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 stress abscission in pepper is mediated by ethylene. The results obtained indicate that stress abscission in pepper is mediated by ethylene. The results obtained indicate that stress abscission in pepper is mediated by ethylene. Wien and Roe-


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 level 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⁻¹ 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

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Table 1. Aluminum concentrations in the shoot and dry weights in the shoots and roots of seven *Prunus* rootstocks grown in sand culture at the indicated Al concentrations.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Al concn (mg·kg⁻¹)</th>
<th>Shoot g/plant</th>
<th>Dry wt</th>
<th>Root g/plant</th>
<th>Dry wt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. besseyi</em></td>
<td>288 b</td>
<td>2.01</td>
<td>59 a</td>
<td>28 b</td>
<td>0.68</td>
</tr>
<tr>
<td><em>P. cerasifera</em></td>
<td>306 b</td>
<td>2.18</td>
<td>57 a</td>
<td>42 a</td>
<td>1.09</td>
</tr>
<tr>
<td><em>P. insititia</em></td>
<td>292 b</td>
<td>1.14</td>
<td>53 a</td>
<td>31 b</td>
<td>0.42</td>
</tr>
<tr>
<td><em>P. persica</em></td>
<td>292 b</td>
<td>2.24</td>
<td>50 a</td>
<td>29 b</td>
<td>1.01</td>
</tr>
<tr>
<td>Nemaguard</td>
<td>306 b</td>
<td>2.82</td>
<td>51 a</td>
<td>46 a</td>
<td>2.00</td>
</tr>
<tr>
<td><em>P. persica</em></td>
<td>408 a</td>
<td>3.02</td>
<td>49 a</td>
<td>44 a</td>
<td>2.04</td>
</tr>
<tr>
<td><em>P. tomentosa</em></td>
<td>408 a</td>
<td>1.50</td>
<td>23 b</td>
<td>14 c</td>
<td>0.53</td>
</tr>
</tbody>
</table>

*Analysis of variance done on arcsine transformation of percentages followed by Duncan’s multiple range test, P = 0.05.

*Means of six observations.

*Roots died.

establishment period, seedlings of *P. tomentosa* Thunb., *P. besseyi* Bailey, *P. cerasifera* Ehrh., *P. insititia* L. and three peach rootstocks (*Nemaguard*, *Nemared*, and ‘Lovell’) were treated with nominal Al levels of 0, 50, and 100 mg·liter⁻¹ by adding Al₂(SO₄)₃·17H₂O to the nutrient solution. Hoagland solution was maintained at pH 4.5 by adding HCl or NaOH. Plants were irrigated daily with 500 ml of nutrient solution. This was sufficient to leach and minimize nutrient accumulation in the sand. The mean daily minimum and maximum air temperatures were 20 and 25°C, respectively, and the mean relative humidity was 79%. A completely randomized design was used with six replications of one plant per treatment. Plants were harvested after a 42-day treatment period. Shoots and roots were dried and weighed. The Al concentration of shoots at 50 mg·liter⁻¹ was determined.

Typical Al toxicity symptoms (Edwards et al., 1976) appeared within 21 days in plants at the 100 mg Al/liter treatment. The shoot Al concentration (Table 1) was higher than the 53 to 205 mg·kg⁻¹ range reported for leaves, twigs, and roots of peach trees in the field by Weaver et al. (1976), Gallager et al. (1975), and Jones and Jones (1974), and corresponds to the levels obtained by Edwards et al. (1976). The average relative shoot dry weight compared to the control was 46% at Al levels of 50 mg·liter⁻¹ and 33% at the 100 mg·liter⁻¹ level. Relative root dry weight was lower than that of the shoot. *P. tomentosa* is very sensitive to the AI treatments, as shown by lower relative dry weight accumulation and its high shoot Al concentration. Of the other six rootstocks tested, *P. besseyi*, although it was not different from the others in relative shoot dry weight, showed less intense visual symptoms and greater relative root dry weight than the other rootstocks at 50 mg·liter⁻¹, but not at 100 mg·liter⁻¹. The relative shoot and root masses of the peach rootstocks (*Nemared*, ‘Lovell’, and *Nemaguard*) are similar at 50 mg Al/liter; however, *Nemared* grew less than *Nemaguard* and ‘Lovell’ at 100 mg·liter⁻¹. We cannot explain the high level of Al in *Nemaguard* shoots, although it may indicate a higher tolerance to Al in the tissue, just as in cranberry (*Vaccinium macrocarpon*) (Madappa and Dana, 1970). This elevated concentration of Al in the shoot tissue of *P. tomentosa* severely reduced growth.

The effects of Al have been investigated in a wide range of plant species. Large differences between species have been categorized by Thornton et al. (1986) into three broad classes: 1) sensitive (injured at <7 mg·liter⁻¹), 2) intermediate sensitivity (injured between 13 and 27 mg·liter⁻¹), and 3) insensitive plants (not affected by >80 mg·liter⁻¹). Our results confirm the intermediate category. This study demonstrated differences between *Prunus* spp. in their sensitivity to Al toxicity, but did not demonstrate that there are *Prunus* rootstocks more tolerant to Al toxicity than the three commonly used peach rootstocks (*Nemaguard*, *Nemared*, and ‘Lovell’). There is one report of an acid-tolerant *Prunus* rootstock, but it is unconfirmed (Rom, 1983). A search for tolerance should begin among naturally occurring peaches that are traditionally used as peach rootstocks. Additional criteria for tolerance should begin among naturalized peaches in the tropics and subtropics. Fruit Var. J. 37:3-14.

