prevailing condition we carried out the trials pollen of 'Conservolia' showed a low germination capacity and/or viability. Moreover this study pointed out that both shoots' and fruits' growth and fruit load regulation of the four cultivars originated in as many as Mediterranean areas can be represented by a unique model, at least when they are grown under the same environmental conditions.

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# Greenhouse Forced and Field Growing of 'Maravilha' Peach

T. CARUSO, P. INGLESE AND A. MOTISI

## Abstract

Ownrooted 'Maravilha' potted peach trees were investigated under field and greenhouse conditions to determine the effect of the environment on the development of fruits and apical shoots. Higher greenhouse temperatures soon after bloom hastened fruit growth rate and shortened the fruit development period without influencing harvested fruit size. Field temperatures during the Stage I of fruit growth were likely to be cooler than the optimum. Furthermore, Stage II of fruit growth was prolonged under field conditions thus fruits grown in the greenhouse from bloom onward reached harvest maturity 9 days earlier than those growing in the field. Absolute and relative shoot growth was enhanced by higher greenhouse temperatures.

## Introduction

Environmental conditions, chiefly temperature, substantially affect the length of the fruit development period (FDP) by advancing or delaying maturity time (13, 17, 23, 26). Forecasting models, based on temperature have been formulated to predict the ripening time of different fruit trees (7, 19, 21). Blake (6) found that FDP in peach was influenced by the prevailing temperatures during March and April. Other authors have confirmed that, in stonefruit, warm temperatures during bloom and soon after fruit set resulted in a shorter FDP and increased fruit size during Stage I of fruit development (2, 8, 16, 23, 24, 26). The larger fruit size reached at the end of Stage I has been associated with enhanced cell division (17) earlier foliation and larger leaf size (2). The interaction between temperature and fruit growth lasts throughout the growing season. Cool temperatures during Stage III of FDP reduce fruit growth while those above the optimal delay ripening and might result in a smaller fruit size at harvest (2, 17, 20). The earlier fruit ripening of peaches growing in the

Istituto di Colture Legnose Agrarie e Forestali. Università di Reggio Calabria. 89061 Italy.

greenhouse compared to field grown fruits has been related to a shorter FDP and, in turn, to a higher fruit growth rate which results from higher greenhouse temperatures (3, 4, 5). Other authors report that the earlier blooming time, rather than the shorter FDP, is primarily responsible for the precocity of fruit ripening of peaches and grapes forced in greenhouse (14, 22, 11). Furthermore the shorter FDP might result in a smaller fruit size if the growth rate does not increase accordingly. Actually, greenhouse conditions might strengthen the competition between fruit and shoot growth (12, 9) during the early stage of FDP while temperatures during the last stage of FDP might be critical for fruit growth (20). The aim of this experiment was to investigate the effect of a differentiated forcing period on fruit development and maturity of an early ripening peach cultivar.

## Material and Method

The experiment was carried out in Palermo (Italy), during 1990, on 60 two-year old own-rooted 'Maravilha' peach trees growing in 15 l pots. Fifteen trees were grown in a greenhouse for 84 days, from pink-bud stage until harvest (P-H); fifteen were left in greenhouse for 50 days, from pink-bud until pit-hardening (P-PH) and fifteen for 21 days, from pink-bud until two weeks after full bloom (P-FB + 2). Fifteen trees remained in the open field, close to the greenhouse, until harvest (OF). Two weeks after full bloom fruit density was reduced to four fruits per tree, spaced 30-35 cm apart along the stem. Polar and suture diameters of each fruit together

