and Boyle MG 1984. CO_2 enrichment effects on soybean physiology. II. Effects of stage-specific CO_2 exposure. *Crop Science* **24**:1150-1154.

Ahmed FE, Hall AE, Madore MA 1993. Interactive effects of high temperature and elevated carbon dioxide concentration on cowpea (*Vigna unguiculata* (L.) Walp.). *Plant, Cell & Environment* **16**: 835-842.

Ainsworth EA, Leakey ADB, Ort DR and Long SP 2008. FACE- in the facts: Inconsistencies and interdependence among field, chamber and modeling studies of elevated [CO_2] impacts on crop yield and food supply. *New Phytologist* **179**(8): 5-9.

Baker JT 2004. Yield responses of Southern US rice cultivars to CO_2 and temperature. *Agricultural and Forest Meteorology* **122**(6): 129-137.

Bunce JA 2008. Contrasting responses of seed yield to elevated carbon dioxide under field conditions within *Phaseolus vulgaris*. *Agriculture, Ecosystems & Environment* **128**: 219-224.

Chen JJ and Sung JM 1990. Gas exchange rate and yield responses of Virginia-type peanut to carbon dioxide enrichment. *Crop Science* **30**: 1085-1088.

Dongxiao L, Huiling L, Yunjhou Q, Youning W, Zhaoming C, Baodi D, Changhai S, Yueyan L, Xia L and Mengyu L 2013. Effects of elevated CO_2 on growth, seed yield and water use efficiency of soybean (*Glycin max* (L) Merr.). *Agricultural Water Management* **129**: 105-112

Drake BG, Gonzàlez-Meler MA and Long SP 1996. more efficient plants: A consequence of rising atmospheric CO_2. *Annual Review of Plant Physiology and Plant Molecular Biology* **48**: 609-639.

Erda L, Wei X, Hui J, Yinlong X, Yue L, Liping B and Liyong X 2005. Climate change impacts on crop yield and quality with CO_2 fertilization in China. *Philosophical Transactions of the Royal Society B: Biological Sciences* **360**(1463): 2149-2154.

Hardy RWF and Havelka UD 1977. Possible routes to increase the conversion of solar energy to food and feed by grain legumes and cereal grains (crop production). CO_2 and N_2 fixation, foliar fertilization, and assimilate partitioning. *Biological Solar Energy Conversions* **5**: 299-322.

Jennifer AL, Joachim S, Laurie RS, Peter BR and Peter T 2008. Direct and indirect effects of CO_2, nitrogen and community diversity on plant-enemy interactions. *Ecology* **89**(1): 226-236.

Jyothi Lakshmi N, Vanaja M, Yadav SK, Maheswari M and Vagheera P 2013. Genotypic variation in growth and yield of blackgram (*Vigna mungo*) genotypes in response to increased carbon dioxide concentration. *Indian Journal of Agricultural Sciences* **83**: 184-188.

Shimono H, Okada M, Yamakawa Y, Nakamura H and Kobayashi K 2009. Genotypic variation in rice yield enhancement by elevated CO_2 relates to growth before heading, and not to maturity group. *Journal of Experimental Botany* **60**: 523-532.

Sreenivasulu M and Damodharam T 2015. Impact of high elevated CO_2 on growth and total leaf soluble protein content in *Arachis hypozeae* (L). *Journal of Biology, Agriculture & Health Sciences* **4**(3): 108-112.

Srivastava AC, Pal M, Das M and Sengupta UK (2001) Growth, CO_2 exchange rate and dry matter partitioning in mungbean (*Vigna radiata* L.) grown under elevated CO_2. *Indian Journal of Experimental Biology* **39**: 572-577.

Stanciel K, Mortley DG, Hileman DR, Loretan PA and Bonsi CK 2002. Growth, pod, and seed yield, and gas exchange of hydroponically grown peanut in response to CO_2 enrichment. *Hort Science* **35**: 49-52.

Vaidya S, Vanaja M, Sathish P, Vagheera P and Anitha Y 2014. Impact of elevated CO_2 on growth and physiological parameters of groundnut (*Arachis hypogaea* L.) genotypes. *Journal of Plant Physiology & Pathology* **3**: 1.

Vanaja M, Raghuram Reddy P, Jyothi Lakshmi N, Maheswari M and Vagheera P 2007. Effect of elevated atmospheric CO_2 concentration on growth and yield of blackgram (*Vigna mungo* L. Hepper)- a rain fed pulse crop. *Plant, Soil and Environment* **53**: 81-88.

Ward JK and Kelly JK 2004. Scaling up evolutionary responses to elevated CO_2: lessons from Arabidopsis. *Ecology Letters* **7**: 427-440.

Ziska LH, Bunce JA and Caulfield FA 2001. Rising atmospheric carbon dioxide and seed yield of soybean genotypes. *Crop Science* **41**: 385-391.

Ziska LH, Morris CF and Goins EW 2004. Quantitative and qualitative evaluation of selected wheat varieties released since 1903 to increasing atmospheric carbon dioxide: Can yield sensitivity to carbon dioxide be a factor in wheat performance? *Global Change Biology* **10**: 1810-1819.

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