

FACTORS AFFECTING TREE CROP EFFICIENCY IN YOUNG PEACH TREES: ROOTSTOCK VIGOUR AND TRAINING SYSTEM

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Abstract

We report the effect of 2 rootstocks (GF 677 and Missouri) and 2 training systems (Y-shape and Free-spindle) on dry matter accumulation and partitioning, starch concentration and crop efficiency of young peach trees (cv Maycrest) grown in large pots. Both training system and rootstock significantly influenced tree growth and productivity in the early ripening Maycrest peach cultivar in the first two growing seasons. Y-shaped trees had $\approx 25\%$ greater trunk cross-sectional area (TCA) than Free-spindle trees (FS), but only about half the number of fruit per tree. Trees on GF677 had $\approx 20\%$ greater TCA and $\approx 13\%$ lower number of fruit than trees on Missouri. Crop efficiency was affected by training system but not by rootstock. FS trees had a three times greater crop efficiency than Y-shaped trees. Training system affected also fruit dry matter accumulation with FS trees having a fruit dry mass that was more than twice that of Y. Dry matter removed with summer pruning of FS trees was less than half that of Y trees. No particular differences were found in the mineral contents among the 4 rootstock-training system combinations. Rootstock had a significant effect on starch concentration in the root system. Maycrest trained to systems as Y that require severe pruning, proved to delay the onset and amount of early fruit production, regardless of the vigour of the rootstock adopted.

1. Introduction

Morphological and physiological relationships between the above ground part of the tree and the root system are responsible for the age in which young grafted trees regain their ability to flower (Zucconi, 1992).

Many horticultural factors, e.g. plantation system, rootstock, pruning etc., influencing shoot/root ratio and dry matter partitioning among various growing part of the tree, can influence the time to come into production (Zimmermann, 1973). In high-density peach orchard systems, early yielding performances may be related to a decrease of the age or the size at which the trees attain their optimum dry matter partitioning to the fruit (Chalmers and Van Den Ende, 1975).

In this study we report the effect of 2 rootstocks, differing in vigour, and 2 training systems, differing in canopy architecture and pruning severity, on dry matter accumulation and partitioning, root starch concentration and tree crop efficiency of young peach trees.

2. Materials and methods

In autumn 1997 trees of the early ripening peach cv Maycrest, onto peach x almond hybrid GF 677 and Missouri (*P. persica*) rootstocks, were planted in large pots (85 l) and trained to Y-shape (Y) and free-spindle (FS). At the end of each of the first two growing seasons (1998 and 1999) 9 trees per rootstock and training system were harvested and divided into fruits, leaves, current season's growth, wood older than one year and roots. Dry matter, mineral content (N, P, K, Ca, Mg) (year 1) and starch content (year 2) of a sub-sample of each tree component were determined

following the methods as described by Caruso et al. (1999). The following data were collected: trunk cross-sectional area (TCA), crop load, leaf area (leaf area meter, Li-Cor LI-3100) and summer pruning weight. Crop efficiency and a modified harvest index (Caruso et al., 1997) [HI] were calculated as the ratio between fruit dry weight and TCA and the ratio between the dry matter allocated to the fruit vs. dry matter allocated to the annual canopy growth (shoot, leaf and fruit), respectively. Data were analysed (ANOVA) using Systat statistical package (Wilkinson, 1990).

3. Results

Both training system and rootstock significantly influenced TCA and the number of fruit per tree. Between training systems, Y trees had $\approx 25\%$ greater TCA than FS trees, but nearly half the number of fruit per tree. Trees on GF677 had $\approx 20\%$ greater TCA and $\approx 13\%$ lower number of fruit than trees on Missouri (table 1).

A training system x rootstock interaction was found for number of fruit per tree. Among the tested training system-rootstock combinations, Y/GF trees, at the end of the second growing season, had the lowest number of fruit per tree (8.39 ± 0.39), whereas FS/Missouri trees had the highest number of fruit per tree (19.56 ± 0.64).

Crop efficiency was affected by training system but not by rootstock with FS trees having three times greater crop efficiency than Y trees. Furthermore, FS trees were most efficient at partitioning fixed C to fruit. In fact the amount of dry matter allocated to the fruit (HI) represented 11% and 23% of the dry matter allocated to the annual canopy growth for Y and FS trees, respectively. The ratio of fruit dry matter produced per unit leaf area was 17.4 and 43.2 g m⁻² for Y and FS, and 25.9 and 34.8 g m⁻² for GF677 and Missouri, respectively. Neither crop efficiency nor harvest index was affected by the vigour of the rootstock. The rootstock significantly influenced total leaf area, current season's growth dry weight, above ground dry weight and total dry weight (table 2). Trees grown on GF677 had greater total leaf area (+27%), current season growth (+25%), above ground dry mass (+18%), and total dry weight (+16%) than those on the weaker Missouri rootstock. At the end of the second growing season trees onto GF677 had an average of 1.49 kg of total dry mass vs 1.28 kg onto Missouri.

Trees trained to FS did not apparently differ in size from Y shape trees. Although they presented a lower TCA than trees trained to Y, they did not significantly differ from Y trees in terms of total leaf area, current season's growth, >1yr-old wood, above-ground dry mass, root and total dry weight. Nevertheless, they required significantly less pruning (-56.8%).

Dry weight of older than 1-year-old wood, root and the ratio between above-ground dry weight and root dry weight were neither affected by the training system nor by the rootstock.

There was a significant increase in dry matter production from year 1 to year 2. Thus, also the calculated above-ground to root dry mass ratio showed a consistent increase from 1998 to 1999 (+45.6%) that accounted both for vegetative growth and yield. Dry matter partitioned to the roots generally decreased from an average of 35.6% (year 1) to 27.3% (year 2) of the total (data not shown).

