Tolerance of *Prunus* Rootstock to Potassium Carbonate-induced Chlorosis

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Abstract. A standardized screening procedure for tolerance to bicarbonate-induced Fe chlorosis using a commercial fertilizer mix (Plantex) as the nutrient source, high solution pH (8.5) and 1.5 mM bicarbonate to simulate a calcareous soil situation was used with a 1 vermiculite :1 perlite (v/v) support media, small pots and topping (pinching back the tops of shoots). The tolerance level of peach [*Prunus persica* (L.) Batsch] rootstock could be assessed by leaf visual-chlorosis ratings and Spad-502 chlorophyll readings instead of extractable leaf-chlorophyll concentration or plant Fe concentration. Although most of the tolerant genotypes had almond [*P. amygdalus* (Mill.) D.A. Webb] in their parentage, a few peaches ('Swat', NJ672281007) showed high to moderate levels of tolerance.

Iron chlorosis is a problem in calcareous soils throughout the world in commercial stone fruit production areas (Byrne et al., 1990). Peaches grown in these soils develop lime-induced Fe chlorosis in young leaves due to Fe deficiency (Egilla and Byrne, 1989; Wallace and Lunt, 1960). Although the application of Fe chelates can alleviate this problem, this approach is expensive. An alternative approach is the use tolerant rootstock. Peach rootstock demonstrate a range of tolerance to calcareous soil (Byrne, 1988; Egilla and Byrne, 1989). Unfortunately, the literature is full of conflicting reports concerning their relative tolerance (Rem. 1983; Layne, 1987).

Bicarbonate has been implicated as the major causal factor in the development of Fe chlorosis in both calcareous soils and solution culture systems (Chancy et al., 1989). Consequently, bicarbonate has been used in solution culture systems to mimic the effects of calcareous soils. In soybeans, the tolerance in bicarbonate-induced chlorosis is well correlated to tolerance to chlorosis in calcareous soils (Coulombe et al., 1984; Dragonuk et al., 1989). Preliminary work with peach rootstock has shown that rootstock tolerant and susceptible to lime-induced chlorosis in calcareous soils are easily distinguished in the greenhouse when grown in a perlite-vermiculite pot mix and watered with a high bicarbonate nutrient solution (Byrne et al., 1990).

The objectives of this study were to 1) assess the correlation of leaf visual-chlorosis ratings with Spad-502 chlorophyll readings (with chlorophyll meter made by Minolta Camera Co., Ltd., Japan) and extractable leaf-chlorophyll concentration, and 2) determine the relative tolerance level of 48 *Prunus* accessions to potassium carbonate induced chlorosis.

Materials and Methods

Seedling establishment. Stratified seeds with roots 1 to 2 cm long were planted in the greenhouse in pots (310 cm³) with a medium composed of 1 vermiculite : 1 perlite (v/v). Plantex (Plantco Inc., Canada) nutrient solution prepared with reverse osmosis purified water (0.57 g-liter⁻¹ pH 6.5; 15% N - 1NH₄⁺: 10 NO₃⁻: 2 urea: 15% P₂O₅ and 18% K₂O) (Table 1) was applied twice

a week to the seedlings after leaf emergence and until the plants grew to 10–12 cm (2–3 weeks).

Correlation among evaluation parameters. Ten uniform seedlings from each of green leaf (GA 102, GF305, Nemaguard, P1442378, Gaschina Novembre, Montclar, NJ672281007) and red leaf (152 AIRH2, Higama, Nemared, R26-2, Rubira, Starks Red Leaf, 'Titun' x Nemared, TXR5989-1R, TXR5989-5R and TXR5989-6) rootstocks were selected. The medium was leached with three pot volumes of K₂CO₃-amended nutrient solution. Pots were set in the large pans on fiberglass saturated with K₂CO₃-amended nutrient solution.