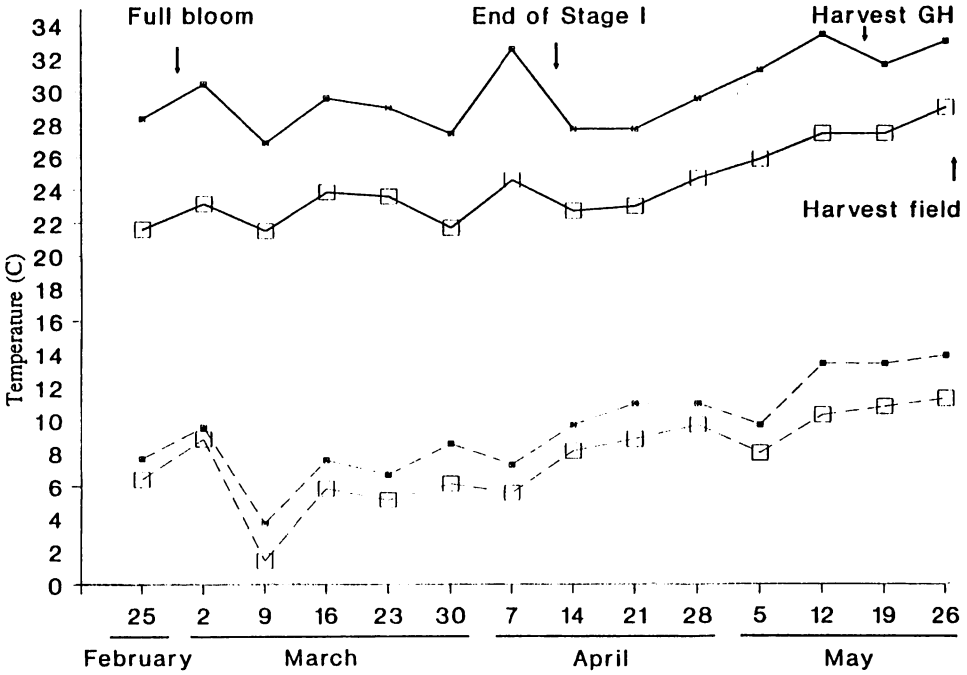



Figure 1. Maximum and minimum weekly temperatures (TMAX and TMIN) in open field and greenhouse (GH): —⊟— TMAX greenhouse; —⊟— TMAX open field; --⊟-- TMIN greenhouse; --⊟-- TMIN open field.

with the length of the apical shoot of each tree were measured weekly from fruit set (a week after bloom) to harvest. Fruits were harvested every second day according to the ground colour and the flesh firmness. Final measurement of shoot length, fruit size and weight, together with the fruit growth rate were analyzed by ANOVA and SNK test, using the trees as single replicates. Daily maximum and minimum temperature (TMAX and TMIN) were recorded both in the greenhouse and in the open field. Thermal time and growing degree hours (GDH) were calculated, from pink-bud stage to harvest using the procedure described by Munoz et al. (21) and ASYMCUR (1). Base temperature was 4 C and critical temperature was fixed at 35 C. The ASYMCUR model was checked within the range of 24 and 30 C and proved the best accuracy when 29 C was used as optimum temperature. Hourly temperatures were calculated according to Linvill (18).

## Results and Discussion

Both maximum and minimum weekly temperatures were higher in greenhouse than in the open field with an average difference of 5.58 C (± 1.15) and 1.77 C (± 0.47), respectively, throughout the FDP (Fig. 1). The GDH percent difference between greenhouse and open field reached the highest values during bloom and remained at high values until 50-55 days after FB; then decreased as the season advanced because of both the increase of open field temperatures and the occurrence of over-optimal temperatures in greenhouse (Fig. 2). ASYMCUR was more accurate than thermal time in predict-

