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Heavy Soil and Bud Union Crease with Some Grapefruit Clones Limit Use of Swingle Citrumelo Rootstock

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Additional index words. *Citrus paradisi*, stunting, bud union disorder, incompatibility

Abstract. **Ten-year tests in 8 locations in the Lower Rio Grande Valley showed that grapefruit (*Citrus paradisi* Macf.) trees on Swingle citrumelo [*C. paradisi* x *Poncirus trifoliata* (L.) Raf.] rootstock grew very poorly on heavy clay soil; trees on sour orange (*C. aurantium* L.) were much less affected. Trees propagated from a single mother tree of an old-line red grapefruit selection on Swingle citrumelo were stunted and had severe bud union crease, whereas trees propagated from a nucellar California Experiment Station (CES) #3 'Redblush' source were large and productive. Old-clone trees on sour orange also were smaller than CES #3 'Redblush' trees, but showed no bud union crease.**

Swingle citrumelo rootstock, released by the USDA in 1974, is widely accepted in Florida, where it ranks 3rd, behind Carrizo citrange [*C. sinensis* x *P. trifoliata* (L.) Osb.] and sour orange, as rootstock for nursery trees sold (Budwood Registration Bureau, Florida Dept. of Agriculture and Consumer Services, personal communication). It also has been used in other countries (13). In tests since the 1940s, Swingle has been found tolerant of tristeza (10), exocortis and xyloporosis (3, 6, 11), citrus nematode (8), and root rot (2). Old-line grapefruit and orange trees on Swingle (tested under the code number C.P.B. 4475) were standard size and productive in Texas (5, 11, 20), but an old-line 'Valencia' orange clone in Florida was stunted, although productive for its size (6). Nucellar virus-free clones of grapefruit (12, 17, 18, 21) and tangelo (19) on Swingle produced more and larger fruit than did trees on sour orange, and various other commonly used rootstocks.

Eight test plots with trees of virus-free, nucellar 'Redblush' and old-line red grapefruit known to carry exocortis and xyloporosis were planted in 1974 throughout the citrus-growing area in Rio Grande Valley, on soil ranging from heavy clay to light sand. Four of the test plots also contained old-line and nucellar grapefruit on Morton and Savage citrange (*P. trifoliata* x *C. sinensis*) rootstock. Two of the test sites were abandoned, one because of a change in ownership of the land, the other because of poor growth of trees on Swingle on heavy, clay soil.

In Aug. 1978, when the trees were 6-years-old, 1 composite leaf sample from each scion/rootstock combination in each of the 6 remaining locations was analyzed for N, P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu, Cl, B, Mo, and Pb by standard methods (17). When the trees were 10-years-old, the size of 9 trees of each scion/rootstock combination at each of the 6 locations was determined by measuring trunk circumference, tree height, and the east-west and north-south canopy diameter. The canopy volume (by the formula $v = 0.5236\ d^2n$) and trunk cross sectional area were calculated and analyzed statistically. Horticultural characteristics and the condition of the bud union were determined. The pH, electrical conductivity, and soil texture by the Bouyoucos hydrometer method (1) of soil samples (0–30 cm) from all 8 locations were determined.

Ranking the trees according to size gave similar results when trunk cross-sectional area, canopy volume or height were used as measures of tree size (Table 1). The size differences between locations apparently were due to differences in soil and cultural practices. The largest trees at all locations were nucellar CES #3 'Redblush' on Swingle citrumelo, followed by CES #3 on sour orange and old-line red grapefruit on sour orange. Old-line red grapefruit trees on Swingle were stunted, only 2.0 to 2.5 m tall at 10 years of age (Table 1). In the 4 locations where there were old-line trees on Morton and Savage citrange, they were also dwarfed. All trees on Swingle citrumelo and the citranges had the bench-type rootstock overgrowth