Leaf visual chlorosis was rated as follows: 1 = healthy green or healthy red leaves; 2 = green and red leaves with slightly yellow interveinal areas. 3 = leaves with distinct yellowing over most of the leaves but the veins remained green. or red leaves with most parts of leaves light red: 4 = whole leaf yellow except green mid-vein, or pale red interveinal areas with pale-green veins; 5 = whole leaf yellow, or very pale-red interveinal areas with greenish-white veins (Byrne, 1988). When Nemaguard was very chlorotic (leaf visual-chlorosis rating = 5, Spad-502 chlorophyll reading (≤ 10)). 10 newly mature leaves from each seedling were collected and rated for leaf visual-chlorosis, and their chlorophyll content was measured with a Spad-502 chlorophyll meter. Leaf visual-chlorosis rating. Spad-502 chlorophyll reading were averaged over 10 leaves, and the 10-leaf composite sample was used to measure the DMSO (dimethyl sulfoxide) extractable leaf chlorophyll concentration (Hiscox and Israelstam, 1979; Bruinsma, 1963). A correlation analysis was performed by 'Proc Corr' procedure (SAS Institute, 1985).

Rootstock evaluation. A minimum of five uniform seedlings of each of 48 *Prunus* accessions were evaluated with a Nemaguard control in eight separate trials in the greenhouse on top of fiberglass saturated with the K₂CO₃-screening solution as described previously. The seedlings were grown individually in pots. Once they were 10 to 12 cm tall, uniform seedlings were selected. and cut back to 8 cm (Wallace, 1988). Leaf visual-chlorosis ratings and Spad-502 chlorophyll readings were taken when the seedlings had grown an additional 8 cm or when Nemaguard controls were very chlorotic (leaf visual-chlorosis rating (≥ 4 or Spad-502 chlorophyll reading (≤ 10)) which was usually after 1 month. All rootstock were evaluated within a 4-month period (Jan. to Apr., 1990). A completely randomized design was used within a given trial and all the rootstock were compared to the control rootstock, Nemaguard. The number of tests depended on the number of seedlings available from each rootstock.

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Table 1. Nutrient concentrations of normal (pH 6.5) and K₂CO₃-amended Plantex nutrient solution (pH 8.5).

Solution ^c	Element (ppm)											
	P	K	Ca	Mg	Na	Cu	Fe ^e	Mn	Mo	Zn	B	S
pH 6.5	39	102	0.3	0.8	41	0.34	0.59	0.36	0.07	0.35	0.64	0.88
pH 8.5	42	267	0.1	0.8	41	0.35	0.58	0.32	0.08	0.37	0.68	0.98

^aThis solution was prepared by adding Plantex (0.57 g.liter⁻¹) to reverse osmosis-purified water and the pH was raised to 8.5 by adding K₂CO₃ (0.25 g-liter⁻¹).

^bIron chelate used is FeEDTA.

Nutrient and bicarbonate (Nelson, 1982) levels of newly made Plantex (0.57 g-liter⁻¹ Plantex, pH 6.5) and KaCO₃-amended nutrient solutions were analyzed. Potassium, Ca, Mg, Mn, Fe, and Zn were measured with a 3510 ICP spectrophotometer (Advanced Research Lab, Sunyland, Calif.) and N and P were analyzed with a Technicon Autoanalyzer. The experiments were conducted in a greenhouse at Texas A&M Univ. (College Station) with a PAR (photosynthetically active radiation) range of 400 to 1000 mol·m⁻²·s⁻¹, a relative humidity of 80 ± 11% (max. 91% and min. 69%) and day and night temperatures of 26 ± 6C (max. 32C and min. 20C) and 22 ± 2C (max. 24C and min. 20C), respectively. Due to the consistency of results among experiments and their similarity in variances, the data were combined over experiments. An analysis of variance with LSD (*P*= 0.05) was used.

Results and Discussion

Correlation among evaluation parameters. Leaf visual-chlorosis ratings were highly correlated with the Spad-502 chlorophyll reading for both green-and red-leaf peach rootstocks (*r* = -0.97*). Green-leaf rootstock had higher cm-relations between leaf visual-chlorosis rating with extractable leaf-chlorophyll concentration than the red-leaf rootstock (*r* = 0.90* vs. 0.80*). The lower correlations for red leaf rootstock were due to some unexpectedly low chlorophyll levels for Titan x Nemared and TXR5989-1R. When these points were removed, the correlation between leaf visual-chlorosis rating or Spad-502 chlorophyll reading with extractable leaf-chlorophyll concentration was 0.91*. Since the chlorophyll levels were well correlated with leaf-visual chlorosis ratings and Spad-502 chlorophyll readings, either of these may be used to evaluate the degree of chlorosis as reported for other crops (DeCianzio et al., 1979; Marquard and Tipton, 1987; Mckenzie et al., 1984; Rashid et al., 1990).

