chemical signals (Cahill et al., 1986; Davies and Flore, 1986b; Jackson and Hall, 1987; Sojka and Stolzy, 1980).

Reductions in A and g_s appeared to occur simultaneously in previous studies with avocado and phytophthora root rot in our laboratories (Ploetz and Schaffer, 1987, 1988; Schaffer and Ploetz, 1987), although the relationship between these two variables was not investigated. Davies and Flore (1986a, 1986b) found that reductions in residual conductance of blueberries subsequent to flooding resulted in increased Ci. Farquhar and Sharkey (1982) suggest that Ci and g_s should decrease together if g_s were limiting A. In contrast, an increase in Ci as g_s decreased would suggest that decreased A is causing decreased g_s. Therefore, determinations of Ci for flooded and nonflooded avocados with root rot could indicate whether reduced g_s or A is the earlier host response to flooding and root rot.

In the present study, g_s was always <100 $mmol \cdot s^{-1} \cdot m^{-2}$ under flooded conditions when root necrosis was $\geq 30\%$ (Fig. 4). Since A and g_s were positively correlated at g_s values <100 $mmol \cdot s^{-1} \cdot m^{-2}$ under flooded and nonflooded conditions, it is possible that g_s is limiting A in avocados with phytophthora root rot (Fig. 4). However, because Ci increased under these conditions (data not shown), a reduced photosynthetic capacity of plants with root rot may instead cause a reduction in g_s. If g_s were limiting A, a reduction instead of an increase in Ci would be expected, since there would be increased resistance to CO_2 entering the leaf (Farquhar and Sharkey, 1982). Davies and Flore (1986a, 1986b) reported reductions in A and g_s and a reduction in Ci within 24 hr after blueberry plants were flooded, thereby supporting their hypothesis that g_s limits A in blueberries under these conditions. However, they observed a subsequent decrease in residual conductance that resulted in increased Ci a few days after flooding. In our study, gas exchange was not determined until 1 week after flooding was imposed, and residual conductance was not determined. Therefore, it is possible that sequential observations of flooded avocado plants may detect an initial decrease followed by an increase in Ci due to root rot. Additional research is needed to determine the relationships among A, g_s, and Ci for flooded and nonflooded avocado plants infected with *P. cinnamomi*.

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HORTSCIENCE 24(4):655–657. 1989.

Screening with Ethephon for Abscission Resistance of Flower Buds in Bell Pepper

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Additional index words. *Capsicum annuum*, stress-induced ethylene, cultivar differences

Abstract. **Under conditions of environmental stress, many pepper (*Capsicum annuum* L.) cultivars lose flower buds, probably due to production of the abscission-causing hormone ethylene. Field applications of the ethylene-generating chemical ethephon (0 to 300 $\mu l \cdot liter^{-1}$) were made to five cultivars of bell pepper growing under nonstressed conditions, but differing in resistance to stress-induced bud abscission. Cultivars were seeded at several times in 1985 to synchronize stages of plant development and allow a single simultaneous spray application to all plots. In the two 1986 experiments, all cultivars were sown on the same date and either two or three sprays were applied to all plots to more closely approximate screening conditions used by plant breeders. One week after application of ethephon at 300 $\mu l \cdot liter^{-1}$, virtually no flower buds remained on any cultivar in either year. Susceptible cultivars exhibited significantly greater abscission than resistant ones at ethephon concentrations of 75 to 200 $\mu l \cdot liter^{-1}$. The use of ethephon shows promise as a simple screening method for resistance to stress-induced flower bud abscission in pepper. Chemical name used: 2-chloroethyl phosphonic acid (ethephon).**

A wide variety of conditions may induce floral abscission in bell pepper, with high temperature being most frequently implicated (1, 5, 7). Cochran (1) found that drought also increased floral abscission, particularly at high temperatures (27/21C day/night vs. 21/16). Irradiance that is either too low (7) or too high (6), and low N status (1), may also favor abscission. Hernandez-Armenta (2) found that bud abscission contributed more to fruit set reduction in peppers than did flower or fruit abscission, and that there were significant cultivar differences in bud abscission.