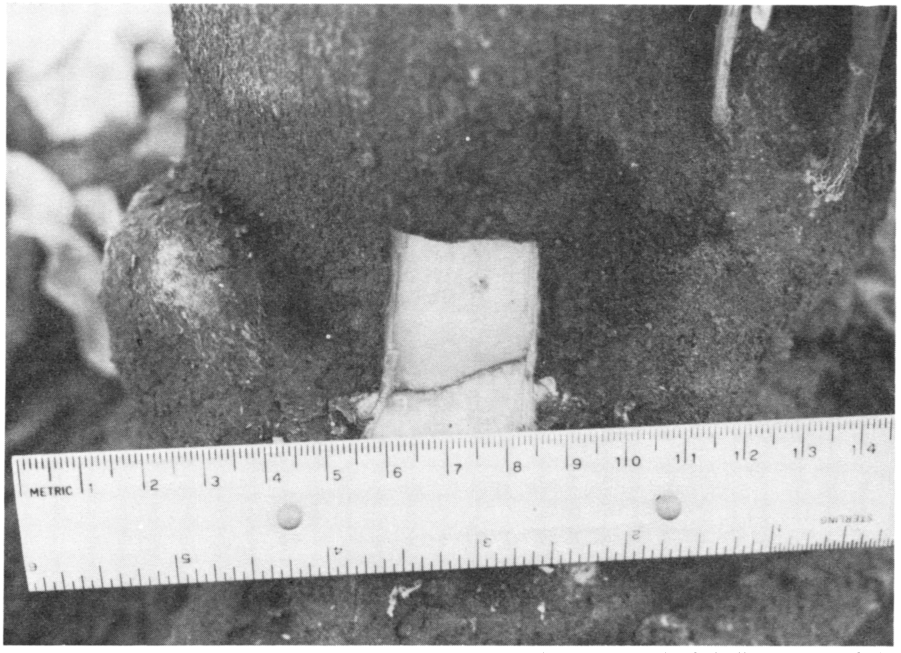

Fig. 1. Window in bark showing bud union crease which encircles tree trunk of old-line red grapefruit on Swingle citrumelo rootstock.

Table 1. Tree size of the 4 scion/rootstock combinations in the test.

Scion/rootstock combination	Trunk cross-sectional area (cm^2)	Canopy volume[x] (m^3)	Tree height (m)
CES #3/Swingle	276.9 a[z,y]	65.3 a	4.34 a
CES #3/Sour Orange	225.6 b	38.3 b	3.69 b
Old line/Sour Orange	179.3 c	32.1 c	3.41 c
Old line/Swingle	95.9 d	10.8 d	2.28 d

[z]Mean separation in columns by Duncan's new multiple range test, 5% level.
[y]Mean of 6 locations, 9 trees each.
[x]Calculated by formula $v = 0.5236\ d^2h$.

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Table 2. Element concentrations in leaves (dry weight) from 9 trees each of CES #3 'Redblush', and old-line red grapefruit on Swingle citrumelo and sour orange rootstocks at 6 locations.

Cultivar	Percentage					Parts per million								
	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	Cl	B	Mo	Pb
Combination														
CES#3/Swingle	2.44 a[z]	0.162 a	1.61 a	4.28 b	0.33 b	732 a	81 a	37 ab	21 a	46 a	1051 ab	186 a	2.0 ab	8.8 a
CES#3/Sour	2.25 bc	0.143 a	1.37 a	4.56 a	0.37 a	871 a	193 a	41 a	16 a	36 a	888 ab	183 a	2.3 a	9.2 a
Old-line/Swingle	2.38 ab	0.163 a	1.52 a	3.94 c	0.28 c	1034 a	103 a	31 b	14 a	41 a	1284 a	171 a	1.4 b	7.5 b
Old-line/Sour	2.11 c	0.144 a	1.37 a	4.75 a	0.34 ab	841 a	84 a	40 a	11 a	38 a	803 b	148 a	2.2 a	9.5 a
Rootstock														
Swingle	2.41 a	0.162 a	1.57 a	4.11 b	0.30 b	882 a	92 a	34 b	18 a	44 a	1167 a	178 a	1.7 b	8.2 b
Sour	2.18 b	0.143 b	1.37 b	4.66 c	0.35 a	856 a	138 a	40 a	14 a	37 a	845 b	166 a	2.3 a	9.3 a
Scion														
CES#3	2.34 a	0.152 a	1.49 a	4.43 a	0.35 a	801 a	137 a	39 a	19 a	41 a	969 a	185 a	2.1 a	9.0 a
Old-line	2.24 a	0.153 a	1.44 a	4.35 a	0.31 b	937 a	93 a	35 a	13 a	40 a	1043 a	159 a	1.8 a	8.5 a

[z]Mean separation within rootstock by Duncan's multiple range test, 5% level.

characteristic for trifoliate orange and its hybrids. Bud unions of old-line red grapefruit on Swingle, Morton, and Savage had a distinct bud union crease encircling the trunk (Fig. 1). Longitudinal sections (Fig. 2) showed separations of the stocks and scions extending as much as 1.0 cm into the trunk, with a definite line of demarcation across the bud union. The unions were not structurally weak, however, because the scions did not break off easily at the union.

