Effect of elevated CO2 levels on some growth parameters and seed quality of groundnut (Arachis hypogaea L.)

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Sushil Kumar Yadav
Central Research Institute for Dryland Agriculture, India

Maddi Vanaja
Central Research Institute for Dryland Agriculture, India

Maheswari Mandapaka
Indian Council of Agricultural Research

Sharma K.L.
Central Research Institute for Dryland Agriculture, India

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Short Communication

Effect of Elevated CO_2 Levels on Some Growth Parameters and Seed Quality of Groundnut (*Arachis hypogaea* L.)

SK YADAV*, M VANAJA, PR REDDY, N JYOTHILAKSHMI, M MAHESWARI, KL SHARMA and B VENKATESWARLU
Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad-500 059, India

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, two cultivars of groundnut (*Arachis hypogaea* L.) viz., JL 24 and ICGV 91114 were raised in open top chambers at two elevated CO_2 levels (550 and 700ppm) during *Kharif* 2010 to investigate the effect of raised levels of CO_2 on various growth parameters and seed quality. The seed oil and protein contents were higher in JL 24 compared to ICGV 91114 in all the treatments and showed a declining trend with elevated carbon dioxide concentrations. The oil and protein contents in ICGV 91114 showed a decline at 550 ppm of CO_2 and a slight increase at 700 ppm of CO_2. The saturated fatty acids (palmitic and stearic) showed a decreasing trend while oleic acid (omega-9) registered an increasing trend in JL 24 at elevated CO_2 levels. The trend was similar in ICGV 91114 except at 550 ppm of CO_2 where oleic acid registered a decline before an increase at 700 ppm. Linoleic acid (omega-6) content decreased at 550 ppm and then increased slightly at 700 ppm of CO_2 in JL 24, whereas it showed a reverse trend in ICGV 91114. In general, the saturated fatty acid levels decreased in both the genotypes while a corresponding increase was observed in unsaturated fatty acids under elevated CO_2 concentrations which could prove to be beneficial from the human nutritional point of view under future changed climatic scenario.

Key words: Elevated carbon dioxide, oil and protein content, fatty acid composition

Exposure to environmental stress induces numerous physiological changes in plants that may alter the chemical composition of crops and thus the quality of the harvested products (1,2). Under the present global scenario, CO_2 has been rising steadily mainly by man-made activities over the past few decades and has become 380ppm from approximately 280 ppm prevalent before the industrial revolution (3). Soit has become very relevant for researchers all over the world to know the impact of elevated CO_2 levels on future food security. Carbon dioxide is a plant nutrient and its atmospheric enrichment has potential to enhance crop growth and productivity both in terms of quantity and quality (4,5) by increasing photosynthesis and water use efficiency and decreasing transpiration through reduced stomatal conductance. Information about the effect of elevated atmospheric carbon dioxide concentrations on lipid metabolism in oilseed crops is very limited. In the present study, two groundnut genotypes have been evaluated in open top chambers at elevated CO_2 levels of 550 and 700ppm for their response in terms of total biomass, kernel yield, oil and protein content and fatty acid composition of oil in comparison with ambient control (380 ppm).

Two cultivars of Spanish bunch type groundnut (*Arachis hypogaea* L.), JL 24 and ICGV 91114 were raised in open top chambers (6) at two elevated CO_2 levels (550 and 700ppm) during *Kharif* 2010 at Central Research Institute for Dryland Agriculture, Hyderabad to investigate the effect of higher levels of CO_2 over ambient (380ppm) on some growth parameters, total biomass, kernel yield, oil and protein content in kernels and fatty acid composition of oil. The date of sowing of the two cultivars of groundnut was 12th November 2010 and harvesting was done at the physiological maturity. Standard agronomic and plant protection measures were followed to raise the groundnut crop. Two individual chambers were maintained for each CO_2 levels as replicates. The chambers without any external CO_2 supply served as chamber (ambient) control. The crop was maintained with elevated CO_2 levels throughout the growing season. Observations on growth parameters were recorded after the harvest of the crop. Analysis of seed oil content was

*Author for correspondence: Email: skyadav@crida.ernet.in

carried out by following the Soxhlet-extraction method (7). The analysis of fatty acid composition was performed by Gas Liquid Chromatography CIC (Baroda, Gujarat). The esterification of fatty acids was carried out using sulphuric acid (8). 100 mg oil was treated with 2% sulphuric acid in methanol for 2 hrs at 55°C. The process of methanolysis was monitored by TLC using a solvent system of hexane: ethyl acetate (90:10, v/v). The resultant FAME was extracted with hexane, washed with water until neutral, dried over anhydrous $Na_2 SO_4$ to get fatty acid methyl esters. The separations were performed on a Silar 10 C column using a (injector 250°C, carrier gas N_2 at 30 ml min -1, oven 190°C, FID 250°C). Nitrogen content in fat free seed meal was estimated by using Kjeltech 8400. The crude protein content was worked out by multiplying nitrogen values by the factor of 5.46 (%N X 5.46). Measurements for all the parameters were carried out in duplicate.

Carbon dioxide is essential for photosynthetic carbon reduction. Rising CO_2 concentration in the atmosphere can have both positive and negative consequences on plant growth. In the present study, both the groundnut cultivars were observed to possess higher values for most of the yield parameters studied at elevated levels of CO_2 when compared with ambient control. At 550 ppm CO_2, total biomasss, kernel number and harvest index were higher in JL 24 while pod number, husk weight and 100 kernel weight were higher in ICGV91114 (Table 1). Similarly, at 700 ppm CO_2, husk weight and 100 kernel weight were higher in JL 24 while total kernel weight and harvest index were observed to be higher in ICGV91114. The increase observed for various parameters was higher in JL 24 than in ICGV91114 (Table 1).