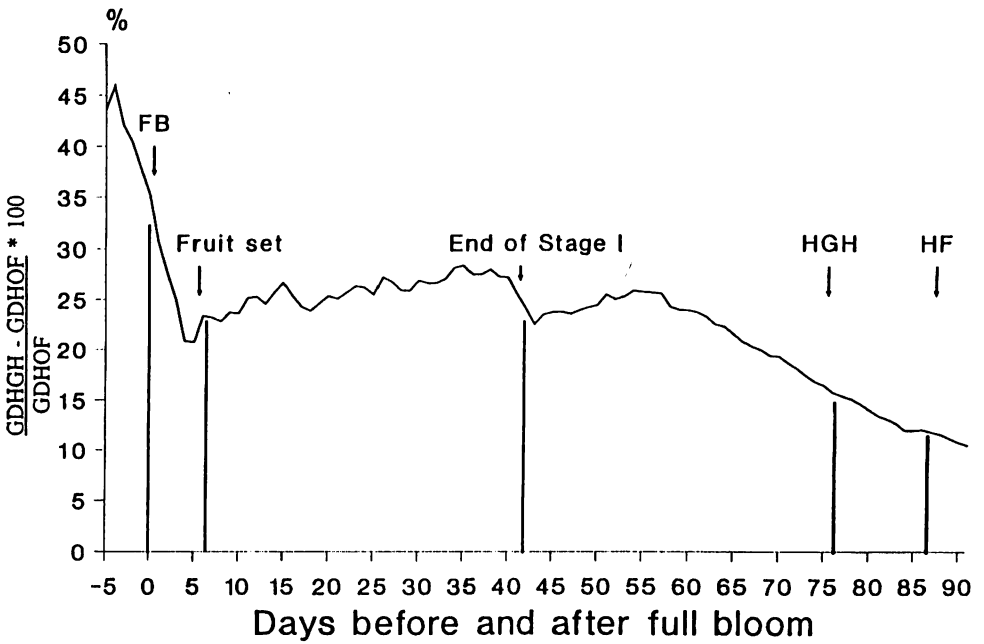



**Figure 2. Growing degree hours (GDH) percent difference between greenhouse and open field, according to the formula (GDHGH - GDHOF)/GDHGH * 100, were GDHGH = GDH in greenhouse and GDHOF = GDH ind open field. FB = Full bloom; HGH = Harvest of greenhouse fruits; HF = Harvest of open field fruits.**

**Table 1. Growth rate of 'Maravilha' peach fruits (mm/day) exposed to different periods of greenhouse and field environments.**

| | Days after full bloom | | | |
|---|---|---|---|---|
| | Stage I | | Stage II | Stage III |
| Treatments (a) | 0/14 | 14/42 | 42/49-56 | 49-56/harvest |
| OF | 0,50b | 0,56b | 0,45 n.s. | 0,69 n.s. |
| P-FB + 2 | 0,72a | 0,69a | 0,43 | 0,71 |
| P-PH | 0,71a | 0,71a | 0,44 | 0,69 |
| P-H | 0,71a | 0,71a | 0,44 | 0,71 |

Different letters denote significant differences within the column at P = 0.01.
(a) OF = open field;
P-FB + 2 = in greenhouse from pink-bud until two weeks after full bloom;
P-PH = in greenhouse from pink-bud until pit hardening;
P-H = in greenhouse from pink-bud to harvest.

ing harvest date, probably because it provides a better estimation of the above-optimal temperatures occurred in greenhouse. The same amount of GDH (25,500) was required for fruit ripening in greenhouse and open field. Thermal time accumulated until fruit maturity in greenhouse (1,300 C) was never reached in the open field. According to thermal time model, those values which correspond to fruit maturity in open field (1,130 C) would be reached ten days earlier than the actual ripening time in greenhouse (Figs. 3, 4). Shoots response to forcing in terms of absolute and relative growth lasted all along their development period. Trees grown in greenhouse developed a canopy more rapidly than those grown in the open field, even leaf size

