Developing Peach Cultivars with Novel Tree Growth Habits

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Abstract

Peach germplasm is rich in diversity for plant growth habit. Most of the growth habits in peach are the result of single gene changes and can be readily manipulated by breeders. In spite of this fact, there has been relatively little effort to genetically alter peach tree growth habit. The peach industry suffers from low productivity and lacks efficient high-density production systems as exist for apple. Alternate tree growth habits could be at least part of the solution for increasing peach productivity while maintaining high fruit quality. The characteristics of various novel peach tree growth habits have been demonstrated. Columnar and upright trees are particularly promising growth types for high-density production systems and several new cultivars have been recently released for grower test. Narrow-leaf trees that allow increased light penetration into the canopy and are more water use efficient also appear promising. Spur-type trees could change the way that peaches are grown and drastically reduce pruning. In the future, growers may have available an array of high quality and productive peach varieties with growth habits such as columnar, upright, spur, semi-dwarf, or narrow-leaf, suited to their particular needs and capabilities.

INTRODUCTION

Peach production world-wide relies on the use of vigorous, spreading scion cultivars grafted onto rootstocks of similar vigor. Regardless of the desired growing system, from low density to high density, from large open-center to closely spaced tree walls to “Y” trellis systems, the standard, vigorous tree type must be made to fit the system. For the development of high density peach production systems using the standard tree type severe pruning is necessary. Pruning invigorates trees and leads to excessive vegetative growth, which may adversely affect fruit quality and subsequent flower bud formation due to shading. Summer pruning of excess regrowth can help to alleviate the problem but the economic benefits of this practice are still not certain.

Peaches, as currently grown, produce rather poorly when compared with other tree fruits. The average production of peaches in the U.S. is approximately half that of apple on a per hectare basis. The advantages of high-density fruit production have been clearly demonstrated in improving apple yields and reducing labor inputs. The apple systems rely on the use of dwarfing rootstocks. Spur-type scions are important for some cultivars. Commercially acceptable dwarfing rootstocks are not available for peach (Marangoni et al., 1984). While there are possibilities for the development of dwarfing rootstocks for peach, there clearly are opportunities for other approaches to growth habit manipulation in peach. These opportunities are based upon: 1) the existence of a great variety of different growth habits, some of which will be discussed below and 2) unlike apple, the vast majority of commercial peach varieties have been developed by breeding programs. Therefore, the development of new varieties with different growth habits is feasible within our current peach breeding programs.
PEACH GROWTH HABITS

Dwarf

Dwarf trees vary in size but rarely reach over 2.45 m in height. There are at least two types of dwarf trees. Very short internodes, long leaves, and a dense canopy characterize the "brachytic" dwarf. The brachytic dwarf has received some attention in breeding programs and high fruit quality brachytic dwarf varieties have been released (Hansche, 1989; Fideghelli, 2002; Stanica et al., 2002). The dwarf tree suffers from a number of difficulties beginning at the stage of nursery propagation. Internodes are very short making propagation through bud grafting difficult. Trees must be budded high on rootstocks to allow for orchard operations thus rootstocks require an extra season of growth. In the orchard, the dense, shaded canopy is an ideal habitat for fungal and bacterial pathogens. It is difficult for chemical sprays to penetrate the canopy, and fruits are difficult to locate for thinning and harvesting. These problems make the future uncertain for commercial fruit production from brachytic dwarfs. Another dwarf type tree (A72) was reported by Monet and Salesses (1975) in France, but it has, surprisingly, received little attention. We have found that seedlings from open pollinations of these dwarf trees exhibit a wide range of sizes. Leaves are not "oversized" as they are in the brachytic dwarf and overall the canopies are more open than those of the brachytic dwarfs except in very dwarf seedlings. Fruit quality of A72 and its first generation progeny is poor and at least several generations of crossing to high fruit quality types will be necessary for variety development.

Compact

Examples of the compact growth habit are 'Com-Pact Redhaven' and 'Compact Gold Medal', which is sometimes marketed as 'Compact Elberta'. Both of these are presumed single gene mutations of the standard varieties (Mehlenbacher and Scorza, 1986). A third compact tree that has been identified is 'Elbertita', presumably a mutation of 'Elberta'. Compact trees have shorter internodes than standard trees, wider branch angles, and a greater number and longer laterals than produced on standard trees (Scorza, 1984). These characteristics make for a dense canopy and reduced light penetration (Scorza et al., 1984). While the reduction in tree size (20-50% smaller than standard) is desirable for peach production, the dense canopy and excessive pruning necessary for adequate light penetration would be disadvantageous for commercial growers. However, our observations suggest that if pruning is kept to a minimum 'Com-Pact Redhaven' will produce numerous spurs that produce fruit throughout the canopy. This reduces the need to prune for new fruiting wood and it may be possible to develop a new strategy of pruning compact trees that would reduce the density of foliage and still favor fruit production. In terms of rootstock potential of the compact genotype, the dense canopy is accompanied by high root system density that may increase exploitation of soil resources by compact trees and affect shoot development (Tworkoski and Scorza, 2001).

