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EFFECT OF SOIL TEMPERATURE AND FORCING METHOD ON SCION BUDBREAK AND GROWTH OF CITRUS NURSERY TREES

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Abstract. **Two experiments were conducted to determine the effect of soil temperature and forcing method on scion bud break and growth of Swingle citrumelo [*Citrus paradisi* (L.) Raf. × *Poncirus trifoliata* (L.) Osb.] and Cleopatra mandarin [*C. reticulata* Blanco] seedlings budded with 'Hamlin' orange [*C. sinensis* (L.) Osb.]. In experiment 1, budded Swingle (S) and Cleopatra (C) seedlings were grown at two soil temperatures (15 and 25°C) for seven weeks following bud forcing by bending. In experiment 2, scion buds were forced by: (1) cutting off the seedling top; (2) bending the seedling top over; or (3) bending + 6-benzylamino purine (BA) at 500 mg/l and grown at one of two soil temperatures (15 or 25°C). In experiment 1, the higher soil temperature treatment resulted in greater percent scion bud break, shorter period from forcing to bud break, and greater scion growth than the lower soil temperature treatment for S plants, but not for C plants. In experiment 2, cutting off rootstock tops resulted in greater percent bud break than bending at the low soil temperature. At the higher soil temperature, bending + BA resulted in 100% scion budbreak compared to bending which gave 75% budbreak. Forcing by bending + BA resulted in greater scion growth than cutting off rootstock tops.**

Inserted citrus scion buds are inconsistent in percent budbreak and time to budbreak following forcing (Halin et al., 1990; Maxwell and Lyons, 1979; Nauer et al., 1979; Orillos, 1953; Van der Poll, 1991). Possible factors influencing scion budbreak of citrus nursery trees include soil and air temperatures, photoperiod, forcing method and rootstock. Temperature is one of the most important environmental factors affecting callus growth needed for bud union formation following budding (Hartmann et al., 1990). Soil temperature has been shown to affect budbreak of sweet orange, sour orange, mandarin and rough lemon seedlings (Reuther, 1973). However, we know of no reports comparing the effects of soil temperature on scion budbreak of budded citrus nursery trees. Forcing method affects scion budbreak and growth. However, its influence depends on the rootstock and season of budding (prevailing environmental conditions) (Amih, 1980; Nauer and Boswell, 1981; Samson, 1986; Williamson et al., 1991). When cutting off is used to force scion growth, percent scion budbreak is often higher but scion growth is less compared to bending or lopping (Rouse, 1988; Williamson et al., 1992). Increased growth from lopping or bending was partially attributed to current rootstock top photosynthates translocated to the roots and scion (Williamson et al., 1992).

Swingle citrumelo is the most widely propagated citrus rootstock in Florida (Youtsey, personal communication, 1993). Scion budbreak is often low when bending or lopping is used to force scion bud growth on Swingle citrumelo. Therefore cutting off is commonly used with Swingle citrumelo but scion and root growth are probably less than would be achieved from lopping or bending. The objective of this study was to determine the effect of soil temperature and forcing method on budbreak and plant growth of 'Hamlin' orange budded on Swingle citrumelo rootstock.

Materials and Methods

Two experiments were conducted using 'Hamlin' orange budded on Swingle citrumelo and Cleopatra mandarin rootstocks. Swingle and Cleopatra seedlings were budded using the inverted T-bud procedure, wrapped for 3 weeks, and forced by bending the rootstock tops over and tying them in place. In experiment 2, bending and 2 additional forcing treatments were used: (1) cutting off the rootstock tops just above the scion bud; and (2) bending plus 6-benzylamino purine (BA) at 500 mg/l.

Experiment 1. Swingle and Cleopatra seedlings were transplanted to citripots (10.2 × 10.2 × 35.5 cm) containing a peat moss and perlite growing media (2:1 V:V) and grown in a greenhouse. About 4 months after transplanting, all plants were budded. Three weeks later, buds were unwrapped and forced by bending. After forcing, plants were immediately moved to a growth room. Plants were grown for 7 weeks at root temperatures of 15°C or 25°C using computer-controlled chest freezers accurate to ± 1°C. Plants were positioned so that the citripots were in the

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temperature controlled environment and the plant tops were exposed to ambient temperatures (approximately 25°C). One 400 W mercury vapor lamp and four 100 W incandescent lamps were placed above each root chamber. Photosynthetic photon flux was 450 μmol/s/m² at the canopy top, 250 μmol/s/m² at the canopy center and 170 μmol/s/m² at the container surface. Plant and soil temperatures were measured with thermocouples placed on the rootstock stem adjacent to the scion bud, and at 5, 10 and 15 cm soil depths in one pot per temperature chamber. There were 6 temperature chambers (3 for each temperature). A split plot design was used. Soil temperature was the main plot and rootstock was the sub-plot. Eight budded seedlings were used in each sub-plot. The experiment was repeated so that each treatment was replicated 6 times.

