Field Performance of Micropropagated, Own-rooted Peach Trees

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Abstract. Four peach [*Prunus persica* (L.) Batsch] scion cultivars, 'Jerseyqueen', 'Redskin', 'Suncrest', and 'Sunhigh', that were propagated by tissue culture techniques and by bud-grafting onto 'Lovell' seedlings, were compared at Kearneysville, W.Va., and at Beltsville, Md. At Kearneysville, total fruit production was higher for tissue-cultured (TC) trees when compared with budded trees in the first 3 years of fruiting, whereas trunk diameter increases were generally larger for budded trees. In the following year, fruit production was similar for both TC and budded trees, although trunk diameter increases continued to be larger for budded trees. At Beltsville, fruit production was significantly higher for TC trees in 1987, the first fruiting season, but the same for both in the second season. Trunk diameter increases were larger for budded trees both years. Differences in tree growth and productivity in the early years of orchard establishment appeared to be related to the size of plants that were planted. Budded trees, which were smaller than TC trees at planting, increased in size faster than TC trees but were less productive. Crop efficiency was cultivar-specific, but differences among cultivars was less if trees were TC propagated. These results suggested that based on yield and growth, own-rooted TC trees should be an acceptable tree type for commercial orchards.

Propagation of many ornamental plants by in vitro culture techniques has become an accepted commercial practice (Read and Hosier, 1986). The delay in using micropropagation on a commercial scale for propagating scion cultivars of fruit trees has been due, in part, to the need to examine the performance of TC own-rooted plants under field conditions. Several such studies have been conducted that demonstrate that field performance of TC fruit trees varies from species to species. In the first few years in the field, micropropagated apple (*Malus domestica* Borkh.) trees exhibited faster growth rates and delayed cropping when compared to budded trees, but growth rate differences disappeared in later years (Rosati and Gaggioli, 1987; Webster et al., 1985; Zimmerman and Miller, 1986). Similar results have been observed for pear (*Pyrus communis* L.) (Sansavini et al., 1986), whereas micropropagated sour cherry (*Prunus cerasus* L.) trees were less productive, as well as less vigorous than budded trees in the first 2 years in the field (Rosati and Gaggioli, 1987). Reports concerning TC peach trees have shown them to produce earlier and to be more vigorous than grafted trees in the first season of production (Martin et al., 1983). Conversely, TC trees have been found to be less productive and less vigorous than budded trees for the first fruiting years when TC plants were smaller at planting. After 3 years, TC and budded trees were equal (Cobianchi et al., 1988; Liverani et al., 1990). No differences have been observed in tree performance on TC vs. conventionally propagated peach rootstocks (Edin et al., 1987; Rosati and Gaggioli, 1987). The research presented in this paper describes the field performance of four peach scion cultivars, propagated either by tissue culture or by bud-grafting.

Materials and Methods

Scion cultivars Jerseyqueen, Redskin, Suncrest, and Sunhigh were used in all studies. 'Lovell' seedlings were used as the rootstock for all bud-grafted trees. In vitro propagation, rooting, and acclimatization of peach plants were described previously (Hammerschlag et al., 1987). The schedule for budding and planting TC-propagated and budded trees is described in Table 1. Sixteen plants per treatment per cultivar were planted in blocks of four in a randomized block design. Trees were placed 4 m apart within rows, with rows 6 m apart. Trees in Kearneysville, W.Va., were fertilized in 1986, 1988, and 1989 with 250 kg urea/ha and in 1987 with 300 kg 10N-4P-8K/ha. Trees in Beltsville, Md., were fertilized in 1987 to 1988 with 335 kg NH_4NO_3 /ha. Insecticides and fungicides were applied when necessary.

Trunk diameter was measured 20 cm above the ground following field planting and recorded yearly in the dormant season. Trunk cross-sectional area was calculated assuming the trunk to be a circle. Beginning 2 years after field planting, total weight and number of fruit were recorded. Fruit diameter was measured on a sample of 10 fruit/tree. At Kearneysville, due to the large volume of fruit produced in the 3rd and 4th years, two trees per block were sampled. Total fruit weight was recorded. A subsample of 10 fruit/tree was weighed and the average individual fruit weight determined. Fruit count per tree was then calculated as total fruit weight/average individual fruit weight. Trunk diameter continued to be measured each year on all trees in both plantings. Trees were pruned to an open-center form, beginning in the second growing season, and fruit were thinned to allow for proper fruit development and prevent limb breakage, as is practiced in commercial orchards. Data on fruit production and tree growth were submitted to analysis of variance and Duncan's mean separation test.

