

EFFECT OF ORCHARD SYSTEM ON FRUIT QUALITY OF FOUR EARLY RIPENING PEACH CULTIVARS: PRELIMINARY RESULTS

E. Barone, T. Caruso, L. Di Marco
Ist. Colture Legnose Agr. e For.
University of Reggio Calabria
89061 Gallina (RC)
Italy

F. Sottile
Ist. Colt. Arboree
University of Palermo
90128 Palermo
Italy

Abstract

The preliminary results of a study on the effect of orchard system on fruit quality of 'Flordaprince', 'Flordastar', 'Flordacrest' and 'Maravilha' low-chill and early ripening peach cultivars on micropropagated GF677 rootstock is reported in this paper. With the aim of evaluating the different factors that could affect fruit quality under different planting systems, two experimental orchards were established in 1990 in Sicily. Two orchard systems, 'Y' and free spindle, with planting densities respectively of 1850-2000 and 670-930 trees/ha, were compared. Data regarding yield, crop efficiency and fruit qualitative characteristics are discussed.

Index words: training system, fruit quality, *Prunus persica*.

1. Introduction

High density planting and intensive cultural systems are world-wide accepted practices in the modern peach growing, specially where precocious and heavy cropping are requested. As a consequence, excessive shade within and between trees can easily occur and affect fruit quality (Jackson, 1980), even in sunny climates (Sansavini et al., 1981). The short fruit development period and the competition of the simultaneous shoot growth can further depress fruit quality in early ripening cultivars. Orchard system (training system, pruning, row orientation and tree space, and so on) can reduce such negative effects by regulating light interception and distribution. Most of these aspects have been studied on medium or late ripening cultivars. On the contrary, few data are still available about the effect of orchard design on fruit quality of early ripening cultivars.

The objectives of this study were to determine if orchard system: 1) affects yield and fruit quality in early ripening peach cultivars since first productions, and 2) influences partitioning between fruit and vegetative growth from the early age of orchard life. With these aims, two related experiments were designed. Preliminary results concerning four low-chill and early ripening cultivars, under southern Italy conditions, are presently discussed.

2. Material and methods

2.1 Experiment 1

In 1990 an experimental orchard was planted on a sandy loam soil (active lime 5.1% and pH 7.6) at Castelvetro, Sicily (37° 36'N), at 50 m. a.s.l.

The orchard systems were: Fusetto (free spindle), 5x3 m (670 trees/ha; max. tree height m 3.00) and free standing "Y", 5x1 m (2000 trees/ha; max. tree height m 2.20), with 'Maravilha', 'Flordastar' and 'Flordacrest' as test cultivars and GF677 as rootstock. The experimental design was: 3 randomised plots with 7 trees/cultivar each. Five trees/cultivar for each plot were considered in order to avoid border effects. During 1993 (i.e. tree age "3rd leaf"), data regarding number of fruit, yield and trunk circumference (25 cm above ground) per tree were collected. Length, number of flower buds, flower bud drop and fruit set were determined on 3 twigs per tree. Fruit was hand harvested at the most suitable shipping-maturity stage. Fruit firmness (8 mm tip), split pit percentage, soluble solids concentration (SSC), pH and titratable acidity (malic acid) were measured on 30 fruits per plot.

2.2 Experiment 2

The experimental orchard was planted on a sandy loam soil (very low active lime and pH 7.3) at Sciacca, Sicily (37° 30'N), at 120 m a.s.l.

The orchard systems were: Fusetto (free spindle), 4.5x2.4 m (930 trees/ha), and free standing "Y", 4.5x1.2 m (1850 trees/ha), with 'Flordaprince' as test cultivar and GF677 as rootstock. On 5 trees per system, fruit number per tree, yield, and trunk circumference were recorded in 1993 (3rd leaf). Leaf weight and area were determined on samples of 100 leaves per tree. On 30 fruits per tree, flesh firmness (8 mm tip), soluble solids concentration (SSC), pH and titratable acidity (malic acid) were measured at harvest. Soon after harvest each tree was cut down, and dry weight of shoots, 1-year-old wood, >1-year-old wood, leaves and fruits was determined, separately. Data were submitted to a two-way analysis of variance.