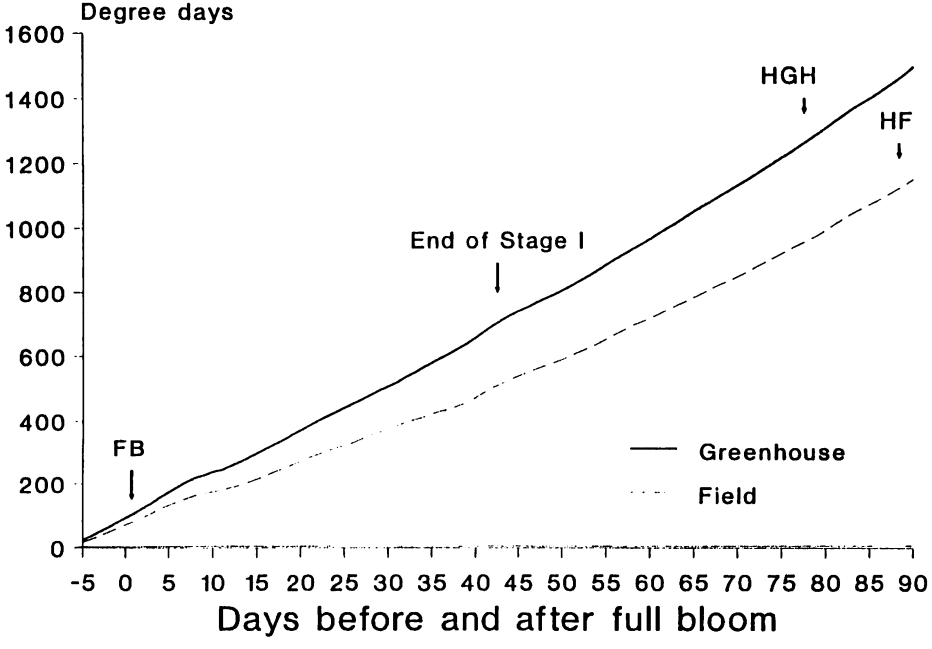



**Figure 3. Thermal time in open field and greenhouse from pink-bud to harvest. FB = Full bloom; HGH = Harvest of greenhouse fruits; HF = Harvest of open field fruits.**

was larger (data not shown). Apical shoots of trees left in the greenhouse for at least seven weeks after bloom (P-PH) were twice the final length of those on trees which were grown in the open field (OF) or those moved outside the greenhouse two weeks after bloom (P-FB + 2) (Fig. 5). Significant differences in shoot length between the greenhouse and open field grown trees begun in the earliest stages of their growth. The rate of apical shoot growth of trees placed in the greenhouse at pink-bud stage reduced significantly when moved outside two weeks after bloom (P-FB + 2) and, at the end of the season, they were the same length as those grown in the open field. The growth rate of the shoots showed a steady-state until five weeks after bloom then peaked 42 days after FB, at the beginning of Stage II, to decrease during the last weeks of growth recorded in April

**Table 2. Fresh weight of thinned and mature fruits of 'Maravilha' peach exposed to different periods of greenhouse and field environments.**

| Treatment (a) | Thinning | Ripening |
|---|---|---|
| OF | 5.78b (b) | 84.13 + 4.16 n.s. |
| P-FB + 2 | — | 82.40 + 3.75 |
| P-PH | — | 80.50 + 4.37 |
| P-H | 11.42a | 84.27 + 5.11 |

Different letters denote significant differences within the column at P = 0,01.
(a) OF = open field;
P-FB + 2 = in greenhouse from pink-bud until two weeks after full bloom;
P-PH = in greenhouse from pink-bud until pit hardening;
P-H = in greenhouse from pink-bud to harvest.
(b) Average weight of 25 fruits.

(Fig. 6). The effect of greenhouse temperature on fruit growth became evident at the earliest stages, both in terms of fruit size (Figs. 7, 8) and growth rate (Table 1). Thinned fruits of greenhouse forced trees were twice the length of those of the open field