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Abbreviations: TC, tissue culture; TCSA, trunk cross-sectional area.

Table 1. Schedule for budding and planting TC-propagated and budded trees at Kearneysville, W.Va., and Beltsville, Md.

Location	TC to:			Budded		
	Greenhouse	Nursery	Field	Rootstock seed sprouted in nursery	Plants budded	Plants to field
Kearneysville	Feb. 1983	May 1983	May 1984	Apr. 1983	Sept. 1983	Nov. 1984
Beltsville	Feb. 1984	June 1984	June 1985	Apr. 1984	June 1984	May 1985

Results and Discussion

No phenotypic anomalies were observed in the TC trees in the field, as previously reported (Cobianchi et al., 1988; Edin et al., 1987; Liverani et al., 1989; Martin et al., 1983; Rosati and Gaggioli, 1987). This result is consistent with reports indicating that plants derived from axillary shoots are likely to be identical to the parent plant (D'Amato, 1975; Murashige, 1974).

Tree growth. At Kearneysville, trees were budded in the nursery in Fall 1983, but TC trees were planted in the nursery in May 1983, giving the TC trees the advantage of one season's growth. Thus, the mean trunk cross-sectional area (TCSA) of TC trees was significantly larger than that of budded trees in Dec. 1985, 19 months after field planting of TC trees and 13 months after field planting of budded trees (32.8 cm² and 9.2 cm², respectively; mean significant difference at $P = 0.05$). Although bud-grafted trees had a significantly greater mean increase in TCSA in 3 out of 4 years (Table 2), they did not attain the TCSA of TC trees. By the end of the study period (1989), TC trees still had a significantly larger mean TCSA than budded trees (150 cm² and 119 cm², respectively; mean significant difference at $P = 0.05$).

Trees at Beltsville were manipulated on a schedule that more nearly equalized the growth of TC and budded trees at the time of planting (Table 1). Mean TCSAs of TC and budded trees 6 months after planting were similar (0.67 cm² and 0.57 cm², respectively). The Beltsville plot was heavily infested with nematodes, and trees were removed in 1989. At the time of removal, mean TCSAs of the TC and bud-grafted trees remained nearly equal (33.1 cm² and 30.1 cm², respectively). These data suggest that tree size at planting may be more important in tree growth during the first few years of orchard establishment than the propagation method, whether TC or bud-grafted. Further, this study points out the difficulty of comparing own-rooted (TC-propagated) vs. budded trees. If seedlings are grafted 1 year

before the TC plants are rooted (Cobianchi et al., 1988; Liverani et al., 1989), then budded trees will be larger than TC trees at the time of planting. If seedlings are grafted after TC plants are rooted (as in this study), then TC trees will be larger at the time of planting in relationship to the amount of time that grafting follows rooting of the TC trees.

Fruit production. Trends in fruit production were similar in both plots (Tables 2 and 3), although fruit production in Beltsville was relatively low due to poor tree growth that resulted from nematode infestation. At Kearneysville, total fruit production and fruit size was significantly higher for TC trees than for budded trees for the first 3 years of evaluation (Table 2). The difference in production appeared to be related to tree size, particularly in the early years. Tree pruning and an increase in the size of budded trees probably accounts for similarities in fruit production of budded and TC trees in later years.

To more effectively compare TC-propagated and budded trees and to reduce the effects of differences in tree size, cropping efficiency data were calculated (Tables 2 and 3). At Kearneysville, the mean number of fruit per square centimeter of TCSA produced on TC trees was higher in the first 2 years of cropping than that on budded trees. The number of fruit per square centimeter of TCSA for TC trees in the first fruiting season (1987) at Beltsville was significantly higher than that on budded trees. In subsequent years, the production was the same.

Differences among cultivars was observed for cropping efficiency regardless of the method of propagation (Table 4). This result is consistent with previous reports on TC trees (Liverani et al., 1989). Differences among cultivars, however, were less in TC trees than in budded trees, suggesting greater uniformity in the former.