The bud union crease had relatively little effect on leaf element levels (Table 2): only the Ca, Mg, and Pb levels were reduced in old-line trees on Swingle. Trees on Swingle citrumelo had higher leaf levels of N, P, K, and Cl and lower concentrations of Ca, Mg, Mn, Mo, and Pb than trees on sour orange. Comparing the 2 scions, the only differences in nutrient element concentrations in the leaves were slightly increased Mg levels in CES #3 'Redblush'. The stunting of old-line red grapefruit on Swingle apparently was not caused by restriction of mineral element translocation.

The bud union crease was similar to the effects of citrange stunt virus (9, 14, 16). The trunk wood above and below the bud union did not show any abnormalities; rootstock sprouts, however, showed indentations and yellow pockets in the wood similar to xyloporosis, not leaf mottling and distortion associated with citrange stunt (9, 16). The disorder is limited only to certain old-line clones; no bud union crease or stunting occurred when other exocortis and xyloporosis-carrying old-line clones were grown on Swingle rootstock (4, 5, 6, 7, 11). The early decline and stunting of trees on Swingle citrumelo at location 8, which caused abandonment of the test plot, seems to have been caused by a clay content of the soil twice that of other plots (Table 3). Salinity at location 8 also was increased. Trees on Swingle citrumelo on similar soil in South Texas (15) and Mexico (Juan Ramirez, personal communication) also failed to grow. With increasing use of Swingle citrumelo rootstock in many areas, more of its limitations will become known. At this, time heavy soils and a yet undetermined virus are its only observed weaknesses.

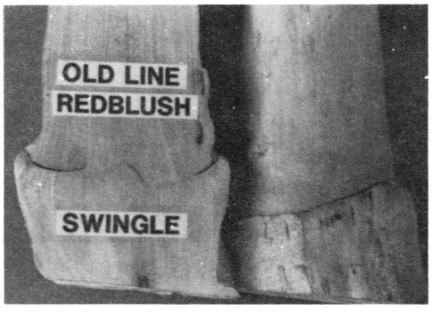

Fig. 2. Longitudinal section of bud union of old-line red grapefruit on Swingle citrumelo rootstock (left); and bud union crease on trunk with bark removed (right).

Table 3. Soil characteristics of the surface 30 cm at all 8 locations.

Location[z]	pH	EC (mmho/cm)	Sand (%)	Silt (%)	Clay (%)
1	7.3	1.20	75	11	14
2	8.1	1.73	73	14	13
3	7.9	1.50	68	18	14
4	7.5	1.40	62	16	22
5	7.9	1.40	72	9	19
6	7.3	0.90	71	8	21
7	7.8	1.55	74	12	14
8	7.4	2.15	46	12	42

[z]Locations 7 and 8 were not used in data analysis due to missing trees.

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Embryo Growth and Germination of American Ginseng Seed in Response to Stratification Temperatures

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Additional index words. gibberellic acid, seed germination, embryo dormancy

Abstract. **Embryos of American ginseng (*Panax quinquifolius* L.) seeds stratified 570 days at 0° or 5°C did not increase in size, whereas embryos of seeds stratified 570 days at 20° grew to a length of 2.5 mm. Embryos of seeds stratified at 5° for 120 days, treated with 1000 ppm gibberellic acid (GA), then transferred to 20° grew to the same length as those held at a constant 20°. None of the GA treated seeds germinated. However, seeds stratified outdoors and those provided 5° for 120 days, 20° for 300 days, and then held at 5°C germinated after 540 days. The embryos of these latter treatments had similar growth patterns. Growth of the cotyledons paralleled the growth of the entire embryo. Cool-warm-cool stratification patterns are necessary for efficacious germination of American ginseng seeds.**

Ginseng has been cultivated in the United States only since the 1890s. Since its discovery in 1716, persistent harvesting of wild populations has reduced severely native stands in North America. To supply oriental markets, increasing amounts of ginseng have been cultivated in the United States. This production has stimulated a need for information on all aspects of ginseng culture. Seeding is the principal method of propagating ginseng. Commonly, seeds are stratified outdoors in moist sand for 12 to 14 months, removed from stratification, and planted into ground beds in the fall; germination occurs the following spring, 18 to 20 months after fruit ripening (7).

