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INITIAL BELL PEPPER (*Capsicum annuum*) GROWTH AS INFLUENCED BY DIFFERENT LEAF-APPLIED ETHANOL CONCENTRATIONS

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ABSTRACT. Experiments were conducted under controlled conditions to determine the effect of different ethanol concentrations on the initial growth of 'Camelot' bell pepper. Plants in the two-true leaf stage were submersed for 2 minutes in either 0, 5, 10, 15 or 20% ethanol solution (v/v). Plant height, leaf area per plant, number of floral buds per plant and leaf and stem dry weight per plant were collected 40 days after treatment. Bell pepper plants had the highest values for all variables under study when solutions containing 10% ethanol were applied. In most cases, 20% solutions reduced variables studied at or below control levels.

INTRODUCTION

Short chain alcohols such as ethanol and methanol have been proposed as seed germination, biomass accumulation and yield enhancers in a number of plant species (Adkins et al. 1984; Rowe et al. 1994; Smits et al. 1995). Understanding of the metabolism and possible mode of action of ethanol in plants is fragmentary. A proposed exogenous alcohol pathway in higher plants has been proposed (Figure 1), in which alcohols are metabolized to CO_2 via formaldehyde formation, or assimilated into organic compounds, especially serine and methionine (Cossins 1964; McGiffen and Manthey, 1996). Alcohol-mediated stimulation in C3 plants is thought to result from increased serine biosynthesis, decreased photorespiration activity, higher concentrations of available CO_2 in the leaf mesophyll and presumed transitory modifications in the CO_2 fixation process during photosynthesis and enhanced efficiency of water utilization (Nonomura and Benson 1992; McGiffen and Manthey 1996).

Because of their different CO_2 fixation mechanisms, C3 plants appear to be responsive to ethanol and methanol treatment, whereas C4 plants such as maize (Zea mays) and barley (Hordeum vulgare) are not (Devlin 1994). In fact, when Kentucky bluegrass (Poa pratensis) plants were sprayed with methanol, toxic effects were observed (Crowe et al. 1994). On the other hand, C3 crops such as tomato (Lycopersicon esculentum), foliar applications of ethanol (up to 20%) have been reported to increase above-ground biomass (Rowe et al. 1994). When 'South Bay' lettuce (Lactuca sativa) transplants were submersed in ethanol aqueous solutions (up to 15%), crop biomass was significantly increased above that of untreated plants (Morales-Payan and Santos 1997). According to some reports (Devlin 1994; Li et al. 1995; Nonomura and Benson 1992), foliar methanol treatment has significantly increased shoot biomass accumulation in cotton (Gossypium hirsutum), eggplant (Solanum melongena), palm (Washingtonia robusta), peas (Pisum sativum), radish (Raphanus sativus), rose (Rosa spp.), savoy cabbage (Brassica oleracea Capitata group), soybeans (Glycine max), strawberry (Fragaria x ananassa), tomato, watermelon (Citrullus lanatus) and wheat (Triticum aestivum).

In contrast, no stimulatory effect of ethanol or methanol was detected in 'Black Seeded Simpson' loose leaf lettuce (Morales-Payan 1997) and methanol rates above 30% were toxic to desert-grown lettuce (McGiffen et al. 1995). In separate experiments, cotton (Mauney and Gerik 1994), melon (Cucumis melo) (Hartz et al. 1994), carrots (Daucus carota), wheat

(Albrecht et al. 1995), sour orange (Citrus aurantium) (Idso et al. 1995) and lemon (Citrus limon) (McGiffen et al. 1995) did not respond to foliar applications of methanol. It is apparent that alcohol rates, environmental conditions, cultivar responsiveness and experimental methodology have played an important role in the results obtained by the researchers reporting the effects of exogenous ethanol and methanol in crops. The objective of this study was to determine the effect of different ethanol rates on the biomass accumulation of 'Camelot' bell pepper.

MATERIALS AND METHODS

Experiments were conducted under greenhouse conditions during spring and summer 1997 at Gainesville, Florida. Young 'Capistrano' bell pepper plants (10 cm tall) were transplanted in 1.5 l plastic containers filled with a potting medium containing 50% vermiculite, 30% perlite and 20% spaghnum peat (v/v). Plants were submersed in solutions containing 0, 5, 10, 15 or 20% ethanol (v/v) for 2 minutes before transplanting. Fertilization, insect and disease control were provided as needed based on current recommendations for bell pepper production (Maynard et al. 1995).

Pepper plant height, leaf area per plant, floral buds per plant, and leaf and stem dry weight were collected 40 days after treatment (DAT). Analysis of variance (ANOVA) was performed at the 5% significance level to test treatment effects. If significant differences were found, standard error bars were used to separate treatment means for each variable studied.