Couvillon and Erez (1982) indicated that peaches and nectarines perform well on their own roots and are not inferior to grafted material when the rootstock used has no specific resis-

Table 2. Comparison of TC vs. standard propagation on growth and fruit production of peach plants at Kearneysville, W.Va.^{a,y}

Year	Propagation method	Avg fruit diam (cm)	Fruit/tree (no.)	Fruit/cm ² TCSA (no.)	Total fruit wt/tree (kg)	Fruit wt (kg)/cm ² TCSA	Mean trunk diam (cm)	Tree trunk diam increase ^x (%)
1986	Budded	4.2 b	24 b	1.1 b	3.1 b	0.08 b	5.9 b	69 a
	TC	6.3 a	293 a	5.3 a	34.5 a	0.57 a	8.6 a	25 b
1987	Budded	6.6 b	175 b	2.9 b	25.7 b	0.43 b	8.2 b	39 a
	TC	7.0 a	295 a	3.7 a	50.3 a	0.62 a	10.1 a	17 b
1988	Budded	7.1 b	237 b	2.8 a	42.3 b	0.49 a	10.3 b	26 a
	TC	7.4 a	297 a	2.9 a	58.2 a	0.56 a	12.1 a	20 b
1989	Budded	7.8 a	181 a	1.6 a	42.0 a	0.38 a	12.3 b	19 a
	TC	7.9 a	195 a	1.4 a	48.7 a	0.36 a	13.8 a	14 b

^aAverage over four cultivars.

^yMean separation within columns at each date by Duncan's multiple range test, $P = 0.05$.

^xIncrease in trunk diameter measured from the year previous to the year listed on the table.

Table 3. Comparison of TC vs. standard propagation on growth and fruit production of peach plants at Beltsville, Md.^{z,y}

Year	Propagation method	Avg fruit diam (cm)	Fruit/tree (no.)	Fruit/cm ² TCSA (no.)	Total fruit wt/tree (kg)	Fruit wt (kg)/cm ² TCSA	Mean trunk diam (cm)	Tree trunk diam increase* (%)
1987	Budded	5.7 b	15 b	0.6 b	1.4 b	0.06 b	4.9 a	58 a
	TC	6.1 a	27 a	1.3 a	3.4 a	0.15 a	5.1 a	31 b
1988	Budded	5.6 a	128 a	3.7 a	10.9 a	0.31 a	6.5 a	32 a
	TC	5.5 a	134 a	4.3 a	10.7 a	0.34 a	6.2 a	22 b

^zAverage over four cultivars.^yMean separation within columns at each date by Duncan's multiple range test, $P = 0.05$.^xIncrease in tree trunk diameter measured from the previous to the year listed on the table, i.e., 1987 = increase from 1986 to 1987.Table 4. Comparison of fruit production of four peach cultivars propagated either by TC or by grafting at Kearneysville, W.Va.^z

Cultivar	Total wt of fruit/tree (kg)						Fruit/cm ² TCSA (kg)					
	1987		1988		1989		1987		1988		1989	
	TC	Budded	TC	Budded	TC	Budded	TC	Budded	TC	Budded	TC	Budded
Jerseyqueen	55.1 a	42.8 a	51.4 b	47.8 a	61.2 a	25.2 d	0.69 ab	0.60 a	0.52 ab	0.51 b	0.43 a	0.21 b
Redskin	55.4 a	21.2 b	64.9 a	44.5 ab	50.3 ab	48.0 b	0.79 a	0.47 b	0.69 a	0.62 a	0.43 ab	0.50 a
Suncrest	42.9 a	17.0 b	60.0 ab	36.2 c	48.9 ab	58.6 a	0.50 b	0.29 c	0.54 ab	0.39 c	0.34 ab	0.52 a
Sunhigh	48.1 a	21.9 b	57.0 ab	40.3 bc	37.5 b	36.2 c	0.53 b	0.33 c	0.49 b	0.43 bc	0.28 b	0.25 b

^zMean separation within columns by Duncan's multiple range test, $P = 0.05$.

tance to either abiotic or biotic soil stresses that may exist. More recently, Couvillon et al. (1989) demonstrated that own-rooted peach trees were able to withstand higher levels of water stress than trees propagated on seedling rootstocks. We now have provided additional evidence for the feasibility of using in vitro methods for propagating own-rooted peaches and have shown that own-rooted peach cultivars are similar to budded trees in fruit yield. We also showed that comparisons of TC-produced, own-rooted trees and budded trees are dependent on the manipulation of the trees before planting. In our study, the budded trees, which were smaller than TC trees when planted, grew faster but were less productive than TC trees in the first few years of fruiting. Direct comparisons between TC and budded trees are difficult, if not impossible. Apparent advantages of one system over the other may last for one or a few growing seasons (Liverani et al., 1989).