3. Results

3.1 Experiment 1

'Maravilha' had the greatest flower density followed by 'Flordastar' which had the greatest bud drop (table 1). Bud drop was higher for Y than for Fusetto. This was probably due to incomplete flower bud organogenesis caused by more severe summer pruning practised for the Y trees than for the Fusetto ones. However, no difference was found for fruit set. There was no interaction of cultivar and system.

Table 1 - Effect of orchard system on flower density, bud drop and fruit set of 3 early ripening peach cultivars.

	Flower density fl. buds/cm	Bud drop %	Fruit set %
Cultivar			
Maravilha	0.62	8.0	55
Flordastar	0.49	15.0	64
Flordacrest	0.44 **	7.0 **	60 NS
Orchard system			
Fusetto	0.62	5.0	55
Y	0.53 NS	12.0 *	59 NS
Interaction			
Cv x syst.	NS	NS	NS

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

Trunk cross-sectional area (TCA), yield and fruit number/tree were not significantly different among cultivars (table 2). Between systems, the Fusetto trees had the largest TCA/tree while the reverse was true for TCA/ha due to the highest tree density of the Y. For the same reason, while no significant difference was observed on yield/tree, the Y trees had the highest yield/ha which was much more than double that of Fusetto.

Table 2 - Effect of orchard system on trunk cross-sectional area (TCA), yield and no. of fruit/tree of 3 early ripening peach cultivars.

	TCA		Yield		Fruit number
	cm ² /tree	m ² /ha	kg/tree	t/ha	no./tree
Cultivar					
Maravilha	33.0	4.4	7.5	10.0	76.0
Flordastar	40.5	5.4	6.6	8.8	73.7
Flordacrest	41.7	5.6	9.1	12.1	96.9
Orchard system					
Fusetto	44.3	3.0	8.5	5.7	86.5
Y	33.8 **	6.8 **	7.1 NS	14.2 **	79.0 NS
Interaction					
Cv x system	NS	NS	NS	NS	NS

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

Yield efficiency and crop density as defined by Lombard et al. (1988), did not differ either among cultivars or between systems (table 3). No cultivar x system interaction was observed.

Table 3 - Effect of orchard system on yield efficiency and crop density of 3 early ripening peach cultivars.

	Yield efficiency kg fruit/cm ² TCA	Crop density no. fruit/cm ² TCA

Cultivar		
Maravilha	0.23	2.3
Flordastar	0.16	1.8
Flordacrest	0.22	2.3
	NS	NS
Training system		
Fusetto	0.19	1.9
Y	0.21	2.3
	NS	NS
Interaction Cv x syst.	NS	NS

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

However, orchard system was effective in influencing the rate of not marketable-sized fruit (table 4).

Table 4 - Effect of orchard system on marketable production per hectare and percentage of discarded fruit of 3 early ripening peach cultivars.

	Marketable production t/ha	Cull t/ha	Cull/Total production %

Cultivar			
Maravilha	6.3	3.7	37.0
Flordastar	5.0	3.8	43.2
Flordacrest	7.4	4.7	38.9
	NS	NS	
Orchard system			
Fusetto	4.40	1.30	22.8
Y	7.70	6.50	45.8
	NS	**	
Interaction Cv x system	NS	NS	

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

While Y system gave best yield per hectare as shown before, marketable-sized fruit (total amount of fruit with diameter ≥ 56 mm), although greatest with Y, did not differ significantly between systems. Moreover, with Y a significantly higher amount (about five times) of discarded fruits (< 56 mm) was produced than with Fusetto.

No difference emerged among cultivars. No interaction of cultivar x orchard system was detected.

Fruit quality characteristics were not significantly influenced by orchard system (table 5).

