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Effect of Different Fruit-thinning Patterns on Crop Efficiency and Fruit Quality for Greenhouse-forced 'May Glo' Nectarine Trees

T. Caruso,[1] P. Inglese,[2] C. Di Vaio,[3] and L.S. Pace[4]

SUMMARY. Fruit thinning is the most effective tool in regulating fruit growth potential for early-ripening peach and nectarine (*Prunus persica*) cultivars, and the common strategy is to space fruit 25 to 30 cm (9.8 to 11.8 inches) throughout the canopy, while scarce attention to the canopy environment in which the fruit develops. It is likely that different light environments within the canopy require different thinning patterns and to test this hypothesis, an experiment was set up to evaluate various fruit thinning patterns (fruit densities) in relation to fruit location within the canopy of early-ripening 'May Glo' nectarine trees trained to Y-shape. Differentiated fruit thinning resulted in higher yield efficiency due to a higher fruit number and average fruit weight. Differentiated thinning hastened fruit harvest and shortened the harvest period. Differentiated thinning reduced fruit variability within the tree in terms of size and soluble solids content, resulting in a higher crop value.

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[1]Professor of horticulture, Istituto di Coltivazioni Arboree, Universitè degli Studi di Palermo, 90128 Palermo, Italy.

[2]Professor of horticulture, Istituto di Coltivazioni Arboree, Universitè degli Studi di Palermo, 90128 Palermo, Italy; corresponding author, email: pinglese@unipa.it.

[3]Associate professor of horticulture, Dipartimento di Arboricoltura, Botanica e Patologia Vegetale, Universitè degli Studi di Napoli, 80055 Portici, Italy.

[4]PhD, Dipartimento Agrochimica ed Agrobiologia, Universitè degli Studi di Reggio Calabria, 89061 Reggio Calabria, Italy.

Early-ripening peaches and nectarines often produce fruit that are small, poorly colored and low in sugar content. The variability of fruit quality of peach is caused by different sources that may act independently (Genard and Bruchou, 1992). Plant effects include crop load (Corelli Grappadelli and Coston, 1991), fruit position within the canopy and on the shoot (Marini and Sowers, 1994), shoot type, competitive growth of vegetative and reproductive sinks (Inglese and De Salvador, 1996).

Crop distribution within the canopy plays a key role in determining the fruit growth potential and final size (Caruso et al., 1998; Sansavini et al., 1984), due to differences in canopy light environments and training system (De Salvador and DeJong, 1989, Erez and Flore, 1986, Marini et al., 1991, Sansavini et al., 1984).

Caruso et al. (1998) showed that in Y-shaped trees, the size and the color of 'Spring Lady' peach fruit decreased from the tree top to its base, and most of the crop (75%) came from the upper and midcanopy.

In early-ripening peach and nectarine cultivars, fruit thinning, together with summer pruning, is the most effective tool in regulating fruit growth potential. This is because the enhanced competition between vegetative and reproductive sinks, which occurs during the whole fruit development period (DeJong et al., 1987), strongly affects fruit growth (Caruso et al., 1999), particularly under greenhouse conditions (Caruso et al., 1993).

Fruit thinning in peach is necessary to set the crop load that allows the fruit to approach its growth potential (Grossman and DeJong, 1995). The common strategy is to space fruit along the bearing shoots (25 to 30 cm), while scarce attention is devoted to the canopy environment in which the fruit develops. Appropriate timing of thinning is also essential to enhance the effect of fruit thinning (Byers, 1989).

However, it is likely that different light environments within the canopy require different thinning patterns for fruit growth to be fully supported. For example, thinning may be different within the canopy to allow different fruit spacing in relation to the environment specific light microclimate. If this hypothesis is true, one could leave more fruit in the sun-exposed position of the canopy, increasing plant efficiency and

