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Effect of Climate Change on Growth of Groundnut (*Arachis hypogaea* L.)

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ABSTRACT

The present investigation on climate change and its impact on growth of groundnut crop was conducted during kharif season of 2015-16 using Open Top Chamber (OTC's) at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Raichur, Karnataka. Four circular OTC's at MARS, Raichur were used for the present investigations. groundnut was raised in different OTC's having standard climate change treatment[10] (IPCC, 2013). Elevated CO_2 and temperature significantly influenced the plant growth parameters of groundnut at various crop stages. Groundnut grown in eCO_2 (550 ppm) exhibited significantly higher plant height (16.90 cm) with maximum number of leaves (38.25 leaves/plant) and the corresponding values were significantly lower (9.28 cm plant height and 31.94 leaves/plant) in aCO_2 + eTemperature (390 ppm + 2 °C). The growth indices viz., leaf area index (LAI) significantly highest (0.31) in eCO_2 (550 ppm) and same was lower in aCO_2 + eTemperature (390 ppm + 2 °C) treatment (0.11).

Key words: *OTC's, LAI., Groundnut, Kharif*

INTRODUCTION

Climate which is the mean of variability of key weather parameters is a primary determination of agricultural productivity. Persistent and significant change in the average pattern of weather in a place for an extended period is known as climate change[2]. Given the role of agriculture in human welfare, concerns are raised regarding the potential effects of climate change on agricultural productivity. Climate change is closely linked with atmospheric concentration of CO_2, methane, nitrous oxide and other greenhouse gases which are known to trap the heat from solar radiations. As the concentrations of greenhouse gases increase, the overall temperature also increase resulting in differential precipitation leading to abrupt variation in crop productivity and herbivore action in agriculture[2].

It is well established that the global atmospheric CO_2 level is increasing due to eater process[6] and biological activity. It has been reported by federal agencies that CO_2 has been increased approximately 30 per cent since the industrial revolution which is believed to be responsible for an increase of about 0.66 °C in mean annual global surface temperature.

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Further, the temperature is anticipated to increase 1.4 to 5.8 °C by 2100 with equally increasing atmospheric CO_2, which is considered to be chiefly responsible for the greenhouse effect, which has increased from approximately 310 ppm in 1950 to about 400 ppm in the year 2011. This concentration is estimated to reach levels of 421 to 936 ppm by the end of the 21st century, according to forecasting models, depending on the magnitude of future human activities[10].

These changes in climatic factors (CO_2, temperature, vapor pressure deficit and rainfall) will alter plant growth and development processes and most likely have negative impact on crop productivity, especially in the semi-arid tropical regions, where the current temperatures are already high and close to the upper limits beyond which the plant processes will be adversely affected. Therefore, in spite of some expected benefits of increased CO_2 concentration on some crops, global warming poses a potential threat to agricultural production and productivity throughout the world. Increased incidence of weeds, pests and plant diseases with climate change may cause even greater economic losses to agricultural production. It is projected that even small rise in temperature (1-2 ºC) at lower latitudes, especially in the seasonally dry tropical regions would decrease crop productivity.

In general, C3 plants are more responsive to elevated CO_2, which lead to greater main shoot length, elongation of branches, individual leaf area per plant and dry mass. It is understood that accumulation of sugars and starch in the leaves of elevated CO_2 grown plants reflect higher photosynthetic carbon assimilation[7]. So, to study the implications of climate change in terms of eCO_2 and temperature, groundnut was chosen for study. Groundnut (*Arachis hypogaea* L.) is C_3 plant and is popularly known as “King of oilseed crops” and considered as an important source of edible oil and third most important source of vegetable protein. It contains about 50 per cent oil, 25-30 per cent protein, 20 per cent carbohydrate and five per cent fibre and ash which make a substantial contribution to human nutrition and also a valuable source of vegetable protein.

It contains about 50 per cent oil, 25-30 per cent protein, 20 per cent carbohydrate and five per cent fibre and ash which make a substantial contribution to human nutrition and also a valuable source of vitamins namely, E, K and B, high energy value, protein content and minerals. It is grown over an area of 26.62 million ha spread over 84 countries with an annual production of 35.66 million tonnes of pods with a productivity of 1348 kg ha-1[1]. China, India, Nigeria, the United States of America and Myanmar are the major groundnut growing countries. India is the second largest producer of groundnut in the world, with an average annual production of 5.51 million tonnes[1]. In India groundnut is being grown over an area of 5.52 million hectares with a total production of 9.62 mt with productivity of 1750 kg ha^{-1} [4]. Six major groundnut growing states *viz*., Gujarat, Andhra Pradesh, Tamil Nadu, Rajasthan, Karnataka and Maharashtra, contribute 90 per cent of total groundnut production. Karnataka ranks fifth in the country with a production of 0.65 million tonnes from an area of 0.73 million hectares and an average yield of 907 kg ha^{-1} [4].