The total biomass registered an increase of 25.6 and 12.9 % respectively at both 550 and 700 ppm CO_2 levels compared to ambient control in JL24 while it was 14.4 % in ICGV91114 at 550 and 700 ppm. 100 kernel weight did not show any increase at 550ppm and 6.4% increase at 700 ppm of CO_2 in JL 24. ICGV 91114 registered an equal increase of 7.0% at both 550 and 700 ppm CO_2. The seed oil and protein contents were higher in JL 24 compared to ICGV 91114 in all the treatments and showed a declining trend with elevated carbon dioxide concentrations. The oil and protein contents in ICGV 91114 showed a decline at 550 ppm of CO_2 and a slight increase at 700 ppm of CO_2. The content and quality of groundnut oil changed with elevated CO_2 levels. The values for oil content were 50.4 and 48.4 % at ambient, 49.8 and 47.9 % at 550 ppm and 48.3 and 47.9 % at 700 ppm CO_2 levels, respectively in JL 24 and ICGV 91114. Similarly, protein content decreased from 57.3% at ambient to 56.1% at 550 ppm and 53.4% at 700 ppm CO_2 levels in JL 24 while it fluctuated from 53.5% at ambient to 52.8% at 550 ppm and 53.6% at 700 ppm CO_2 levels in ICGV 91114. Overall the absolute values for these parameters did not change much for the genotype ICGV91114. The protein content also remained higher in JL 24 at ambient and 550 ppm of CO_2 while the values were almost similar at 700 ppm of CO_2. The saturated fatty acids (palmitic and stearic) showed a decreasing trend while oleic acid (omega-9) registered an increasing trend in JL 24 at 550 ppm of CO_2 levels and a further slight increase at 700 ppm CO_2 (Table 2). It declined in ICGV 91114 at 550 ppm of CO_2 and then registered an increase at 700 ppm of CO_2. Linoleic acid (omega-6) content decreased at 550 ppm

Table 1: Performance of two genotypes of groundnut under elevated levels of CO_2

CO_2 level	700ppm		550ppm		Ambient	
Parameter/Variety	JL 24	ICGV	JL24	ICGV	JL24	ICGV
Total biomass (g)	40.3	41.7	47.2	41.7	35.1	35.7
Pod wt (g)	18.4	15.7	19.7	17.6	16.0	13.8
Pod No.	28.3	25.3	33.3	34.3	28.3	28.0
Husk wt (g)	7.2	4.5	6.4	7.0	6.3	5.5
Kernel wt/pl (g)	11.2	11.3	13.3	10.7	9.7	8.2
Seed number	41	41.7	50	43.3	35	36.3
100 kernel wt (g)	28.3	27.1	26.5	27.1	26.5	25.2
Harvest index (%)	27.8	27.0	28.2	25.6	27.6	23.1
Oil content (%)	48.2	48.0	49.8	47.9	50.4	48.4
Protein content(%)	53.4	53.6	56.1	52.8	57.3	53.5

Table 2: Oil quality as influenced by elevated CO_2 concentration in two genotypes of groundnut

Treatment	Fatty acid composition of oil (%)							
	Palmitic		Stearic		Oleic		Linoleic	
	JL 24	ICGV	JL 24	ICGV	JL 24	ICGV	JL 24	ICGV
Ambient	15.16	14.41	2. 02	1.97	40.80	41.42	42.00	42.18
550ppm	14.88	14.26	1.79	1.92	42.26	40.61	41.05	43.19
700ppm	14.31	13.85	1.75	1.94	42.42	43.63	41.50	40.55

and then increased slightly at 700 ppm of CO_2 in JL 24, whereas it showed a reverse trend in ICGV 91114.

Earlier studies have shown that higher levels of CO_2 lead to reduced uptake of nitrogen resulting in crops with lower nutritional value (9). This would primarily impact on populations in poorer countries less able to compensate by eating more food, more varied diets, or possibly taking supplements. The protein content of the rice grain has been observed to decrease under combined increases of temperature and CO_2 (10). Elevated CO_2 concentration has been observed to impact the edible quality of maize grains and soybean seeds (11-13). Oleic acid increased while linoleic acid decreased with elevated levels of carbon dioxide in oilseed rape (14). Thus the changes in the atmospheric CO_2 not only affect the productivity and physiological processes in crops like wheat, rice and *Brassica* but also alter their composition and grain structure. These changes in grain quality may affect their use as food ingredients and may prove a threat to their application.

In the present investigation, significantly higher quantity of linoleic acid and oleic acid was found in the seeds of CO_2 enriched plants. The increase in oleic acid content due to elevated CO_2 is a positive effect, as it would provide better thermo-stability to the edible oil which is desirable from the cooking and nutritional point of view. The conversion of linoleic acid to linolenic acid requires sufficient quantity of O_2 that was not available due to higher intercellular concentration of CO_2, which, in turn, resulted in the reduction of polyunsaturated fatty acid. The oil and protein contents (%) decreased with enhanced levels of carbon dioxide but their overall yields increased due to rise in per plant productivity and kernel weight. The saturated fatty acid levels decreased in both the genotypes while a corresponding increase was observed in unsaturated fatty acids under elevated CO_2 concentrations which could prove beneficial from the human nutritional point of view under changed climatic scenario. Since there could be various abiotic stresses faced by plant at the same point of time, the extent of the interaction between elevated CO_2 and other parameters can vary, depending on the species and genotype, gas concentrations, and other experimental and environmental conditions. The challenge before the scientists is to take advantage of the inevitable increase in atmospheric CO_2 concentration by selecting crops and genotypes that will produce more and yet maintain desirable quality characteristics.

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