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Effect of elevated atmospheric CO_2 concentration on nutrient quality of different maize genotypes

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Abstract: Maize crop grown under elevated CO_2 treatments in Open Top Chambers (OTCs) comprising ambient and elevated CO_2 treatment of 550 ppm was carried out to determine phytochemical parameters. Effect of elevated atmospheric CO_2 concentration on nutrient quality of three different maize genotypes i.e., DHM 117, Harsha and Varun was analysed. Protein content (%) of Varun variety found to contain significantly higher protein content compared to Harsha variety at elevated CO_2 level. The 100 seed weight of DHM 117 genotype was found to be significantly higher compared to Varun at ambient levels and 550 ppm eCO_2. Total mineral content (g/100g) of DHM 117, Harsha and Varun genotypes grown at 550ppm was significantly higher compared to 380 ppm eCO2. Zinc content (mg/100g) of DHM 117 recorded significant increase in DHM 117 genotype grown in chamber control compared to enriched 550ppm CO_2. The effect of elevated CO_2 on iron, copper, manganese, magnesium and crude fibre found to be non significant among the three maize genotypes.

Keywords: Elevated CO_2, maize genotypes, phytochemical quality, protein, minerals.

INTRODUCTION

Elevated CO_2 concentrations and temperatures under global climate change scenarios projected for coming decades could impact food crop quality[1-2]. Carbon emissions related to human activities have been significantly contributing to the elevation of atmospheric CO_2 and temperature[3]. More recently, carbon emissions have greatly accelerated, thus much stronger effects on crops are expected[4]. Within the conditions expected for the next few years, the physiological responses of crops suggest that they will grow faster, with slight changes in development, such as flowering and fruiting, depending on the species. There is growing evidence suggesting that C3 crops are likely to produce more harvestable products and that both C3 and C4 crops are likely to use less water with rising atmospheric CO_2 in the absence of stressful conditions[5]. Changes in food quality in a warmer, high CO_2 world are to be expected, e.g., decreased protein and mineral nutrient concentrations[6]. Studies related to changes in food quality as a consequence of global climatic changes should be priority areas for further studies, particularly because they will be increasingly associated with food security[1,4]. Hence, there is a need to understand the effects of these environmental factors on nutrient quality parameters of edible part of the crop.

MATERIALS AND METHODS

An Open Top Chambers (OTCs) experiment was conducted at Central Research Institute of Dryland Agriculture (CRIDA) Hyderabad, Food crop quality analysis of maize crop was grown under elevated CO_2 treatments, comprising ambient and elevated CO_2 treatment of 550 ppm. For each treatment one OTC at 550ppm and other OTC was maintained at ambient CO_2 level (390ppm) without any external CO_2 supply which served as chamber control (CC). The elevated levels of CO_2 were maintained 24h a day from the sowing to maturation of the crop. OTCs were tied with transparent PVC sheet each having 3m×3m with 3m height. Three genotypes of maize, i.e., DHM 117, Harsha and Varun were grown in OTCs in duplicates and after harvesting, maize grain was subjected to determine different phytochemical parameters. The effect of elevated atmospheric CO2 concentration compared with ambient conditions on nutrient quality of three different maize genotypes was studied. Estimation of quality parameters were analysed with standard methods. Nitrogen content was estimated by micro-kjeldal method as described by Dhyan Singh *et. al.*, [7], and crude protein was calculated (N X 6.25). Crude fiber content was determined by Fibertech method as described by Sadasivam and Manickam [8]. Nutrient profile minerals iron, zinc, copper, manganese, magnesium, total ash (mineral) was analyzed by Atomic Absorption Spectrophotometer. All analysis was carried out in triplicates and the results were calculated on dry weight basis. Analysis of variance was carried out as described by Snedecor and Cochran[9].

RESULTS AND DISCUSSION

Protein content of elevated maize grain

The response of different phytochemical parameters to elevated carbondioxide concentrations in three different maize crop genotypes i.e., DHM 117, Harsha and Varun grown showed mixed results. Protein content (%) of Harsha genotype of maize was significantly higher ($P<0.05$) compared to DHM 117 genotype at 550 ppm of elevated CO_2 concentration. Varun variety found to contain significantly higher ($P<0.05$) protein content compared to Harsha variety at elevated CO_2 level. The most influential factor in reducing grain nitrogen concentration was determined to be low soil nitrogen and under this conditions atmospheric CO_2 enrichment further reduced grain nitrogen and protein concentrations, although the change was much less than that consumed by low soil nitrogen. When soil nitrogen was not limiting however, increases in the air CO_2 concentration did not affect grain nitrogen and protein concentrations[10]. Literally thousands of studies have assessed the impact of elevated levels of atmospheric CO_2 on the quantity of biomass produced by agricultural crops, but only a tiny fraction of that number have looked at any aspect of food quality. From what has been learned about protein substances that have been investigated in this regard, however, there is no reason to believe that other plant constituents would be present in any lower concentrations in a CO_2 enriched world of the future than they are currently. Indeed, there is ample evidence to suggest they may well be present in significantly greater concentrations, and certainly in greater absolute amounts [11]. The effects of atmospheric CO_2 enrichment reported on plant constituents of significance to human health reported by Idso and Idso [12] cited a number of studies that indicated elevated levels of atmospheric CO_2 may at times increase, decrease or have no effect upon the protein contents of various foods.