Relative tolerance to bicarbonate-induced chlorosis of peach rootstock. Leaf visual-chlorosis ratings and Spad-502 chlorophyll readings varied with the rootstock evaluated (Table 2). Leaf visual-chlorosis ratings were inversely related to Spad-502 chlorophyll reading. Nemaguard, the control rootstock, was susceptible to bicarbonate-induced chlorosis (low Spad-502 chlorophyll reading and high leaf visual -chlorosis rating), and most rootstocks were more tolerant than Nemaguard. In future comparisons among the more tolerant rootstock, a moderately tolerant control would be useful.

'Titan' x Nemared and 'Titan' x Nemaguard have been reported to be tolerant to Fe chlorosis in calcareous soils (Byrne, 1988) and in high bicarbonate or low Fe solution culture (Byrne et al., 1990; Romera et al., 1991), which agrees with the current evaluation. Many of the most tolerant accessions in this test are peach-almond hybrid lines (TXR4989-2, 'Titan' x Nemaguard. TXR5989-7R. 'Titan' x Nemared, TXR5989-1R) which obtain their tolerance from their almond parentage (Byrne et al., 1989; Egilla and Byrne, 1989; Kester and Hansen, 1966); however, some rootstocks with almond parentage, such as USSR0137 and TXR4989-1R, did not appear to be tolerant in the current study. Although most peach

Table 2. Means of chlorosis ratings and Spad readings of peach rootstocks evaluated in 1 vermiculite : 1 perlite medium (v/v) using K₂CO₃-amended nutrient solution in the greenhouse.

Rootstock	Mean		No. rests	No. plants
	Chlorosis rating	Spad reading		
TXR4989-2	1.7	34	2	16
Swat	1.8	32	1	9
Titan x Nemared	1.9	31	3	28
TXR5989-7R	1.9	30	2	15
Titan x Nemaguard	2.1	28	2	16
TXR5989-1R	2.1	28	4	18
NJ672281007	2.3	27	2	29
Prisco Veracruz	2.3	27	1	9
Liveoak	2.1	27	1	12
Clarkhill plum	2.3	26	2	36
Montclar	2.5	26	3	15
TXR5989-5R	2.3	25	1	18
TXR4989-1R	2.4	25	2	18
Bolivian Cling	2.5	25	1	8
PI442378	2.5	25	3	26
Rubira	2.4	25	1	30
Starks Red Leaf	2.3	24	2	20
Mexico sdg	2.5	23	3	17
Rutgers Red Leaf	2.4	23	2	17
USSR0137	2.5	23	2	22
Rancho Resistant	2.6	23	2	16
Siberian C	2.7	23	1	9
PI55776	2.7	23	1	10
Indian Cling	2.7	22	1	12
BY520-9	2.8	22	1	8
Agua6-4	2.9	22	1	12
Nemared	2.8	22	2	18
Transvaal Yellow	2.8	22	2	22
J68-271	2.8	21	1	10
TXR4989-4	2.8	21	3	21
TXR1588-1	2.6	21	2	23
TXR5989-6	2.9	21	3	26
Baladi	2.9	20	3	35
Boone County	2.9	20	1	20
NJ62325	3.0	20	2	22
Kakamas	3.1	20	1	10
SCRS-1	3.1	20	3	18
<i>Prunus ferganensis</i>	2.8	20	1	12
Higama	3.0	20	1	11
<i>Prunus davidiana</i>	3.1	20	3	23
T01-13	3.0	19	3	24
S82	3.0	19	2	24
BY82P6212	3.1	18	2	16
TXR4989-3	3.3	18	2	26
Bangalow	3.4	16	2	16
Salcaja	3.5	14	1	12
Nemaguard	3.7	14	8	475
S163	4.4	9	1	5
LSD (5%)	0.5	4.1		

seedlings are susceptible to bicarbonate-induced Fe chlorosis, Montclar and a few other selections have been reported to be moderately susceptible to moderately tolerant (Egilla and Byrne, 1989). Generally, the same results were obtained in this study. However, several peach genotypes (NJ672281007 and 'Swat') showed a moderate to high level of tolerance. It was encouraging that a moderate level of tolerance does exist among peaches. Using peach as a source of tolerance would avoid the disadvantages of using almond, which has poor propagation qualities and is more susceptible than peach to water logging, nematodes and crown gall (Egilla and Byrne, 1989; Layne, 1987; Rom, 1983).

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