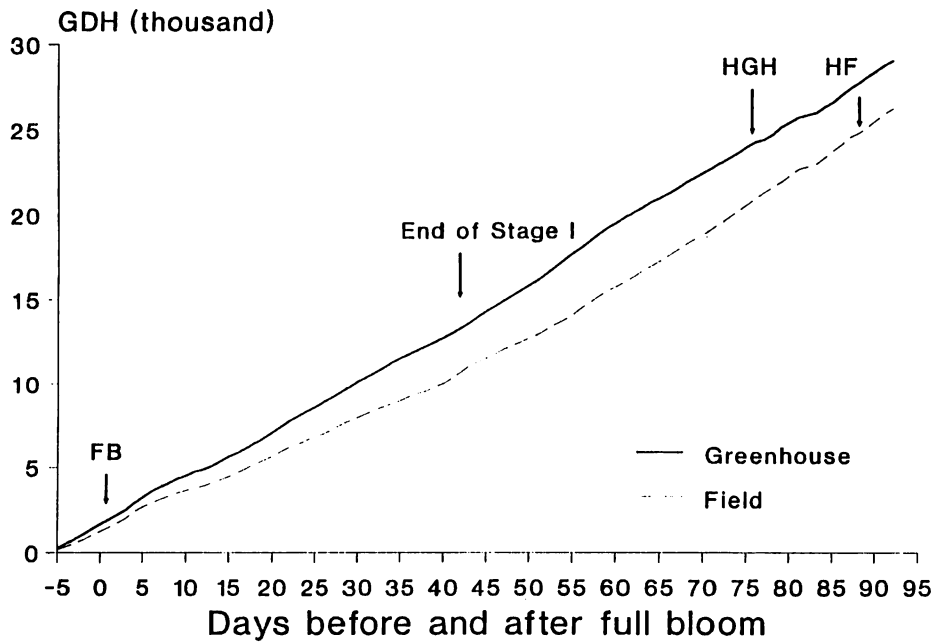



**Figure 4. Growing degree hours (GDH) summation in open field and greenhouse from pink-bud to harvest. FB = Full Bloom; HGH = Harvest of greenhouse fruits; HF = Harvest of open field fruits.**

(Table 2). Fruit growth follows the model described for early ripening cultivars (27). Stage II begins in greenhouse and open field 42 days after bloom irrespective of fruit size and growing conditions (25), but in the open field lasted for a longer time (15 days). The phase of reduced fruit growth (Stage II) was more evident in terms of polar than suture diameter (27) (Figs. 7, 8). Fruit growth rate did not differ among treatments during Stage II and Stage III of FDP (Table 1). No differences on shoot and fruit growth were recorded between trees which were grown in greenhouse from pink-bud stage to harvest (P-H) and those moved outdoors at pit-hardening (P-PH) (Figs. 5, 6, 7, 8). Average harvest time of fruits grown in greenhouse since pink-bud stage was 9 days earlier (77 days after bloom) than those grown in the open field. The fruit ripening period in trees that were moved outside the greenhouse at pit-hardening (P-PH) was more scattered than in trees grown continuously in greenhouse (P-H), so the average harvest date was delayed 2 days. Trees which were moved outside the greenhouse two weeks after bloom ripened their fruits 5 days earlier than those kept in the open field (OF). The shorter FDP in the greenhouse depended mostly on the higher fruit growth rate during Stage I, when greenhouse forcing provided temperatures more suitable for fruit growth than those in the open field. Actually, the GDH differential between the greenhouse and open field was higher early in the season than later on. This points out the importance of an accurate screening of the growing areas suitable for