RESULTS AND DISCUSSION

Data collected indicated that ethanol rates significantly influenced pepper plant height, leaf area per plant, floral buds per plant, and leaf and stem dry weight at 40 DAT. Plant height was not affected by an ethanol concentration of 5% as compared to the untreated control (Figure 2). However, as ethanol concentration reached 10%, there was a 32% increase in height. Higher ethanol levels proved to reduce plant height to levels below the control. Leaf area per plant showed highest values (+15%) at the 10% concentration, with no significant differences among other treatments including the control.

Number of floral buds per plant at 40 DAT was increased by 10% ethanol concentrations, no existing significant differences among the untreated control, 5 and 15% ethanol (Figure 3). A 20% treatment seemed to have detrimental effects on floral bud formation, since a 50% decrease was observed. Maximum values for aboveground biomass were measured when 10% ethanol was applied, representing a 45% increase. Leaf and stem dry weight followed the same growth patterns for treatments, with no differences for either variable among the control, 5, 15 and 20% ethanol. No significant differences in the partitioning between leaves and stems was observed, with stems contributing in about 61% to the total dry weight per plant.

From the data collected, it can be interpreted that ethanol has a general effect on plant growth at a concentration of 10%, with overall increase in leaf and stem dry biomass, number of floral buds, leaf area and plant height. As ethanol concentration increased to 15 and 20%, there was a decrease in growth and development by pepper plants. This finding may be explained by the fact that in some instances ethanol could be phytotoxic, diminishing pepper plant height and number of buds per plant at the 20% concentration respecting to the untreated control (-27 and 49%, respectively). It has been suggested that high alcohol concentrations are toxic due to excessive amounts that can overwhelm the enzymatic system that catalizes ethanol and methanol into other non-toxic carbon compounds (McGiffen et al. 1995). Additional research need to be conducted to determine the effect of various ethanol concentrations on different cultivars of bell pepper transplants under field conditions.

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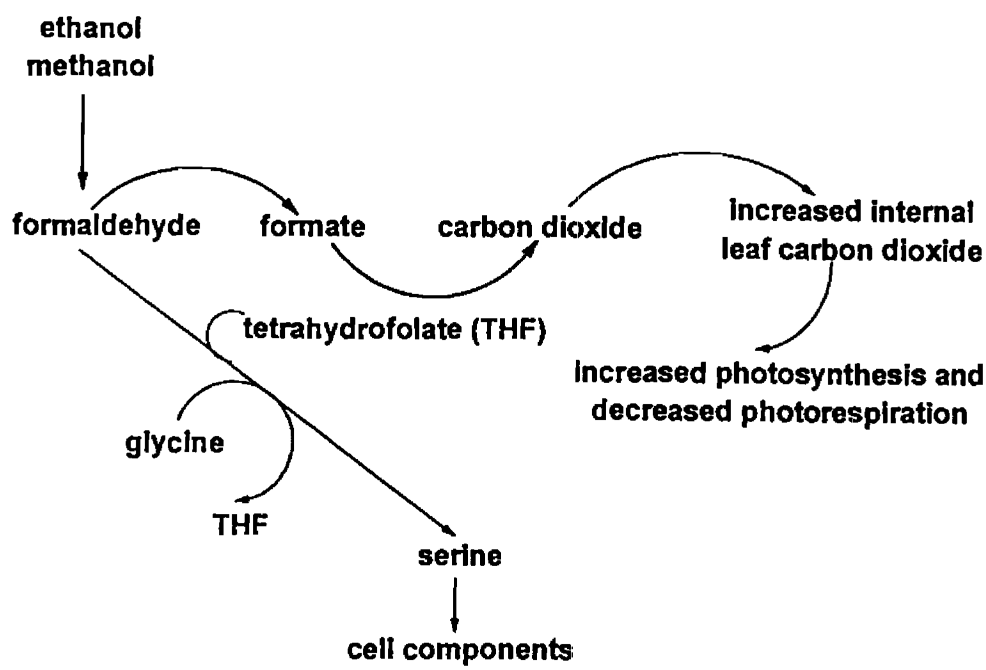

Figure 1. Proposed mechanisms of growth enhancement of methanol-ethanol treated C3 plants (Modified from McGriffen and Manthey, 1996).