Experiment 2. Swingle seedlings were budded with 'Hamlin' orange during fall, 1992. Three weeks after budding, scion buds were unwrapped and forced by bending. Scion buds did not grow and were maintained in a quiescent condition in the greenhouse. Eight weeks after forcing, the plants were moved into the growth room described in experiment 1. Plants were subjected to one of 2 soil temperatures (15°C or 25°C) and one of 3 forcing methods (cutting off, bending or bending + BA). The experimental design was a split-plot with soil temperature as the main plot and forcing method as the sub-plot. Two budded seedlings were used in each sub-plot. The experiment was conducted twice for a total of 6 replications per treatment.

Results

Experiment 1. Soil temperature affected percent scion budbreak differently for Swingle citrumelo and Cleopatra mandarin (Table 1). For Swingle plants, percent budbreak was higher at 25°C than at 15°C. Budbreak for Cleopatra was similar for the 2 soil temperatures. Scion budbreak for both rootstocks occurred sooner for plants grown at the higher soil temperature compared to the lower soil temperature (Fig. 1 and 2). For scion buds that grew during the experiment, more than 50% of the 25°C plants began growing during the first 5 days regardless of rootstock. Less than 20% of the 15°C plants began growth during the same period. Scion length was greater at the higher soil temperature for both rootstocks (Table 1). Scion length did not differ between rootstocks at the 25°C soil temperature. However, at the lower soil temperature, scion length was less for Swingle than for Cleopatra. Scion dry weight followed a trend similar to scion length. Scion dry weights were greater for both rootstocks at the higher soil temperature, and were greater for Cleopatra than for Swingle plants at the lower soil temperature (data not shown). Whole plant dry weight did not differ between soil temperature treatments or rootstocks.

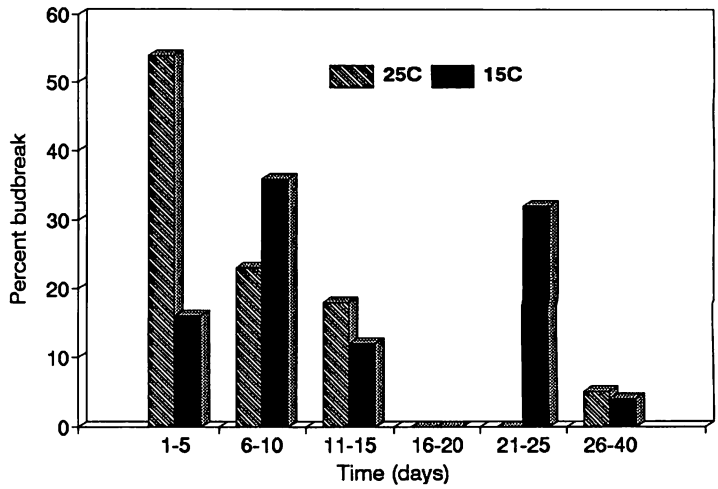

Fig. 1. Percent scion budbreak over time for growing buds of 'Hamlin'/Swingle at two soil temperatures.

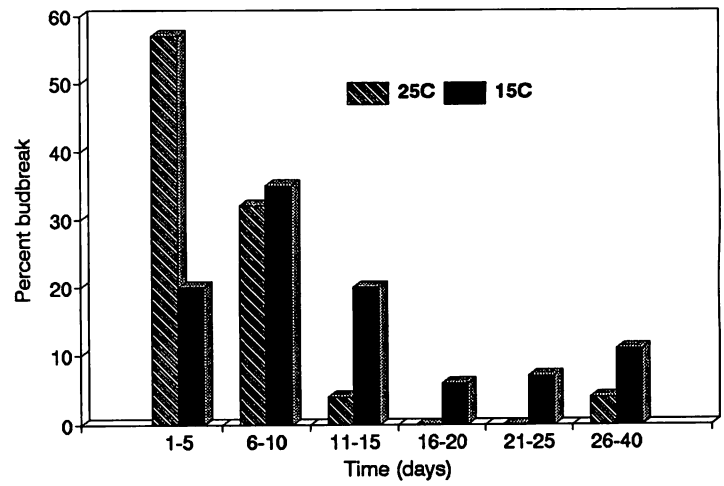

Fig. 2. Percent scion budbreak over time for growing buds of 'Hamlin'/Cleopatra at two soil temperatures.