Physical quality of maize grain

Varun genotype showed significantly higher ($P<0.05$) 100 seed weight at 550 ppm elevated CO_2 compared to ambient concentration of CO_2. The 100 seed weight of DHM 117 genotype was found to be significantly higher ($P<0.01$) compared to Varun at ambient levels and 550 ppm of CO_2 concentrations. Harsha genotype was found to contain significantly higher ($P<0.01$) 100 seed weight grown at 550ppm compared to ambient concentrations. The mean 100 seed weight of DHM 117 genotype was found to have significantly higher seed weight compared to Harsha genotype grown under both ambient and 550 ppm levels CO_2 concentrations (Fig 2). Elevated levels of atmospheric CO_2 have also been determined to increase the total ash content was supported by Vanaja *et.al.*,[13] where the response of total biomass of blackgram was increased.

Mineral quality of maize grain

Total mineral content (g/100g) i.e., total ash content of DHM 117, Harsha and Varun genotypes grown at 550ppm was significantly higher ($P<0.05$) compared to 390 ppm levels of CO_2 concentration(Fig. 3).

Zinc content (mg/100g) of DHM 117 recorded significant increase ($P<0.05$) in DHM 117 genotype grown in chamber control compared enriched CO_2 levels of 550ppm. DHM 117 and Varun genotypes found to contain highly significant ($P<0.01$) zinc content compared to Harsha genotype grown at ambient conditions. The effect of elevated CO_2 on iron, copper, manganese, magnesium and crude fibre found to be non significant among the three maize genotypes.

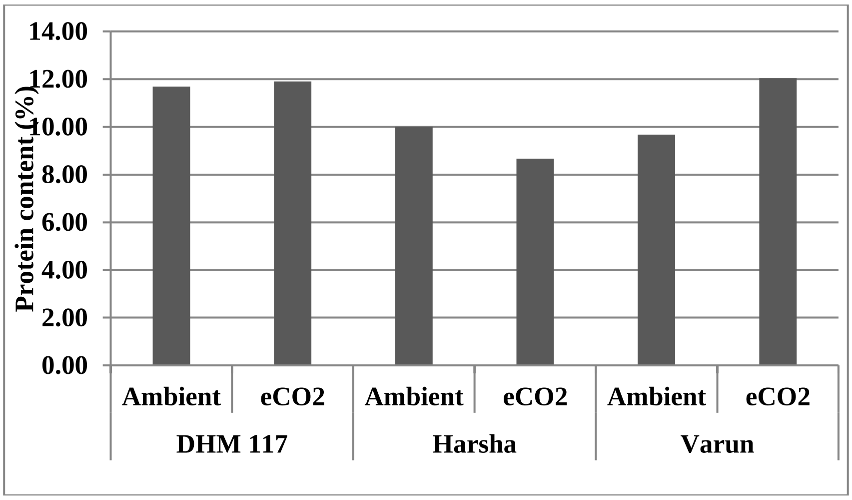

Fig 1: Protein content of different genotypes of maize grain under ambient and eCO_2 concentrations

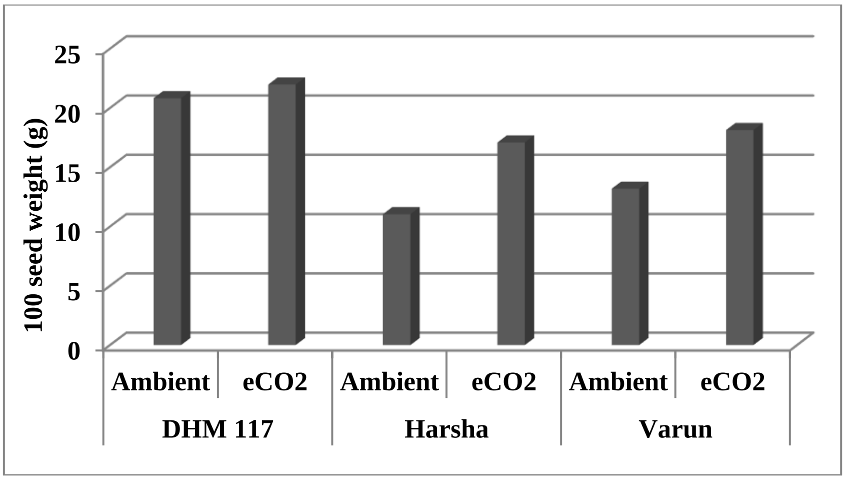

Fig 2: 100 seed weight of Maize grain of different genotypes of maize under ambient and eCO_2 concentrations