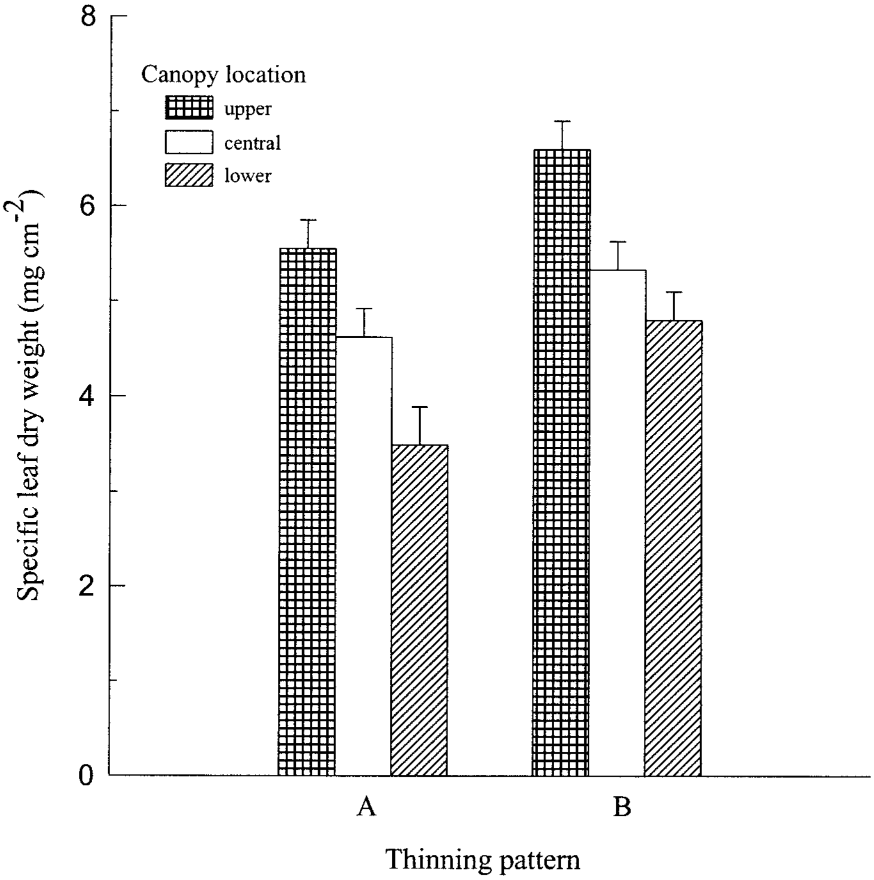

Fig. 1. Specific leaf dry weight (mean ± SE) by canopy location and fruit thinning pattern for 'May Glo' nectarine trees in 1998 and 1999; A = thinned to one fruit every 30 cm (11.8 inches) of bearing shoot throughout the canopy; B = thinned to one fruit every 15, 30, or 45 cm (5.9, 11.8, or 17.7 inches) of bearing shoot within upper, central, or lower canopy locations, respectively; 1.0 mg·cm^{-2} = 0.023 oz/inch2.

production with no reduction of fruit quality.

To test this hypothesis, an experiment was set up to examine different fruit thinning patterns in relation to canopy location for early-ripening 'May Glo' nectarine trees.

Materials and methods

The experiment was carried out in 1998 and 1999 in a 6-year-old 'May Glo' nectarine orchard, located at Battipaglia, Italy (lat. 42°25'N). Trees were on 'GF 677' (*P. persica* x *P. amygdalus*) rootstock, planted in north–south rows, spaced at 4 × 2 m (13.1 × 6.6 ft) and trained to a Y shape. To advance the fruit harvest time, plants were forced under a 3.5-m (11.5-ft) high and 4.5-m (14.8-ft) wide tunnel made up with plastic polyethylene film, 13 mm (0.5 inches) thick, which was fully closed from the end of dormancy (end of January) to fruit ripening (end of May). Routine horticultural care was applied throughout the season in terms of winter and summer pruning, irrigation, fertilization and pest control. The experiment was laid out in a complete randomized block design, with five replicates of three trees each. The canopy was divided into three portions of equal size, the lower [50 to 120 cm (19.7 to 47.3 inches)], the central [120 to 200 cm (47.3 to 78.8 inches)] and the upper [200 to 270 cm (78.8 to 106.4 inches)] parts of the two main scaffolds of the tree. One week after petal fall the following thinning patterns were applied: "A" where one fruit was left every 30 cm