Early studies of ginseng propagation by seeds were conducted on the true or Chinese ginseng, *Panax ginseng* C.A. Mey., and were reported by Japanese and Russian researchers. Baronov (1) cites some of these studies. Information concerning seed propagation of American ginseng is found primarily in popular publications and generally provides an iteration of methods developed by trial and error (2, 3, 4, 5, 9, 10). Most of these authors refer to stratifying seeds to overcome dormancy, but duration and temperature for stratification are not given.

Stoltz and Garland (8) found that the most rapid embryo growth of American ginseng seeds stratified 8 months at constant temperatures of 0°, 5°, 10° or 20°C occurred at 20°. They reported that American ginseng has an immature embryo which is 0.4 to 0.5 mm long at the time the fruit ripens. Lee et al. (6) reported that the optimal stratification temperature for embryo growth before seed dehiscence is 15° and the 5° was needed to break and dormancy of fully grown embryos, 5 to 6 mm in length.

For this study, 5 temperatures, 0°, 5°, 10°, 20°, or 30°C, were chosen to study the effect of constant temperatures on embryo development during stratification. Each of 5 lots of freshly harvested seeds was mixed with about 5 volumes of moist sand in a polyethylene bag and placed in one of the temperature treatments. As a check of normal embryo development, seeds also were buried 4 cm deep outdoors in a shaded location. A separate lot of seeds was held at 5° for 120 days, then split into 2 lots, one of which was treated with 1000 ppm GA for 24 hr and then held at 20° for the remainder of the experiment. The 2nd lot was held at 20° for 420 days, and then placed back into 5° for the remainder of the experiment. At the end of each 30 day period, 5 seeds were taken at random from each treatment. The embryos were dissected out and placed in a film of water on a glass slide to prevent desiccation. The length and width of the radicle, cotyledons, and the entire embryo were measured with a binocular microscope fitted with an ocular micrometer and calibrated with a stage micrometer. The incubator used for the 10° treatment malfunctioned after 270 days of stratification, and the seeds were lost. The seeds placed at 30° had all rotted after 150 days. After 570 days of stratification, 50 seeds of the 0°, 5°, 20°, or 20° treated with 1000 ppm GA treatments were planted in soil in a warm greenhouse.

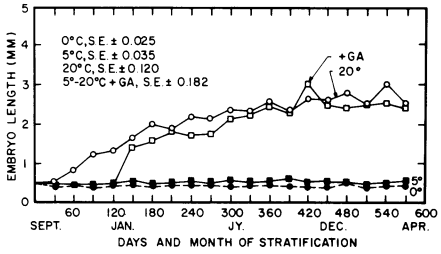

Fig. 1. Average length of embryos of American ginseng seeds stratified at constant 0°, 5°, or 20°C or stratified at 5° for 120 days, treated with 1000 ppm GA and held at 20° for the remainder of the stratification period.

After 570 days stratification, the embryos of seeds stratified at 0° and 5° were not significantly longer than at the start of stratification (Fig. 1). The embryos of seeds stratified at 10° also showed no significant increase in any dimension through 270 days of stratification. Embryos of seeds stratified at 20° grew slowly to a length of 2.5 mm during the first 360 days of stratification and remained at about this size until the end of stratification (Fig. 1). The embryos of seeds held at 5° for 120 days, then treated with 1000 ppm GA and stratified at 20° responded

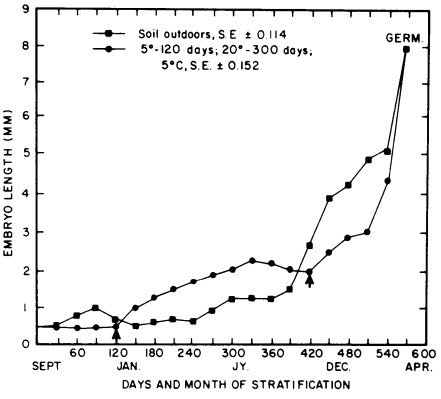

Fig. 2. Average length of the embryos of American ginseng seeds stratified beneath 4 cm of soil outdoors or held at 5°C for 120 days, at 20° for 300 days at 5° for the remainder of the stratification period. Arrows indicate when temperature transfers were made.

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