Profound impacts of elevated CO_2 on terrestrial ecosystem, especially on chemical composition and nutrient quality of plants, are expected, that is significant increase in photosynthesis, growth, water use efficiency, leaf area, yield and decrease in foliar nitrogen of plants, particularly C_3 plants[5]. This paper attempts to review the current state of knowledge of climate factor effects on growth and development response of groundnut.

MATERIAL AND METHODS

The present investigation on effect of climate change on growth and yield of groundnut was conducted during *kharif* season of 2015-16 using Open Top Chamber (OTC’s) at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Raichur, Karnataka. Raichur is situated in the North Eastern Dry Zone (Zone-II) of Karnataka between 16°15' N latitude and 77° 20' E longitudes with an altitude of 389 m above the mean sea level.

The eCO_2 and temperature (abiotic factors) were considered as the main treatments in the present investigations. Each OTC was considered as a treatment for this study and the set of treatments designed as the recommendations of IPCC[10], are as follows.

T_1: Ambient CO_2 of 390 ± 25 ppm with 2 °C rise in temperature.

T_2: Elevated CO_2 of 550 ± 25 ppm.

T_3: Elevated CO_2 of 550 ± 25 ppm with 2 °C rise in normal temperature.

T_4: Reference OTC

T_5: Reference plot. (As saturated check)

Establishment of crop in OTC's

Popular groundnut variety TMV-2 was raised in eight cement pots size of 1×1 ft which was filled with red soil, FYM (7.5 tonnes/ha) and chemical fertilizers were added to each pot (25:75:25 kg/h through straight fertilizers) and vermicompost (1 ton/ha) as per recommendations of University of Agricultural Sciences, Raichur. Each treatment has eight pots and each pot consisting of two groundnut plants were treated as replicates in different OTC's having standard climate change treatment[10]. Pots were irrigated regularly and observations were taken[3].

Effect of elevated CO_2 and temperature on growth of groundnut

Plant growth parameters like number of leaves per plant, plant height were recorded at 30, 60 and 90 days after sowing.

Statistical analysis

The effects of CO_2 treatment on growth and yield were analyzed using one-way ANOVA. Treatment means were compared and separated using least significant difference (LSD) at $p < 0.01$.

RESULTS

Elevated CO_2 and temperature significantly influenced the plant growth, physiological, biochemical and yield parameters of groundnut at various crop stages. As evidenced at 30 days after sowing (DAS), the groundnut grown in eCO_2 (550 ppm) exhibited significantly higher plant height (16.90 cm with 22.84 per cent increase in plant) with maximum number of leaves (38.25 leaves/plant) and the corresponding values were significantly lower (9.28 cm plant height and 31.94 leaves/plant) in aCO_2 + eTemperature (390 ppm + 2 °C) which was on par with the reference plot (10.41 cm plant height and 33.19 leaves/plant). When observations were registered at 60 DAS, leaf area index was once again significantly highest (1.61) in eCO_2 (550 ppm) which was on par with eCO_2 + temperature (550 ppm + 2 °C) treatment (1.54) and significantly lowest in aCO_2 + eTemperature (390 ppm + 2 °C) treatment (0.81). Similar trend was noticed at 90 days of crop growth (Table 1 and 2).

DISCUSSION

Growth parameters *viz*., plant height and number of leaves increased in the climate change treatment as compared to the ambient treatments. These results indicated that the growth has increased in the elevated conditions in terms of plant height and leaves which may be reasoned to the fact that the carbon dioxide has direct fertilizing effect on plant growth. Groundnut, being a C_3 leguminous plant has found to show increased growth rates in elevated CO_2 conditions. These studies on growth parameters are well supported by various studies[14,15] who reported increased growth rate of groundnut in the elevated CO_2 treatments.

The results from the present investigations revealed that the eCO_2 and temperature have influenced positively in increasing the plant growth parameters *viz*., plant height, number of leaves and leaf area index. Many of earlier studies are in line with the present findings which reported that groundnut being a C_3 plant, respond positively to CO_2 showed increase in photosynthetic rate, biomass[15], increased plant height, root length, shoot length, stem length, leaf area and total biomass compared to the aCO_2 condition[14]. Similarly, in some other crops like cotton[9], green gram and black gram[13], lucerne[11], soyabean[8] and legume[12] more plant height, leaf area, photosynthesis and total dry matter was noticed under eCO_2 condition.