Major effects on fruit characteristics were observed due to cultivar. Titratable acidity was higher in Maravilha than in the other two cultivars as expected due to the higher firmness. 'Flordacrest' had the highest SSC/TA ratio, while 'Maravilha' had the lowest. Flordastar had the greatest split pit percentage. There were no significant differences in fruit size, SSC and pH. No interaction between cultivar and orchard system was observed.

Table 5 - Effect of orchard system on fruit size, firmness, split pit percentage, soluble solid concentration (SSC), titratable acidity (TA), pH and SSC/TA ratio of fruit of 3 early ripening peach cultivars.

	Fruit size g	Firmness Kg	Split pit %	SSC %	TA g/l	pH	SSC/TA
Cultivar							
Maravilha	98.7	9.1	0.5	10.9	1.38	3.36	7.9
Flordastar	89.6	6.1	13.2	10.7	1.00	3.33	10.7
Flordacrest	93.9	8.9	2.7	10.8	0.97	3.46	11.1
	NS	**	**	NS	**	NS	**
Orchard system							
Fusetto	98.2	9.2	4.3	10.5	1.46	3.32	7.2
Y	89.9	7.8	6.5	11.1	1.10	3.70	10.1
	NS	NS	NS	NS	NS	NS	NS
Interaction							
Cv x syst.	NS	NS	NS	NS	NS	NS	NS

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

3.2 Experiment 2

Trunk cross-sectional area per tree of Fusetto was significantly larger than for Y (table 6) but, when TCA per hectare was considered, no differences were observed. While Y yield and fruit number per tree resulted respectively 54% and 58% of Fusetto, no significant differences emerged for yield per hectare due to the counteraction of tree densities. Similarly, yield efficiency and crop density did not emerge significantly different between the two systems,

since TCA per tree of Y resulted in about 50% that of Fusetto.

Table 6 - Trunk cross-sectional area (TCA), yield, yield efficiency, no. of fruit/tree and crop density of 'Flordaprince' peach trees under two orchard systems.

Orchard system	TCA		Yield		Yield effic.	Fruit number	Crop density
	cm ² /tree	m ² /ha	kg/tree	t/ha	kg fruit/cm ² TCA	No./tree	No. fruit/cm ² TCA
Fusetto	93.5	8.7	16.9	15.7	0.18	170.2	1.83
Y	47.9 **	8.9 NS	9.1 **	16.8 NS	0.19 NS	98.7 **	1.99 NS

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

Among fruit quality characteristics, significant differences were observed for all the parameters, except pH (table 7).

Fruit size was slightly different between systems. 'Flordaprince' produced a little larger fruit with Fusetto than with Y. However, Y system enhanced SSC and reduced TA, thus improving SSC/TA, despite the highest flesh firmness.

Table 7 - Fruit size, flesh firmness, soluble solids concentration (SSC), titratable acidity (TA), pH and SSC/TA ratio of 'Flordaprince' peach trees under two orchard systems.

Orchard system	Fruit size	Flesh firmness	SSC	TA	pH	SSC/TA
	g	kg	%	g/l		
Fusetto	99.5	6.1	10.8	1.01	3.30	10.7
Y	91.8 *	7.8 **	12.9 **	0.80 **	3.34 NS	16.1 **

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

Dry matter of each of the above-ground parts of the tree was significantly higher in Fusetto than in Y (table 8). Particularly evident resulted the difference between the amount of dry matter in old wood, due to the distinct architecture of the two training systems adopted. However, partitioning of current year dry matter (fruits+leaves+shoots) was not altered by orchard system:

dry matter of leaves and that of fruits represented respectively about 50% and 35% in both tree systems.

Table 8 - Dry matter of fruit, leaves, shoots, 1 year-old wood and >1 year-old wood of 'Flordaprince' peach trees under two orchard systems.