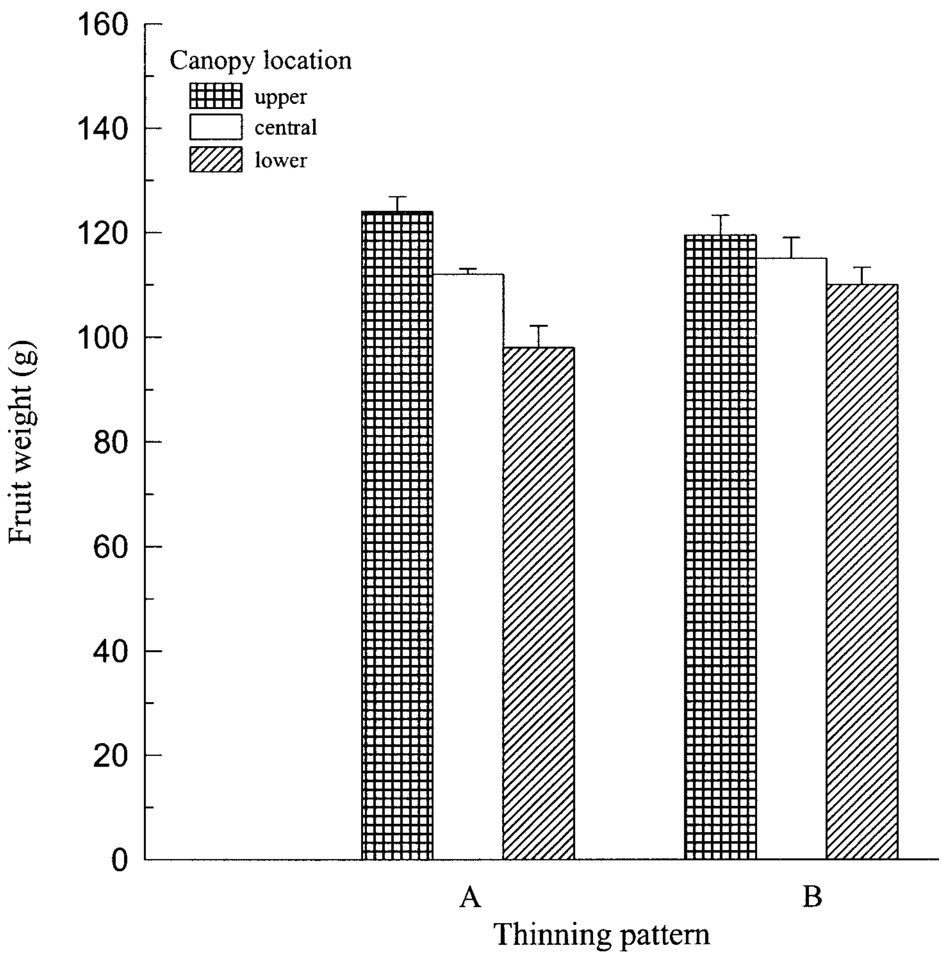

Fig. 2. Harvest fruit weight (mean ± SE) by canopy location and fruit thinning pattern for 'May Glo' nectarine trees in 1998 and 1999; A = thinned to one fruit every 30 cm (11.8 inches) of bearing shoot throughout the canopy; B = thinned to one fruit every 15, 30, or 45 cm (5.9, 11.8, or 17.7 inches) of bearing shoot within upper, central, or lower canopy locations, respectively; 1.0 g = 0.035 oz.