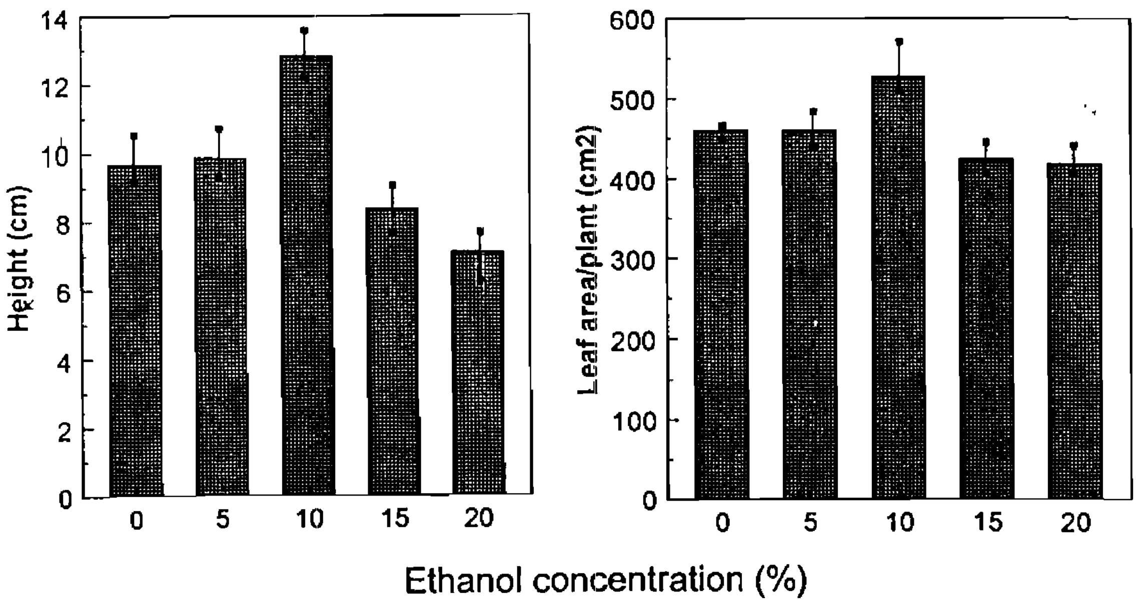

Figure 2. Bell pepper height and leaf area per plant as affected by ethanol concentrations.

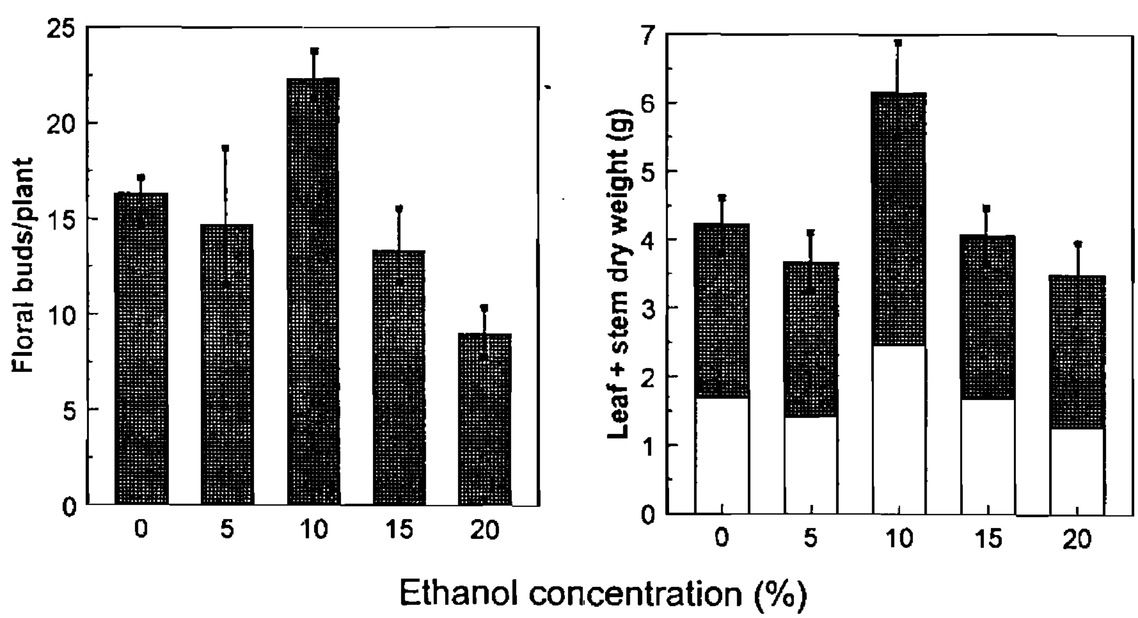

Figure 3. Bell pepper floral bud number per plant and leaf and stem dry weight per plant as affected by ethanol concentrations.