Orchard system	Fruit	Leaves	Shoots	1 yr.-old wood	>1 yr.-old wood	Total
Fusetto	2.4	3.3	1.1	1.7	8.5	17
Y	1.3 **	1.9 **	0.6 **	1.0 *	2.3 **	7.1 **

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

Some calculated indexes (table 9) substantially confirmed that in our experiment sink-source balance was not modified by orchard system. In fact, orchard system did not affect either leaf dry weight per unit-leaf area (LDW/LA) or leaf area index (LAI), leaf dry weight per fruit dry weight (LDW/FDW) and fruit dry weight per unit-leaf area (FDW/LA).

Significant differences were observed only for total leaf surface per tree (TLS) that was, as expected, highest in Fusetto, due to the largest size of the trees.

Table 9 - Leaf dry wt./leaf area (LDW/LA), total leaf surface (TLS), leaf area index (LAI), leaf dry wt./fruit dry wt. (LDW/FDW) and fruit dry wt./leaf area (FDW/LA) of 'Flordaprince' peach trees under two orchard systems.

Orchard system	LDW/LA g/m ²	TLS m ²	LAI	LDW/FDW g/g	FDW/LA g/m ²
Fusetto	62.3	53.1	4.9	1.4	45.7
Y	71.6 NS	26.7 **	4.9 NS	1.5 NS	54.4 NS

NS, *,** Nonsignificant or significant at 5% and 1% level, respectively

4. Discussion

High performances and yield can be achieved early in the lifetime of an orchard by adopting the appropriate orchard design. For early-ripening low-chill peach cultivars, Y systems have proved to be among the most attractive systems under greenhouse conditions (Caruso et al., 1989; Caruso et al., 1993). Our results, as confirmed by Corelli et al. (1986) for medium-early ripening cultivars, show that also in full field conditions and for early-ripening low-chill

cultivars, Y system gave high performance both in terms of yield and fruit quality.

In these trials, in fact, Y system in comparison to the Fusetto one arranged to:

- Increase yield without decay in fruit internal quality when Y trained tree density was three times that of Fusetto (2000 vs. 670 trees/ha; Exp. 1).

- Improve fruit internal quality, although with a minor fruit size, without affecting yield when the density of the Y was double that of Fusetto (1850 vs. 930 trees/ha; Exp. 2).

Nevertheless, the minor fruit size and the great amount of discarded fruit obtained with Y in the first experiment cannot be neglected and suggests the need for a more accurate orchard management (i.e. thinning and pruning) in order to increase the percentage of marketable fruit. On the other hand, the best fruit internal quality obtained with Y in the second experiment is likely to be related to the different architecture of the trees on the two orchard systems. In fact, while both systems showed similar values of LAI, yield efficiency, crop density, and so on, Y enhanced flesh firmness together with SSC and TA, probably due to a better exposure of fruit to direct sunlight during the last stage of fruit development. This hypothesis is supported by other works that found a strong influence of light on peach fruit quality. Erez and Flore (1986) demonstrated that solar radiation positively influenced anthocyanin development in 'Redhaven' and also that SSC and flesh firmness were lowered by shading fruits for 18 days prior to harvest. Marini et al. (1991) observed that a high PPFD during the final swell of fruit growth is important for maximum SSC and conclude that low PPFD may negatively affect fruit quality. Similar results confirming a poorer light distribution in those designs with low SSC were reported for apples (Jackson et al., 1977). Loreti et al. (1993), working on 'Stark Redgold' nectarine, found that the deprivation of solar radiation in fruits at the 3rd growth stage increased fruit weight and water content, and reduced flesh firmness. Our results suggest that Y trained trees would likely allow a better light distribution to the fruits in the inner and lower part of the canopy than Fusetto. This conclusion is supported by the findings of De Salvador and DeJong (1989) that reported, for 'Flavorcrest' peach cultivar, a 35% increase of sunlight distribution into the 'Y Shape' tree canopy compared to the 'Central Spindle'. However, to fully clarify these aspects, additional studies including light penetration and distribution are needed. Furthermore, it should be studied whether and how long this best performance of the Y could be maintained in the next years.

Acknowledgements

Finalized Research Project "Fruitculture" supported by the Italian Ministry of Agriculture and Forestry. Paper no. 6.

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