Received for publication 7 Dec. 1987. Veg. Crops Paper no. 858. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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Table 1. Mean percent abscission combined over branching levels 1 and 2 for five cultivars of pepper sprayed once with four concentrations of ethephon in 1985.

		Abscission (%)[z]			
		Ethephon ($\mu l \cdot liter^{-1}$)[y]			
Experiment	Cultivar	0[y]	100	200	300
1	Shamrock	7 a	85 d	98 c	98 b
	Big Bertha	2 a	82 d	97 c	100 b
	Lady Bell	4 a	42 c	83 b	83 a
	Canape	0 a	28 b	79 b	95 b
	Ace	0 a	14 a	58 a	82 a
	Significance	NS	**	**	*
		0	75	150	300
2	Shamrock	3 a	50 c	95 d	100 b
	Big Bertha	5 a	34 b	74 c	100 b
	Lady Bell	2 a	17 a	51 b	87 a
	Canape	13 a	20 a	53 b	83 a
	Ace	2 a	19 a	47 a	89 a
	Significance	NS	**	**	*

[z]Effects of ethephon concentration, cultivar, and their interaction were all significant at $P = 0.01$ as determined by two-way analysis of variance.
[y]Means within columns and experiments followed by different letters are significantly different at $P = 0.05$ as determined by protected LSD values of the arcsine-transformed data. Protected LSD values were determined for the arcsine-transformed data as the data were percentages. For clarity, letter rankings within columns are presented instead of the LSD values for the arcsine-transformed data.
[NS,*,**]Difference between cultivars within treatments nonsignificant or significant at $P = 0.05$ or 0.01, respectively.

Table 2. Mean percent abscission combined over branching levels 1 and 2 for five cultivars of pepper sprayed repeatedly with four concentrations of ethephon in 1986.

		Abscission (%)[z]			
		Ethephon ($\mu l \cdot liter^{-1}$)[y]			
Experiment	Cultivar	0	100	200	300
3	Shamrock	1 a	84 d	99 a	99 a
	Big Bertha	1 a	89 d	98 a	97 a
	Lady Bell	0 a	71 c	100 a	100 a
	Canape	2 a	51 b	99 a	98 a
	Ace	2 a	23 a	96 a	99 a
	Significance	NS	**	NS	NS
		0	100	200	300
4	Shamrock	13 a	73 b	98 c	95 a
	Big Bertha	1 a	62 b	86 bc	97 a
	Lady Bell	1 a	54 b	83 b	98 a
	Canape	8 a	50 a	68 a	98 a
	Ace	2 a	24 a	67 a	94 a
	Significance	NS	**	**	NS

[z]Effects of ethephon concentration, cultivar, and their interaction were all significant at $P = 0.01$ as determined by two-way analysis of variance.
[y]Means within columns and experiments followed by different letters are significantly different at $P = 0.05$ as determined by protected LSD values of the arcsine-transformed data. Protected LSD values were determined for the arcsine-transformed data as the data were percentages. For clarity, letter rankings within columns are presented instead of the LSD values for the arcsine-transformed data.
[NS,*,**]Difference between cultivars within treatments nonsignificant or significant at $P = 0.05$ or 0.01, respectively.

Screening for cultivar differences in resistance to stress often involves direct imposition of the stress, e.g., heat (2, 4, 10). Because reliable high-temperature field screening in a temperate environment is difficult and/or costly, a less expensive method is needed. Since many abscission responses are mediated by ethylene (e.g., ref. 8), an ethylene-generating agent might simulate the effect of stress-generated ethylene. Such a technique was used by Wien and Roesingh (12) to identify thrips-resistant cowpea cultivars; thrips infestation resulted in ethylene evolution and flower bud abscission in thrips-susceptible cultivars. The present work was designed to determine if ethephon application could differentiate among pepper cultivars as to susceptibility to stress-induced abscission.

