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CARBON DIOXIDE ENRICHMENT ON GROWTH AND YIELD OF SWEET POTATOES *(IPOMOEA BATATAS,* cv GEORGIA JET)

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ABSTRACT

This study was conducted to obtain field data on the growth and yield of sweet potaotes in elevated levels of carbon dioxide (CO_2). Sweet potato plants were planted in open-top chambers as well as in open field plots. The plants were grown at ambient CO_2 with and without chambers, ambient +75, +150, and +300 ppm (90 days). Enriched CO_2 concentration increased the number of tubers and the percentage of dry matter of the tubers. The density, length and diameter of the tubers did not vary significantly in enriched CO_2 levels.

RESUMEN

Este estudio se llevó a cabo con el objeto de obtener información sobre los ensayos relacionados con el desarrollo y la producción del camote con niveles altos de dioxido de carbón (CO_2) Los camotes fueron plantados en camaras sin techos, como tambien, se los cultivó en parcelas de campo. Las plantas fueron cultivadas al ambiente CO_2, en camaras y fuera de ellas, ambiente +75, +150 y +300 ppm (noventa dias). Una concentración mas fuerte de CO_2 incremento el numero de tubérculos. La densidad, el largo y el díametro de los tubérculos no vario significativamente en niveles altos de CO_2.

The global carbon dioxide (CO_2) concentration is gradually increasing due to fossil fuel consumption, rapid advancement in industrialization and deforestation. It has been estimated that atmospheric CO_2 concentration will be doubled by 2025 (Clark *et al.*, 1982). Extensive literature is now available to demonstrate that elevated CO_2 results in the increase of dry matter accumulation in both vegetation and reproductive components of plants (Wittwer, 1980, 1983; Kimball, 1983).

Although there are a number of reports on the influence of atmospheric CO_2 enrichment on photosynthesis and short-term growth, very few reports are available on crops which have been subjected to CO_2 enrichment during their entire growing season. Furthermore, little information is available on plant responses to CO_2 enrichment under field conditions (Kramer, 1981; Strain *et al.*, 1984). It is therefore, imperative to have a better understanding of the effects of CO_2 enrichment on crop plants.

Reports on the influence of elevated CO_2 levels on tuber crops like radish *(Raphanus sativus* L. 'Whitetip'; Knecht, 1975) and potato *(Solanum tuberosum,* 'Kennebec'; Collins, 1976; Goudriaan and deRuiter, 1983) did not consider the effects of long-term exposure to elevated CO_2. Therefore, more information is needed to understand the overall effects of CO_2 enrichment on growth, development, and yield potential of root crops.

Sweet potatoes *(Ipomoea batatas* L.) were selected as an experimental crop in the southern United States. In addition, sweet potatoes are one of the world's major food crops. Currently, little is known about the responses of sweet potatoes to elevated CO_2 (Strain *et al.*, 1984). Sweet potatoes have widespread growth ranges and, consequently, can be easily grown for experimental purposes. In the present study, CO_2 enrichment has been applied to sweet potatoes in order to investigate its effect on their growth, physiology, and yield under field conditions.

In the summer of 1984, under the sponsorship of DOE and Tuskegee University, experiments were conducted to study the physiological and biochemical effects of enriched CO_2 on sweet potatoes in open top chambers at the George Washington Carver Agricultural Experiment Station, Tuskegee, Alabama. The techniques for the generation of large scale test atmospheres in the field for the purpose of obtaining dose response relationships of crop plants were developed at the USDA Air Quality Laboratory at Raleigh. The main task of the 1984 study at Tuskegee University was to assemble equipment to generate test atmospheres of CO_2 in the field, using open top chambers as the basic exposure unit for studying the responses of sweet potatoes and cowpeas to enriched CO_2.

Plant responses to CO_2 in open top chambers have been demonstrated by several investigators in a variety of crops. This study focused on growth and development of sweet potatoes at levels of CO_2 ranging from the ambient level of 354 ppm to 659 ppm. The effects of CO_2 on leaf and stem weights, stem length, leaf area, and stomatal number and conductance were studied. Additional studies on sweet potatoes included the effects of CO_2 on the weight, chemical content and quality of tubers.

In addition to the field studies, a series of experiments by Tuskegee University scientists conducted at the Duke University Phytotron were completed in 1984. These experiments focused on the biochemical and physiological effects of elevated CO_2 on sweet potatoes grown in controlled environments.

Sweet potatoes grown in open top chambers, at ambient CO_2 concentrations had fewer leaves, less total runner length, and lower fresh and dry weights of shoots, leaves and tubers as compared to sweet potatoes grown in the open field without chambers. These results emphasize the need to quantify more carefully the environmental differences between open top chambers and the open field. These chamber effects need to be considered when drawing conclusions about the effects of elevated CO_2 on the growth and yield of plants grown in open top chambers.

While shoot growth in sweet potatoes increased with increasing CO_2, few of the effects were large enough to be significant. However, the percentages of nitrogen and protein nitrogen in sweet potato leaves decreased significantly at higher CO_2 concentrations. The total fresh weight of tubers increased significantly at the higher levels of CO_2, due primarily to the increase in the number of tubers. This suggests a shift in the partitioning of photoassimilates toward tubers with increasing CO_2. There were no differences in the density of stomates or in stomatal conductances in sweet potato leaves. Analyses of tubers indicated that protein, total carotenoids and insoluble dietary fiber all decreased with increasing CO_2, while dry matter content increased with increasing CO_2. Taste panel tests indicated small but significant preferences in some test categories for potatoes grown at the highest CO_2 level.

In phytotron studies with pot-grown sweet potatoes, plants grown at 675 or 1000 ppm CO_2 showed increases in the length of the main stem, total branch length, the number of branches and leaf area as compared to those grown in 350 ppm CO_2. At each harvest interval the production of total dry matter increased in response to increases in the level of CO_2. Specific leaf weight also increased with increased CO_2 concentrations. At the final harvest, the dry weights of roots and tubers increased 1.8 and 2.6 times in plants grown at 675 and 1000 ppm CO_2, respectively, compared to those grown at 350 ppm. Carbon dioxide enrichment resulted in early tuber maturation in sweet potatoes.

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