Table 1. Effect of soil temperature and rootstock on percent budbreak, scion length and plant dry weight of 'Hamlin'/Swingle and 'Hamlin'/Cleopatra nursery plants.

Treatment		Percent of maximum		
Soil temp. (°C)	Rootstock	Budbreak	Scion length	Plant dry wt
15	Swingle	53[z]	55.7	85.6
	Cleopatra	96	74.6	92.3
25	Swingle	94	100	99.0
	Cleopatra	100	99	100
$LSD_{.05}$[y]		12	17.6	10.0
$LSD_{.05}$[x]		8	18.9	18.2

[z]Data analyzed after arc sine transformation.
[y]LSD value for comparing rootstock means at same soil temperature.
[x]LSD value for comparing rootstock means at different soil temperature.

Experiment 2. Forcing method affected percent scion budbreak of Swingle plants differently at the 2 soil temperatures (Table 2). Budbreak of plants forced by cutting was 100% at both soil temperatures. Budbreak for bending was 50% at 15°C and 75% at 25°C. Scion budbreak for bending + BA was 16% at 15°C and 100% at 25°C.

Scion length was greater at the higher soil temperature (Table 2). Bending resulted in greater scion length than cutting off rootstock tops and scion length for bending + BA was greater than for either of the other two forcing methods. Scion dry weight was greater at the higher soil temperature (data not shown). Bending + BA resulted in greater scion dry weight than cutting off (data not shown). Plant dry weight did not differ among forcing treatments, or between soil temperatures (Table 2).

Table 2. Effect of soil temperature and forcing method on budbreak, scion length and plant dry weight of 'Hamlin'/Swingle citrus nursery plants.

Treatment		Percent of maximum		
Soil temp. (°C)	Forcing method	Budbreak	Scion length	Plant dry wt
15	Cutting	100[z]	55.4	93
	Bending	50	73.7	100
	Bending + BA	16	89.8	85
25	Cutting	100	62.9	86
	Bending	75	80.4	87
	Bending + BA	100	100	83
$LSD_{.05}$[y]		24	21.3	26.3
$LSD_{.05}$[x]		22	16.2	17.9

[z]Data analyzed after arc sine transformation.
[y]LSD value for comparing rootstock means at same soil temperature.
[x]LSD value for comparing rootstock means at different soil temperature.

Discussion

Our results suggest that soil temperature is an important factor controlling scion budbreak and growth of citrus nursery trees following bud forcing. Similar results for greater budbreak with increasing soil temperatures have been reported for navel orange budded on trifoliate orange rootstock (Khairi and Hall, 1976) and trifoliate orange seedlings (Stathakopoulos and Erikson, 1966). However, auxillary buds, not inserted scion buds, were studied in these experiments. Budbreak of Swingle citrumelo was affected more by soil temperature than budbreak of Cleopatra mandarin over the range of soil temperatures studied. Percent scion budbreak of Swingle plants forced by bending was nearly doubled in experiment 1 and increased by 50% in experiment 2 by the higher soil temperature treatment.

During experiment 2, scion buds of fall-budded Swingle plants forced by bending in the greenhouse did not grow initially. This situation is common in commercial citrus nurseries in Florida. When the plants were moved to the temperature chambers, most scion buds in the warm soil temperature treatment began growing in less than 10 days. Prior attempts to increase scion budbreak of Swingle nursery plants with BA have been variable (Rouse, personal communication, 1993). Our results may partially explain the inconsistent effects of BA on scion budbreak of citrus nursery trees. Scion budbreak of the bending + BA treatment was increased from 16% at the low soil temperature to 100% at the high soil temperature. Soil temperature is probably a major factor influencing the effectiveness of BA on scion budbreak when used in conjunction with bending to force Swingle plants.

Greater scion growth at the higher soil temperature is in agreement with earlier work with sweet orange and Cleopatra mandarin seedlings (Cahoon et al., 1963), Cleopatra mandarin and rough lemon seedlings (Labanauskas et al., 1958) and navel orange budded on trifoliate orange rootstock (Khairi and Hall, 1976). Total plant dry weight was not affected by soil temperature or forcing method, perhaps because of the relatively short duration of the experiments.

In summary, Swingle citrumelo and Cleopatra mandarin have different soil temperature requirements for scion budbreak when forced by bending. Low scion budbreak of Swingle at 15°C soil temperature may explain the difficulty in forcing scion buds of Swingle plants by bending during the fall and winter. Moreover, the inconsistent results from BA applications to force scion budbreak may be partially explained by soil temperature during forcing.

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