Semi-dwarf

Semi-dwarf trees are generally between compact and standard trees in overall size. Their branch growth is similar to standard trees so the dense canopy is not an issue. Breeders at the Istituto Sperimentale per la Frutticoltura, Rome, have obtained semi-dwarf trees from open-pollinated standard varieties such as 'Sentinal', 'Redhaven', and 'Southland' (Fideghelli et al., 1979). These semi-dwarfs vary in size but are generally about 50-60% of the size of standard trees (Quarta and Scortichini, 1985), otherwise they are quite similar to standard trees in appearance. 'Gage Elberta', a variety no longer commercially grown, is another semi dwarf tree. By simply selecting for reduced tree size and high fruit quality, progress in developing semi-dwarf peach trees is being made. Such trees may allow growers to space trees closer, reduce pruning, and increase yields per hectare.
Spur-type

Many stone fruit species including plum, apricot, and cherry produce fruiting spurs. Scorza published the first report of spur-type growth in peach in 1987. Spur growth type peaches were found in exotic peach germplasm that had been imported into the U.S. Some were apparently peach-almond hybrids and their spurriness was most likely inherited from the almond parent. Yet, the trees that produced the greatest densities of spurs were dwarf (dw/dw) x compact (Ctet) peach hybrids. The spur-type trees recovered were apparently heterozygous at the dw locus (Dw/dw) and homozygous (ctct) (Scorza, 1987). Spur-type peach trees require a completely different production strategy in order to take advantage of spurs. The development of vigorous shoots through heavy pruning defeats the production of spurs. Pruning and production systems for fruits such as apricot, plum and cherry may be appropriate models.

Weeping

Weeping peaches have generally been released as ornamentals. There are at least two programs in Europe, including one in Bologna, Italy and one in Bordeaux, France that have or are developing commercial fruit quality weeping peach varieties. Bassi and co-workers (1994) suggested that the weeping peach may be of interest for new training systems, similar to the Lepage system in pear with a zig-zag stem made from the scaffold branches alternately radiating from the trunk one above the other.

Narrow-leaf

Narrow-leaf or willow-leaf peaches represent a novel growth habit due to a genetic change in leaf width. Narrow-leaf trees produce leaves that may be less than half as wide as normal peach leaves (Glenn et al., 2000). This can produce a more open canopy that would increase light penetration and potentially, improve color, favor more uniform ripening, and reduce disease incidence. Research has shown that narrow leaf trees are more efficient in their water use and may perform better under conditions of water stress than standard leaf peach trees (Glenn et al., 2000). Studies of the productivity of narrow-leaf trees as well as the pruning requirements for commercial production are underway at the USDA stations in Kearneysville, West Virginia and Byron, Georgia. Selection for variety development is also underway at these facilities (Okie and Scorza, 2001).

Columnar

Columnar trees were first reported from Japan where they were developed as ornamentals (Yamazaki et al., 1987). Left to grow naturally, they will attain a height of 5 m and a crown diameter of around 1.5 m. The most striking feature of the columnar tree is its narrow branch angles (Scorza et al., 1989). The fact that columnar trees have a naturally narrow canopy appears to make them ideally suited to high-density spindle tree or “wall” systems. Columnar trees also have higher shoot:root ratios than standard or compact trees and the smaller root systems of columnar trees may facilitate high-density plantings by reducing tree-to-tree competition for edaphic resources (Tworkoski and Scorza, 2001). Fruit quality of the original columnar (also known as “pillar”) tree is very poor and yields are low. The breeding program at USDA, Kearneysville and at several locations in Italy (Bologna and Forli) have significantly improved the fruit quality and productivity of columnar trees and several varieties suitable for commercial trials have been developed including ‘Crimson Rocket’ released by R. Scorza USDA-ARS Kearneysville, WV and ‘Alice-cot’ released by A. Liverani, CRA, Forli, Italy. Pruning and spacing trials have been established in the U.S., Italy, and Canada (Miller and Scorza, 2001).

Upright or Semi-columnar

Columnar growth habit is semi-dominant with homozygous brbr producing columnar and BrBr producing standard tree forms. The heterozygote (Brbr) produces a
unique upright or semi-columnar growth habit. This phenotype is neither columnar nor standard but possesses an intermediate growth habit. The upright cultivar ‘Sweet-N-UP’ was released from ARS-Kearneysville. In experimental trials it has shown good fruit quality and size with high productivity. Upright trees can be readily trained to central leader and “Y” systems.

“Mixed” Growth Habits

We have hybridized a number of different growth habits such as pillar x dwarf, pillar x compact, dwarf x compact, narrow leaf x pillar, etc. Many of these crosses have produced predictable combinations of traits and others have produced unique new types. It is clear that desirable growth traits can be mixed and combined in new ways to produce a range of growth habits limited only by the imagination. Careful study, critical observation, and rigorous testing will decide which traits and combinations of traits are most beneficial for commercial peach production in the future.

Literature Cited