Rootstock did not significantly affect mineral concentration of leaves, current season's growth and roots. The Y-shaped trees had slightly higher leaf Calcium (0.82% of dry weight vs. 0.61%) and higher Nitrogen (1.32% of dry weight vs. 1.02%) in current season's shoots than the FS-trees. Annual shoots had slightly higher Phosphorus on FS than Y-trees (0.19% vs. 0.15%).

The rootstock affected significantly the starch content in roots with Missouri trees having, at the end of the growing season, a 23% higher starch content than GF677 trees (table 3). A significant interaction between training system and rootstock was observed for all of the sampled components.

4. Discussion

The growth data we obtained in this work confirm previous findings which demonstrated that Y shape trees require more time and more pruning to accomplish their structure (Corelli and Coston, 1991).

In conclusion, Maycrest trained to Y system required a more severe pruning and delayed the time to come into production and, consequently, had the lowest crop efficiency, regardless of rootstock vigour. An improved yield was obtained in the second year with the free-spindle and that was likely the result of a better root/shoot balance. In fact, even if no significant difference was observed in the average (yr.1 and yr. 2) ratio between above ground dry weight and root dry weight (2.3 vs. 2.4 for Y and FS, respectively), it may be supposed that the more severe pruning needed for Y determined an intense vegetative regrowth both for the aerial and the below ground part of the tree. Looking separately at the data of each year of observation (data not presented) it can be observed that a more intense regrowth was obtained with Y. Root dry weight increase between year 1 and year 2 averaged 119.5% for Y trees and only 72.4% for FS trees. Moreover, total above-ground increase was 217% for Y and 160.7% for FS. Y trees invested about 71.6% of annual dry mass gain for vegetative structures (i.e. canopy reconstruction and growth), 23.5% for root growth and only 4.9% for fruit vs., respectively, 65.5, 20 and 14.5% of FS. This could explain why we found the highest value of TCA in Y trees and on the other hand, for FS trees, confirm the tendency for TCA to decrease in growth with increasing cropping performance (Caruso et al., 1999). This response to severe pruning that favoured strong vegetative growth at the expense of flower bud formation is well known since a long time (Marshall, 1931).

Our results confirm that the more severely young trees are pruned to obtain the desired shape the later is the onset of fruiting and the lower is the amount of early yield.

Thus, in orchard systems for which early fructification is crucial for economic return the impact of severe pruning required by some training systems such as Y should be evaluated.

Nevertheless, for peach high density planting systems, since Y shape has in many cases (Barone et al., 1995; Caruso et al., 1999; De Salvador and DeJong, 1989) proved to be able to successfully combine high crop efficiency with optimal sunlight interception, factors others than early flowering and fruiting, such as planting density and light interception, have also to be evaluated for their contribution to the enhancement of the efficiency of the entire orchard system.

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Table 1 - Influence of rootstock and training system on trunk cross-sectional area (TCA), number of fruit per tree, modified harvest index (fruit dry wt vs shoot, leaf, and fruit dry wt) [HI], and crop efficiency (fruit dry wt - TCA ratio) in Maycrest peach trees planted in 1997 and harvested in Sept. 1998 (yr. 1) and Sept. 1999 (yr. 2).

	TCA (cm ² /tree)	Fruit (no./tree)	HI (g/g)	Crop efficiency (g cm ⁻²)
Year				
1				
2	7.13	13.12	0.14	12.21
Training System				
Y	8.09	8.47	0.11	6.28
FS	6.16 ***	17.76 ***	0.23 ***	18.15 ***
Rootstock				
GF677	7.98	12.18	0.16	10.86
MISSOUR	6.27 **	14.06 **	0.19 NS	13.57 NS
Interaction				
Tr.Syst.xYr.				
Tr.Syst.xRootst.	NS	**	NS	NS

NS, *, **, *** not significant or significant at $P \leq 0.5, 0.01, 0.01$, respectively

In no case interaction was observed for Rootstock x Year, and Year x Training System x Rootstock

Table 2 - Influence of rootstock and training system on leaf area and on dry matter accumulation in Maycrest peach trees planted in 1997 and harvested in Sept. 1998 (yr. 1) and Sept. 1999 (yr. 2).

	Total Leaf Area (m ² /tree)	Dry weight (g/tree)			
		Current season's growth	Fruit	Summer pruning	Total above ground
Year					
1	0.90	165.24		32.04	350.77
2	4.24	181.12	76.60	78.29	1007.71
	***	NS		***	***
Training System					
Y	2.67	185.36	46.51	77.12	695.38
FS	2.47	161.00	106.72	33.21	663.09
	NS	NS	***	**	NS
Rootstock					
GF677	2.88	192.70	74.63	59.45	735.34
MISSOUR	2.26	153.66	78.60	50.88	623.13
	*	**	NS	NS	*
Interaction					
Tr.Syst.xYr.	NS	**		*	NS
Tr.Syst.xRootst.	NS	NS	NS	NS	NS

NS, *, **, *** not significant or significant at $P \leq 0.5, 0.01, 0.01$, respectively

In no case interaction was observed for Rootstock x Year, and Year x Training System x Rootstock

Table 3 - Influence of rootstock and training system on the content of starch (mg g⁻¹ dry wt) in above-ground and root components of cv Maycrest (1999).

	1-year-old wood	>1-year-old wood	Roots
Training System			
Y	1.26	1.02	3.51
FS	1.42	0.94	3.09
	NS	NS	NS
Rootstock			
GF	1.27	1.13	2.87
MISS	1.41	0.83	3.73
	NS	NS	*
Interaction			
Tr.Syst.xRootst.	*	*	***

NS, *, **, *** not significant or significant at $P \leq 0.5, 0.01, 0.01$, respectively