The impact of elevated carbon dioxide on the stress tolerance of selected vegetable crops / Razifah Mohd Razali.

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The impact of elevated carbon dioxide on the stress tolerance of selected vegetable crops

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Te Whare Wānanga o Otāgo

November 2014

Table of Content

Abstract

Plant responses to different stresses are highly complex and involve changes at both the cellular and physiological levels. The physiological interaction between carbon dioxide (CO_2) enrichment, biotic and abiotic stressor was studied in crop plants. Metabolic acclimation through the accumulation of protective metabolites is regarded as a basic strategy for protection and survival of plants in stress environments. The aim of this study was to investigate the relations between CO_2 enrichment and stress-inducing microcystins or *Red clover necrotic mosaic virus* (RCNMV) replication on plant growth and physiology. A preliminary study was carried out to investigate the growth and developmental response of selected leafy vegetable crops that were exposed to elevated carbon dioxide (CO_2). Lettuce cvs. Great Lake and Red Fire, spinach, Swiss chard and cabbage were grown under ambient (380 ppm) and elevated (760 ppm) CO_2 concentrations. Elevated CO_2 was positively correlated with increased plant height, number of leaves and total leaf area except in cabbage. However, the photosynthetic pigments for lettuce, Swiss chard and cabbage decreased under elevated CO_2, while the photochemical efficiency of PS II (f_v/f_m) remained unchanged under elevated CO_2 except in cabbage and Swiss chard.

Microcystin contamination of soil is a widespread environmental problem. A large-scale experiment was conducted to study the mechanisms involved in plant adaptation to microcystin stress under increasing atmospheric CO_2 levels. Selected leafy vegetable species were grown under ambient (380 ppm) and elevated (760 ppm) CO_2 concentrations. Microcystins caused oxidative damage, with increased levels of protein carbonyls and lipid hydroperoxides in microcystin-treated plants. Subsequently a significant increase in antioxidant enzymes (i.e. superoxide dismutase, catalase, glutathione reductase, glutathione peroxidase and ascorbate peroxidase) was observed. A significant increased of total ascorbate was recorded in microcystin-treated plants under elevated CO_2 levels, but the percentage of oxidized ascorbate increased in microcystin-treated plants at both CO_2 levels. The level of total glutathione increased rapidly in microcystin-treated plants under elevated CO_2 levels and the oxidation process increased in microcystin-treated plants. Microcystin treatments drastically influenced the accumulation of polyamine compounds especially in the plants grown at ambient CO_2 levels. It has been suggested that an increased ability to accumulate polyamines represents a plant defence mechanism. Results from this study provide evidence

that microcystins cause oxidative stress and that exposure to microcystins through the irrigation route poses a threat to the yield and quality of leafy vegetables.

The effect of RCNMV on Top Crop beans was also investigated in this study. Following RCNMV inoculation, plants were grown at ambient (380 ppm) and elevated CO_2 (760 ppm) levels. Findings suggest that, CO_2 enrichment could help infected plants to survive under biotic stress (RCNMV infection). It was observed that Top Crop beans grown at elevated CO_2 levels showed increased antioxidant and polyamine metabolisms, accompanied by an increased in virus resistance. The virus titre was reduced as indicated by significantly lower amounts of RCNMV coat protein in plants grown at elevated CO_2. The combination of elevated CO_2 and RCNMV infections promoted an increase in antioxidant metabolism in Top Crop beans. Polyamine metabolism also increased following RCNMV infection under elevated CO_2. Therefore, it was suggested that the increase in antioxidant and polyamine levels in plants exposed to elevated CO_2 is associated with stress tolerance to RCNMV infection.

In conclusion, results from this study show that both stressors (biotic and abiotic) have common defense mechanisms. Since H_2O_2 is one product of stress, the necessity for H_2O_2 detoxification is required for the survival of plants. The results also underline that environmental conditions can have a strong and complex modifying influence on antioxidant and polyamine metabolism. There are metabolic similarities between virus infection and toxin exposure.