Own-rooted peach plants may be produced in vivo through cuttage or by in vitro shoot-tip multiplication and rooting. Erez and Yablowitz (1981) reported that the most economical peach tree is one produced from hardwood cuttings rooted directly in the orchard; however, the percentage rooting of scion cultivars from hardwood cuttings is generally very low (Erez, 1984). Couvillon and Erez (1980) reported 90% rooting of commercial cultivars from semihardwood cuttings. High rates of rooting have also been achieved for commercial cultivars propagated by TC techniques (Hammerschlag et al., 1987). TC propagation can also facilitate the production of many virus-indexed plants or new cultivars in a short period. The economic feasibility of producing TC plants has yet to be determined.

In conclusion, there appear to be advantages to all methods of propagating peach trees. The method chosen will depend on whether rootstocks are necessary to resist particular soil or pathogen problems, cost, and the ease of rooting cultivars of interest.

Literature Cited

Cobianchi, D., F.R. De Salvador, W. Faedi, O. Insero, A. Liverani, L. Rivalta, and A. Minguzzi. 1988. Preliminary field observations on in vitro propagated trees. *Acta Hort.* 227:514-515.

Couvillon, G.A. and A. Erez. 1980. Rooting, survival and development of several peach cultivars propagated from semihardwood cuttings. *HortScience* 15:41-43.

Couvillon, G.A. and A. Erez. 1982. Production potential and tree regeneration in a peach meadow orchard in the southeastern U.S. *Compact Fruit Tree* 15:166-175.

Couvillon, G.A., M. Rieger, R. Harrison, J. Daniell, and J. Gomez Aparisi. 1989. Stress-mediated responses of own rooted peach cultivars. *Acta Hort.* 243:221-230.

D'Amato, F. 1975. The problem of genetic stability in plant tissue and cell cultures, p. 333-348. In: O.H. Frankel and J.G. Hawkes (eds.). *Crop genetic resources for today and tomorrow*. Cambridge Univ. Press, Cambridge, England.

Edin, M., J.F. Mandrin, J.C. Navatel, P. Rosati, and D. Gaggioli. 1987. Comportamento nel frutteto di portinnesti ottenuti attraverso la micropropagazione: Ibrido pesco × mandorlo INRA GF677. *Riv. Frutticoltura* 49(8):61-64.

Erez, A. 1984. Improving the rooting of peach hardwood cuttings under field conditions. *HortScience* 19:245-247.

Erez, A. and Z. Yablowitz. 1981. Rooting of peach hardwood cuttings for the meadow orchard. *Scientia Hort.* 15:137-144.

Hammerschlag, F.A., G.A. Bauman, and R. Scorza. 1987. Factors influencing in vitro multiplication and rooting of peach cultivars. *Plant Cell Tissue Organ Cult.* 8:235-242.

Liverani, A., D. Cobianchi, F.R. De Salvador, O. Insero, and A. Minguzzi. 1989. Field performance of two peach and nectarine cultivars propagated in vitro. *Acta Hort.* 254:41-46.

Martin, C., M. Carré, and R. Vernoy. 1983. La multiplication végétative in vitro des végétaux ligneux cultivés: Cas des arbres fruitiers et discussion générale. *Rev. Agron.* 3:303-306.

Murashige, T. 1974. Plant propagation through tissue culture. *Annu. Rev. Plant Physiol.* 25:135-166.

Read, P.E. and M.A. Hosier. 1986. Tissue culture propagation of ornamental crops: An overview, p. 283-292. In: R.H. Zimmerman, R.J. Griesbach, F.A. Hammerschlag, and R.H. Lawson (eds.). *Tissue culture as a plant production system for horticultural crops*. Martinus Nijhoff, Dordrecht.

Rosati, P. and D. Gaggioli. 1987. Field performance of micropropagated peach rootstocks and scion cultivars of sour cherry and apple. *Acta Hort.* 212:379-390.

Sansavini, S., D. Neri, M. Grandi, and W.D. Lane. 1986. Confronto fra portinnesti nanizzanti e alberi micropropagati di pero. *Frutticoltura* 48(1):23-30.

Webster, A.D., V.H. Oehl, J.E. Jackson, and O.P. Jones. 1985. The orchard establishment, growth and precocity of four micropropagated apple scion cultivars. *J. Hort. Sci.* 60:169-180.

Zimmerman, R.H. and S.S. Miller. 1986. Early yield from tissue-cultured apple trees. *HortScience* 21:814. (Abstr.)