Root-zone Carbon Dioxide Enrichment in Field Does Not Improve Tomato or Cucumber Yield

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Mauney and Hendrix (1988) reported that CO₂-saturated irrigation water increased P, Mn, and Zn uptake and vegetative growth and boll count in cotton. Nakayama and Bucks (1980) found that delivering CO₂-amended water through a drip irrigation system increased wheat yields. Based on these and other reports (D'Orazio, 1990), California and Arizona growers have begun to adopt this technique in the field on a variety of crops. This study was conducted to determine the effects of CO₂-amended irrigation water on tomato and cucumber production.

Field experiments were conducted in Summer 1990, at Riverside and Irvine, Calif. Soil types were Buren fine sandy loam (mixed, thermic Haplic Durixeralf) in Riverside and San Emigdio sandy loam [mixed (calcareous), thermic Typic Xerofluvent] in Irvine. Raised beds on 1.5-m centers were prepared, with single drip irrigation lines buried 15 cm in the center of each bed. Beds at Irvine were mulched with black polyethylene film. 'Dasher II' cucumber (*Cucumis sativus* L.) seed and 'Bingo' tomato (*Lycopersicon esculentum* Mill.) transplants were planted on 1 June (Irvine) or 5 June (Riverside); plant population was 17,000 and 29,000/ha for tomato and cucumber, respectively.

Beginning 3 weeks after planting, bottled

CO₂ was injected continuously into the irrigation stream at either 1.0 g-liter⁻¹ (both sites) or 0.5 g-liter⁻¹ (Irvine only). Carbon dioxide-amended and control (unamended) plots received equivalent amounts of water. Irrigation was delivered three times per week, based on estimated evapotranspirational (ET) demand. Upon achievement of full plant canopy, irrigation frequency was increased to daily application at Riverside, which had higher ET rates. The design was randomized complete block with five (Riverside) or four (Irvine) 8-m replications per crop.

Carbon dioxide amendment acidified the irrigation water, causing a drop in pH of ≈ 2.0 units (from ≈ 7.3 to 5.3) at 1.0 g-liter⁻¹ CO₂. This pH change was transitory in these soils, with soil solution samples drawn 1 day after irrigation showing only marginal pH depression. Conventional tissue testing showed no significant differences among treatments in tissue nutrient concentrations.

At Riverside, CO₂ amendment of irrigation water had no effect ($P = 0.10$) on marketable yield of tomato or cucumber ($75 \pm$

2 and 69 ± 1 kg/plot, respectively); at Irvine, yields of tomato and cucumber decreased linearly with increasing level of CO₂ injection (Table 1). The detrimental effect of CO₂ treatment at Irvine may have been related to the use of plastic mulch. Mulch increases CO₂ concentration in the soil atmosphere; further addition of CO₂ through water injection may have resulted in supra-optimal concentrations that appear to have been detrimental to yield. At Irvine, irrigation was less frequent but of longer duration, so the length of time in which soil atmosphere CO₂ was elevated and the maximum soil CO₂ concentration associated with each irrigation may have been more extreme. The higher overall productivity of the Irvine site is consistent with well-documented beneficial effects of plastic mulch on these crops.

The results of these field studies are in contrast to earlier reports on other crops suggesting beneficial results from this treatment. However, other research has demonstrated that plant response to root-zone CO₂ enrichment is strongly influenced by environmental factors (Baron and Gorski, 1986). Species also respond differently (Nakayama and Bucks, 1980; Stolwijk and Thimann, 1957). Clearly, a better understanding of the mechanisms of action and the influence of other environmental factors is required before root-zone enrichment can be advocated as a commercial production practice.

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Table 1. Effects of root-zone CO₂ enrichment on tomato and cucumber yield at Irvine, Calif.

CO ₂ (g-liter ⁻¹)	Marketable yield (kg/plot)	
	Tomato	Cucumber
0	93.9	84.1
0.5	88.8	80.0
1.0	83.1	76.5
Linear significance (P)	0.06	0.04

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