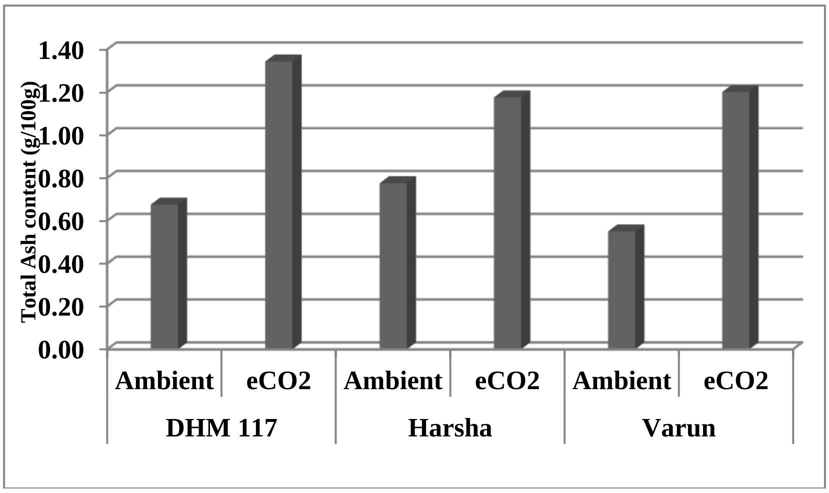

Fig 3: Ash content of of different genotypes of Maize grown under ambient and eCO_2 concentrations

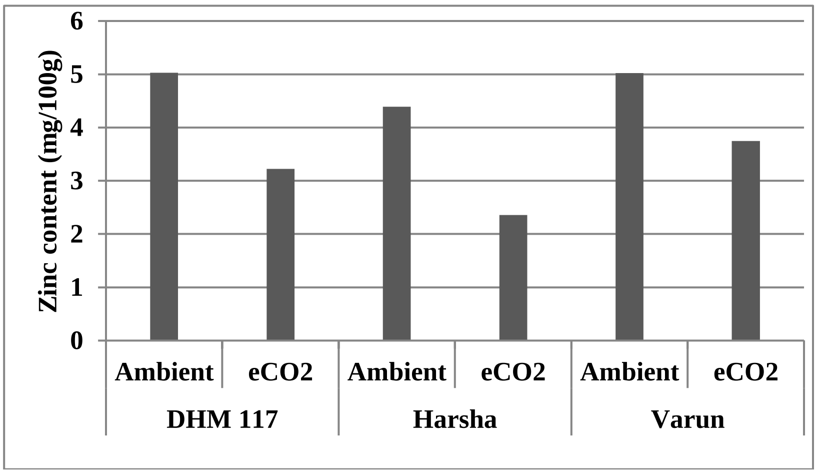

Fig 4: Zinc content (mg/100g) of different genotypes of Maize grown under ambient and eCO_2 concentrations

CONCLUSION

The response of different phytochemical content to elevated carbondioxide concentrations in three different maize crop genotypes i.e., DHM 117, Harsha and Varun grown showed mixed results. Protein content (%) of Harsha genotype of maize was significantly higher compared to DHM 117 genotype at 550 ppm of elevated CO_2 concentration. Varun variety found to contain significantly higher protein content compared to Harsha variety at elevated CO_2 level. DHM 117 genotype showed significantly higher 100 seed weight at 550 ppm elevated CO_2 compared to ambient concentration of CO_2. The 100 seed weight of DHM 117 genotype was found to be significantly higher compared to Varun at ambient levels and 550 ppm of CO_2 concentrations. Total mineral content (g/100g) of DHM 117, Harsha and Varun genotypes grown at 550ppm was significantly higher compared to 390 ppm levels of CO_2 concentration. Zinc content (mg/100g) of DHM 117 recorded significant increase in DHM 117 genotype grown in chamber control compared enriched CO_2 levels of 550ppm. DHM 117 and Varun genotypes found to contain highly significant zinc content compared to Harsha genotype grown at ambient conditions. The effect of elevated CO_2 on iron, copper, manganese, magnesium and crude fibre found to be non significant among the three maize genotypes. Throughout the entire course of the Industrial Revolution, during which time the air's CO_2 content rose by 35% and its near-surface temperature by about 0.6°C, there has been no detectable negative impact on human longevity. In fact, human lifespan has concurrently experienced an almost unbelievable increase that shows no signs of ultimately leveling off or even slowing down. What is more, warming has been shown to positively impact human health, while atmospheric CO_2 enrichment has been shown to enhance the health- promoting properties of the food we eat, as well as stimulate the production of more of it. In addition, elevated levels of atmospheric CO_2 have been shown to increase the amounts and effectiveness of disease- fighting substances found in plants that protect against various forms of cancer, cardiovascular and respiratory diseases. In light of these many well-documented observations, it is abundantly clear we have nothing to fear from increasing concentrations of atmospheric CO_2 and global warming, i.e., the "twin evils" of the extreme environmental movement. Indeed, these phenomena would appear to be our friends and friends of the entire biosphere.

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