Four field experiments were conducted at the H.C. Thompson Vegetable Research Farm at Freeville, N.Y., two each in the summers of 1985 and 1986. Cultural practices were consistent among all experiments in both years. Five cultivars of bell pepper were studied whose relative earliness and susceptibility to heat-induced abscission are known (2). The cultivars were 'Ace' and 'Canape' (early and resistant), 'Lady Bell' (midseason and moderately resistant), and 'Shamrock' and 'Big Bertha' (late and susceptible).

Transplants were raised in a greenhouse in 5 × 5-cm (cell size) styrofoam trays containing a peat–vermiculite soilless mix. All plants within an experiment were transplanted on the same day 6 or 7 weeks after seeding. Spacing was 30 × 30 cm offset in double rows on 152-cm centers on black plastic mulch over a Howard gravelly loam soil (loamy-skeletal, mixed mesic Glossoboric Hapludalf). Plots consisting of 16 plants were arranged in a randomized complete block design of four replications with treatments in factorial combinations. Treatments consisted of five cultivars and four ethephon concentrations (0, 100, 200, or 300 $\mu l \cdot liter^{-1}$ for all experiments except Expt. 2, for which 0, 75, 150, and 300 $\mu l \cdot liter^{-1}$ were used to determine a minimum effective ethephon concentration). Ethephon solutions were made up with tap water (pH 7.1–7.4) and 0.1% liquid detergent as surfactant, and sprayed to run-off with a handheld sprayer. Maximum air temperatures during and 2 days after time of ethephon application in the experiments averaged between 21 and 27C in 1985 and 1986.

In bell pepper, the diameter of the oldest flower buds must be >5 mm before they can be induced to abscise by stress (11). In Expts. 1 and 2, cultivars were seeded at intervals to synchronize stages of plant development and allow a single simultaneous spray application to all plots. 'Shamrock' and 'Big Bertha' were sown first, followed about 2 days later by 'Lady Bell' and 7 days later by 'Ace' and 'Canape'. In Expts. 3 and 4, to simulate the screening for abscission resistance of a pepper population of varying flowering date, the five cultivars were sown on one date and sprayed two or three times. The first ethephon spray was applied to all plots when the earliest cultivars had first bud diameters of 5 mm, followed by a second spray 5 to 6 days later, when the late cultivars reached the same stage of development. Rain fell within 2 hr of the second spray in Expt. 4, necessitating a repeat application the following day.

The main stem of most bell peppers terminates in one or more flowers. Normally, two or three branches arise at this node and again terminate in a flower at their first node, a pattern which is repeated up the plant. Abscission of a bud or flower leaves a distinct scar that can be counted. The combined percentage of bud abscission for the lowest two branching levels was calculated according to the following formula: Percent bud abscission = no. of scars at branching levels 1 and 2/no. of scars and buds at branching levels 1 and 2 × 100. These data were obtained on 12 plants per plot, 1 week after the treatments had been applied. Plants were uprooted to facilitate counting. Analysis of variance on arcsine transformations of percent bud abscission data was performed, least significant differences between cultivars and ethephon concentrations were also calculated.

Under the good growing conditions of these experiments very little abscission occurred in the control plants and differences between cultivars were not significant (Tables 1 and 2). In Expts. 1 and 2, a single spray of 75 to 300 μl·liter^{-1} produced marked increases in bud abscission, with 300 μl·liter^{-1} causing virtually complete bud loss. Differences among cultivars were particularly marked at the intermediate ethephon concentrations of 75 and 100 μl·liter^{-1}. 'Shamrock' and 'Big Bertha' were more subject to bud abscission at the intermediate ethephon concentrations than 'Ace'. 'Lady Bell' and 'Canape' showed an intermediate response. The cultivar differences in ethephon-caused abscission were very similar to those caused by heat stress in the experiments of Hernandez-Armenta (2); however, he rated 'Canape' resistant to heat-induced bud loss, at variance with the present result. The reason for this response difference is unclear, but indicates that a comparison of heat stress and ethephon treatment is needed for a larger number of cultivars.