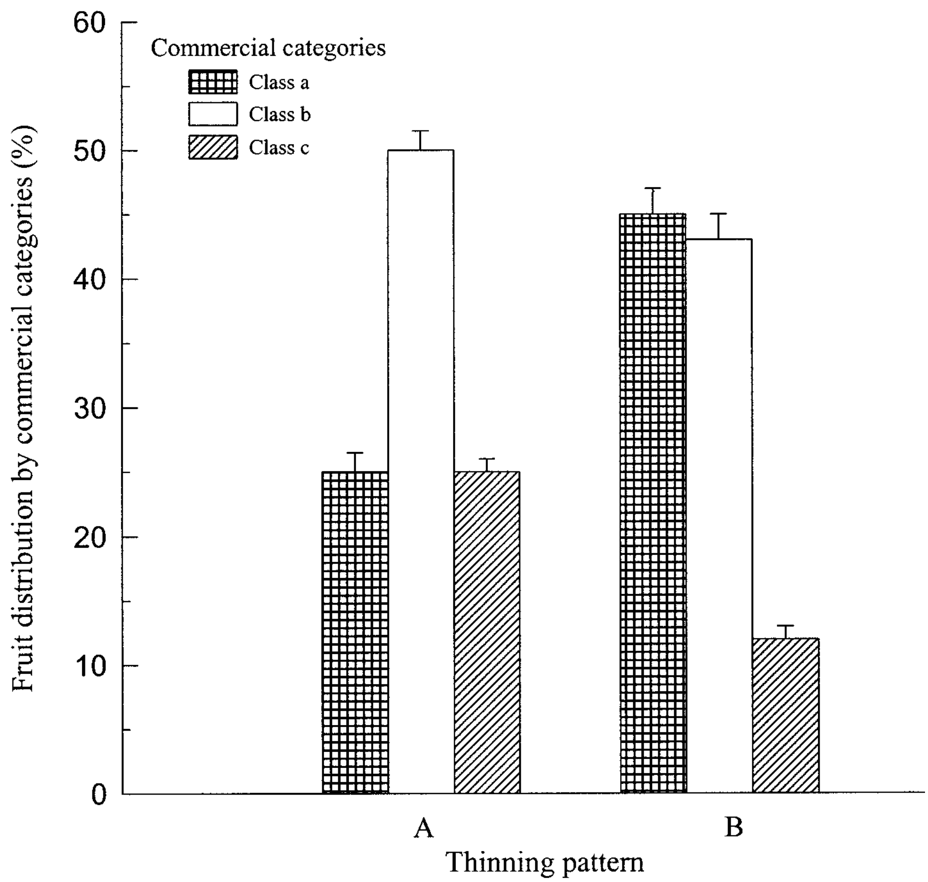

Fig. 3. Distribution of fruit (mean ± SE) in commercial categories [class a = fresh weight >110 g (3.85 oz), class b = fresh weight 90-109 g (3.15-3.80 oz), class c = fresh weight <90 g] from 'May Glo' nectarine trees in 1998 and 1999, in response to different thinning patterns [A = thinned to one fruit every 30 cm (11.8 inches) of bearing shoot throughout the canopy; B = thinned to one fruit every 15, 30, or 45 cm (5.9, 11.8, or 17.7 inches) of bearing shoot within upper, central, or lower canopy locations, respectively].

(11.8 inches) along the bearing shoots throughout the canopy; and "B" where one fruit was left every 15 cm (5.9 inches) along the bearing shoots in the upper part of the canopy, one fruit was left every 30 cm along the bearing shoots in the central part of the canopy, and one fruit was left every 45 cm (17.7 inches) along the bearing shoots in the lower part of the canopy.

Photosynthetic photon flux density (PPFD) was measured at fruit ripening time (22 May 1998 and 20 May 1999) between 1200 hr and 1300 hr, under a clear sky, using quantum sensors (LI-90; LI-COR, Lincoln, Nebr.) placed horizontally at 250 cm (98.5 inches), 150 cm (59.1 inches) and 80 cm (31.5 inches) from the tree base along the two main scaffolds.

Crop weight and fruit number were measured in each canopy location at each harvest date (beginning at the end of June). Fruit distribution within the canopy (percent) and a precocity index were calculated. The precocity index was determined as $\Sigma(yD)/Y$; where y = the yield (weight) per single harvest, D = days elapsed since the first picking, and Y = total yield. At harvest, trunk diameter was measured to calculate trunk cross-sectional area (TCA) and yield efficiency (weight of fruit per unit TCA).