Table 1: Effect of eCO_2 and temperature on groundnut plant height (cm)

Treatment	Plant height (cm) at different period of crop growth									Pooled mean	% increase or decrease in plant height
	30 days after sowing			60 days after sowing			90 days after sowing				
	August sown	September sown	Mean	August sown	September sown	Mean	August sown	September sown	Mean		
eCO_2 (550 ppm)	16.94	16.87	16.90	30.53	30.29	30.41	32.81	32.22	32.52	26.61	22.84
eCO_2+eTemp.(550 ppm+2 °C)	14.48	14.38	14.43	28.30	29.55	28.93	30.98	31.46	31.22	24.86	17.41
aCO_2+eTemp.(390 ppm+2 °C)	9.26	9.29	9.28	22.55	22.89	22.72	22.29	24.08	23.18	18.39	-10.37
Reference OTC	12.47	12.34	12.40	26.45	26.81	26.63	28.97	28.23	28.60	22.54	8.91
Reference plot	10.82	10.00	10.41	24.35	24.72	24.54	26.87	26.45	26.66	20.53	-
C V (%)	**5.47**	**7.81**	**6.64**	**6.30**	**6.18**	**6.24**	**5.94**	**6.24**	**6.09**	**-**	**-**
S.Em±	**0.35**	**0.49**	**0.42**	**0.83**	**0.83**	**0.83**	**0.84**	**0.89**	**0.87**	**-**	**-**
CD(P=0.01)	**1.51**	**2.12**	**1.82**	**3.60**	**3.58**	**3.59**	**3.64**	**3.84**	**3.74**	**-**	**-**

Table 2: Effect of eCO_2 and temperature on number of leaves of groundnut

Treatment	Number of leaves per plant at different period of crop growth								
	30 days after sowing			60 days after sowing			90 days after sowing		
	August sown	September sown	Mean	August sown	September sown	Mean	August sown	September sown	Mean
eCO_2 (550 ppm)	40.13	36.38	38.25	48.13	43.38	45.75	46.50	43.00	44.75
eCO_2+eTemp.(550 ppm+2 °C)	39.38	35.88	37.63	46.75	42.75	44.75	45.38	41.13	43.25
aCO_2+eTemp.(390 ppm+2 °C)	33.00	30.88	31.94	40.00	37.75	38.88	39.38	36.88	38.13
Reference OTC	35.00	34.88	34.94	44.5	41.63	43.06	44.38	40.75	42.56
Reference plot	33.13	33.25	33.19	43.5	40.25	41.88	42.50	40.00	41.25
CV (%)	**6.68**	**5.68**	**6.18**	**5.23**	**5.37**	**5.30**	**5.29**	**5.66**	**5.47**
S.Em±	**1.21**	**0.97**	**1.09**	**1.16**	**1.10**	**1.13**	**1.15**	**1.10**	**1.13**
CD(P=0.01)	**5.21**	**4.20**	**4.71**	**5.03**	**4.77**	**4.90**	**4.99**	**4.20**	**4.59**

The growth indices *viz*., leaf area index (LAI) at 30, 60 and 90 DAS showed significant difference among climate change treatments. At 30 DAS, leaf area index was significantly highest (0.31) in eCO_2 (550 ppm) which was on par with eCO_2 + temperature (550 ppm + 2 °C) treatment (0.30) and same was lower in aCO_2 + eTemperature (390 ppm + 2 °C) treatment (0.11). When observations were registered at 60 DAS, leaf area index was once again significantly highest (1.61) in eCO_2 (550 ppm) significantly lowest in aCO_2 + eTemperature (390 ppm + 2 °C) treatment (0.81). Similar trend was noticed at 90 days of crop growth wherein, highest for LAI was recorded in eCO_2 (550 ppm) treatment as compared to aCO_2 treatments (Table 3).

Table 3: Effect of eCO_2 and temperature on leaf area index of groundnut

Treatment	Leaf area index at different crop growth period								
	30 days after sowing			60 days after sowing			90 days after sowing		
	Aug. sown	Sept. sown	Mean	Aug. sown	Sept. sown	Mean	Aug. sown	Sept. sown	Mean
eCO_2 (550 ppm)	0.32	0.30	0.31	1.61	1.62	1.61	1.73	1.70	1.72
eCO_2+eTemp.(550 ppm+2 °C)	0.30	0.29	0.30	1.52	1.57	1.54	1.63	1.57	1.60
aCO_2+eTemp.(390 ppm+2 °C)	0.11	0.11	0.11	0.81	0.82	0.81	0.86	0.83	0.85
Reference OTC	0.16	0.15	0.16	1.40	1.43	1.42	1.43	1.39	1.41
Reference plot	0.20	0.21	0.21	1.43	1.46	1.45	1.46	1.46	1.46
CV (%)	**5.60**	**7.99**	**6.80**	**5.66**	**2.29**	**3.98**	**6.41**	**5.64**	**6.03**
S.Em±	**0.01**	**0.01**	**0.01**	**0.04**	**0.02**	**0.03**	**0.05**	**0.04**	**0.04**
CD(P=0.01)	**0.03**	**0.04**	**0.03**	**0.17**	**0.07**	**0.12**	**0.20**	**0.17**	**0.18**

CONCLUSIONS

The climate change in terms of eCO_2 and temperature has favoured the growth and development of groundnut, as it was evidenced by the accelerated growth rates in terms of plant height, number of leaves, leaf area index (LAI). The growth parameters showed positive trend along with the yield parameters and resulted in increased yield in eCO_2 treatment. Climate change in terms of eCO_2 alone or in combination with temperature has favoured the groundnut growth, development and yield.

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