Spraying pepper seedlings two or three times with ethephon at 200 μl·liter^{-1} appeared to increase abscission and decreased cultivar differences, compared to single sprays (compare Tables 1 and 2). However, note that experiments were performed in separate years. Repeated applications of 100 μl·liter^{-1} gave comparable results to those obtained in Expts. 1 and 2. Use of foliar sprays of ethephon at 75 to 100 μl·liter^{-1} to determine the susceptibility of pepper cultivars to stress-induced flower bud abscission therefore appears feasible. If populations varying in flowering date are to be screened, the entire population may be sprayed more than once to ensure that all individuals are treated when susceptible.

The apparent relationship between cultivar sensitivity to heat stress (as indicated by percent flower bud abscission) and ethephon applied under nonstressed conditions implies that stress abscission in pepper is mediated by ethylene. The results obtained indicate that when ethephon at 100 μl·liter^{-1} is applied to the foliage, stress-susceptible cultivars show more abscission than stress-resistant lines. Whether the cultivar difference in ethephon response is due to differences in the amount of ethylene generated in the plant from the ethephon applied or to genetic differences in the sensitivity to ethylene, or both, is unknown.

Cultivar differences in ethephon response have been demonstrated previously. In pepper, Singh and Murty (9) showed that two pepper cultivars differed in petiole abscission in response to ethephon. Wien and Roesingh (12) reported marked differences between cowpea cultivars in flower bud abscission following treatment with ethephon foliar sprays. Instances of cultivar differences in ethylene production were described by Kettring and Melouk (3) for peanut cultivars in response to *Cercospora* infection.

Screening for genetic differences in susceptibility to field stresses that result in loss of flower buds thus appears possible by using low concentrations of ethephon. Ethephon screening would be easier and much less expensive than trying to duplicate a stressful environment for large numbers of plants.

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HortScience 24(4):657–658. 1989.

Relative Aluminum Tolerance of *Prunus* Rootstocks

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Additional index words. Nemaguard, Lovell, Nemared, *Prunus cerasifera, Prunus tomentosa, Prunus insititia, Prunus besseyi*

Abstract. **A sand culture system was used to compare growth reduction in *Prunus* rootstocks due to high Al concentration. Aluminum at 50 mg·liter^{-1} nutrient solution resulted in Al tissue levels of 288 to 408 mg·kg^{-1}, shoot growth reduction of 41% to 77%, and root growth reduction of 9% to 86%. Based on relative growth reduction, *Prunus tomentosa* Thunb. was more sensitive to Al toxicity than were Nemaguard, Nemared, 'Lovell' [*P. persica* (L.) Batsch], *P. besseyi* Bailey, *P. cerasifera* Ehrh., and *P. insititia* L. Nemaguard and *P. tomentosa* had higher shoot Al concentration at 50 mg Al/liter than the other rootstocks tested.**

The introduction of low-chill peach cultivars has created an opportunity for increasing peach production in the tropics (Sherman et al., 1977). Many tropical soils are acidic and unsuitable for peach production, unless modified. In the southeastern United States, soil acidity is one of the factors contributing to short peach tree life and depressed yields and growth (Cummings, 1983; Gallager et al., 1975; Jones and Jones, 1974; Weaver et al., 1976). At soil pH 5.0 and below, where Al becomes more soluble (Manrique, 1986), Al toxicity is a factor contributing to poor crop performance.

Edwards et al. (1976) demonstrated in sand culture studies the syndrome of Al toxicity. Commonly, lime is applied to raise soil pH. Surface application of soil amendments affects the A-horizon rapidly, but affects the subsoil slowly. Use of tolerant rootstocks would be a cheaper and permanent solution to Al toxicity. Rom (1983) reported an acid tolerant *Prunus* spp. in Yugoslavia. The objective of this study was to determine the relative tolerance to Al toxicity of seven *Prunus* rootstocks.

Uniform seedlings were established in 15-cm plastic pots (1.4 liters) with acid-washed sand by watering every other day with 500 ml of 0.75 strength Hoagland solution (Hoagland and Arnon, 1950). After a 3-week

Received for publication 5 July 1988. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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