At fruit harvest, the area of 100 leaves per tree canopy location, taken from central nodes of apical shoots, was measured with a leaf area meter (LI-

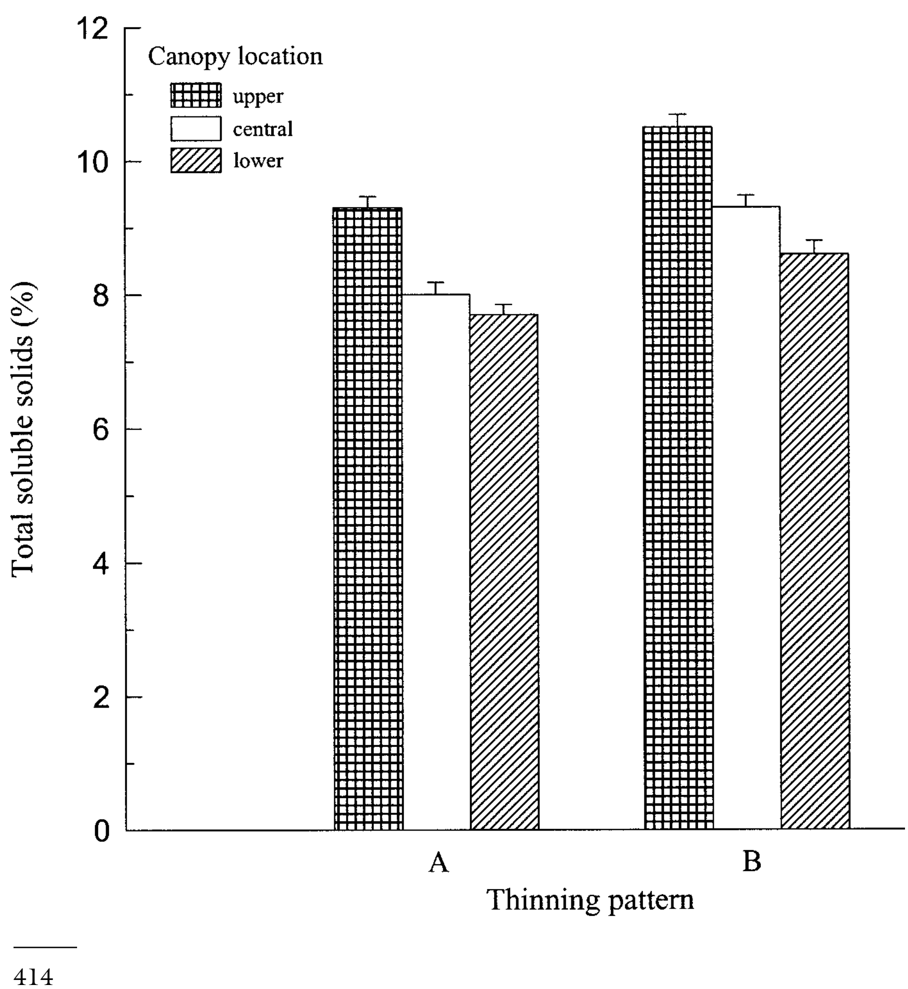

Fig. 4. Total soluble solids (TSS) content (mean ± SE) of fruit from 'May Glo' nectarine trees in 1998 and 1999, relative to thinning pattern [A = thinned to one fruit every 30 cm (11.8 inches) of bearing shoot throughout the canopy; B = thinned to one fruit every 15, 30, or 45 cm (5.9, 11.8, or 17.7 inches) of bearing shoot at upper, central, or lower canopy locations, respectively].

Table 1. Precocity index and fruit characteristics (means ± SE) in relation to different thinning patterns of Y-shaped 'May Glo' nectarine trees.

Treatment[z]	Precocity index[y]	Firmness (kg·cm^{-2})[x]	Total soluble solids (%)	Tritatable acidity (% malic acid)
A	4.3 ± 0.7	5.4 ± 0.08	8.5 ± 0.1	13.3 ± 0.2
B	10.1 ± 1.8	5.0 ± 0.01	9.4 ± 0.1	12.7 ± 0.2

[z]A = thinned to one fruit every 30 cm (11.8 inches) of bearing shoot throughout the canopy; B = thinned to one fruit every 15, 30, or 45 cm (5.9, 11.8, or 17.7 inches) of bearing shoot within upper, central, or lower canopy locations, respectively.

[y]Calculated as $\Sigma(yD)/Y$; where y = the yield (fruit weight) per single harvest, D = days elapsed since the first picking, and Y = total yield of the tree.

[x]1.0 kg·cm^{-2} = 14.2 lb/inch^2.

300), leaves were weighed to determine single leaf fresh weight and then dried in a forced-draft oven at 60 °C (140 °F) to constant mass to determine dry mass; specific leaf weight (SLW) was calculated as the ratio of leaf area to leaf dry weight. Individual fruit fresh weight, flesh firmness, measured on the fruit check, with a table penetrometer 8 mm (0.3 inches), total soluble solids content (TSS), measured with a digital refractometer (model Pr-1; Atago, Tokyo), and total tritatable acidity (TTA), were measured on a 10 fruit sample per tree, from each canopy location (total of 150 fruit per canopy location). Fruit were graded into commercial categories, and the percentage of fruit in class a [>110 g (3.85 oz) fresh weight], class b [90 to 109 g (3.15 to 3.80 oz) fresh weight], and class c (<90 g fresh weight) was calculated accordingly.

Results

Full sun over the canopy in the 2 years averaged 1700 m·mol·m^{-2}·s^{-1}. In the upper canopy layer, PPFD ranged from 1050 and 1120 m·mol·m^{-2}·s^{-1}, being 30% and 60% lower in the central and lower part of the canopy respectively averaged over 2 years. SLW changed with canopy environment, being highest in upper, sun-exposed section of the tree (Fig. 1); SLW was influenced by thinning only in the upper canopy location, where the higher number of fruit left by differentiated thinning resulted also in a higher SLW than in the corresponding location of uniformly thinned trees. Crop yield per tree was 19.8 ± 0.2 kg (43.6 ± 0.4 lb) and 18.2 ± 0.2 kg (40.1 ± 0.4 lb) in 1998 and 21.8 ± 0.3 kg (48.0 ± 0.7 lb) and 20.2 ± 0.4 kg (44.5 ± 0.9 lb) in 1999, respectively under differentiated and uniform thinning. Differentiated thinning resulted in the highest fruit number per tree (data not shown) and the highest yield efficiency in both years that reached 0.20 ± 0.012 and 0.27 ± 0.015 kg·cm^{-2} TCA, respectively for uniform and differentiated thinning.

Fruit weight was not affected by different thinning patterns at the upper and central canopy locations. Uniform thinning resulted in significant differences of fruit weight in relation to canopy location, with the highest fruit weight in the upper part of the canopy and lowest in the lower one. On the other hand, differentiated thinning resulted in the lowest fruit weight variability among canopy locations and in a significant increase of fruit size at the lower canopy location (Fig. 2). This accounts for the highest average fruit fresh weight [113 ± 1.8 g (3.99 ± 0.06 oz)] and the largest occurrence of fruit in class a, and the lowest rate of class c fruit (Fig. 3).

Flesh TSS content was highest in fruit harvested from the upper canopy location. In the upper and central part of the canopy, TSS content was highest in fruit under differentiated thinning patterns (Fig. 4).

Differentiate thinning also resulted in an earlier picking time (2 d) and in a shorter picking period (Table 1).

Discussion

The utility of distributing fruit crop according to canopy light environments was demonstrated since differentiated fruit thinning resulted in higher yield efficiency and reduced the variability of fruit in size and TSS within the tree, resulting in higher crop value. The higher production resulted from a greater fruit number and average fruit weight, and was also accompanied by a higher TSS. The higher crop density left on the upper canopy location (one fruit every 15 cm versus one fruit every 30 cm) did not affect the fruit size, indicating that commercial fruit thinning was overestimated. Moreover, the larger fruit spacing at the lower canopy location (one fruit every 45 cm versus one fruit every 30 cm) resulted in a higher fruit size, indicating that the optimal leaf to fruit ratio changes with canopy environment, i.e., light availability. Harvest time was also hastened by differentiated thinning which resulted in a shorter harvest window. Fruit quality was always better in the upper canopy locations, in terms of size, color and total soluble solids content. Our data demonstrate that thinning management should take into consideration difference in canopy environments that are able to sustain different crop loads.

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