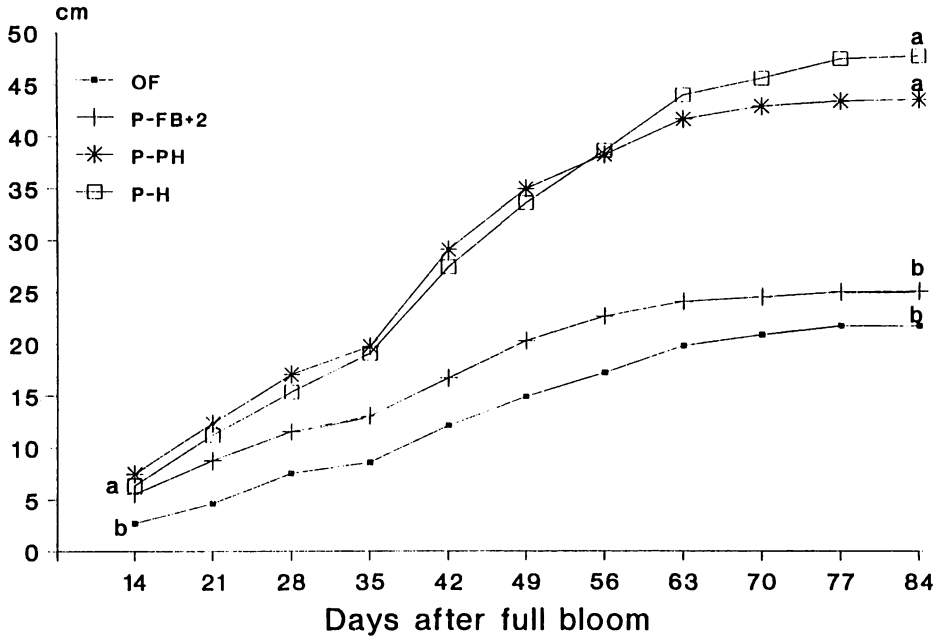



**Figure 5. Accumulated shoot growth (cm) of 1-year old 'Maravilha' peach trees growing for different periods within a greenhouse and in the field. OF = open field; P-FB + 2 = in greenhouse from pink-bud until two weeks after full bloom; P-PH = in greenhouse from pink-bud until pit hardening; P-H = in greenhouse from pink-bud until harvest. Different letters denote significant differences at P = 0.01.**

fruit growth of low chilling and early ripening peaches which bloom early in winter time. Furthermore, Stage II was a week shorter in greenhouse than in the open field grown fruits; this might account for the delay of ripening in trees moved outdoors two weeks after bloom (15, 10). Anyhow, the shorter FDP which results by forcing the trees from pink-bud until harvest partially accounts for the precocity of fruit ripening since fruits of peaches grown in greenhouse, from the earliest stages of bud swelling (40 days before bloom) until harvest, ripe 20-30 days earlier than in the open field (Caruso, unpublished data). The different length of the FDP did not result in any difference of final fruit size among treatments (Table 2) since the shorter FDP resulted from a higher fruit growth rate during the early stages of fruit growth and a shorter reduced-growth phase during Stage II. Finally, fruits growing in greenhouse until harvest showed less red over color than the other three treatments.

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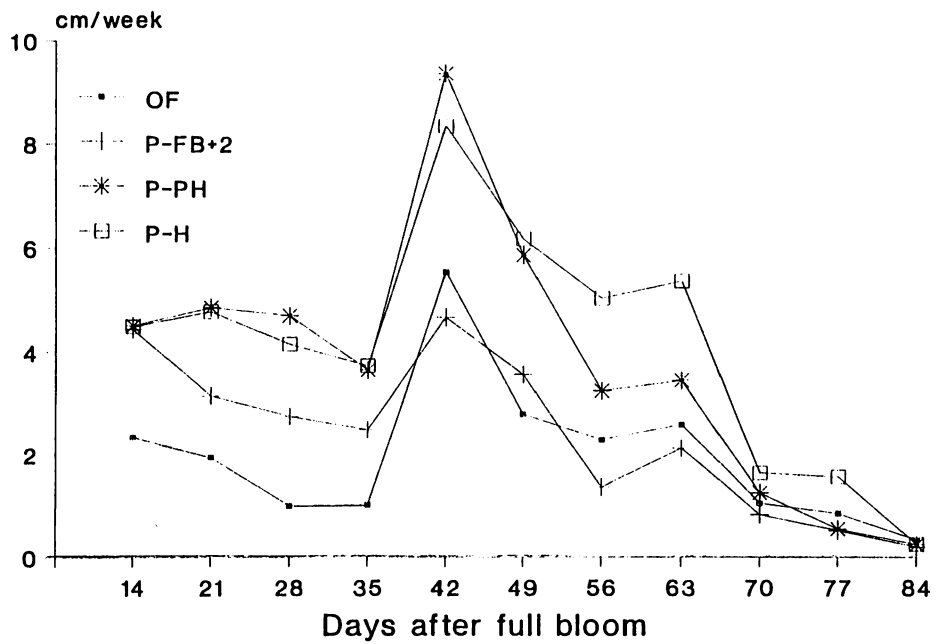




**Figure 6. Apical Shoot growth rate (cm/week) of 1-year old 'Maravilha' peach trees growing for different periods within a greenhouse and in the field. OF = open field; P-FB + 2 = in greenhouse from pink-bud until two weeks after full bloom; P-PH = in greenhouse from pink-bud until pit hardening; P-H = in greenhouse from pink-bud until harvest.**

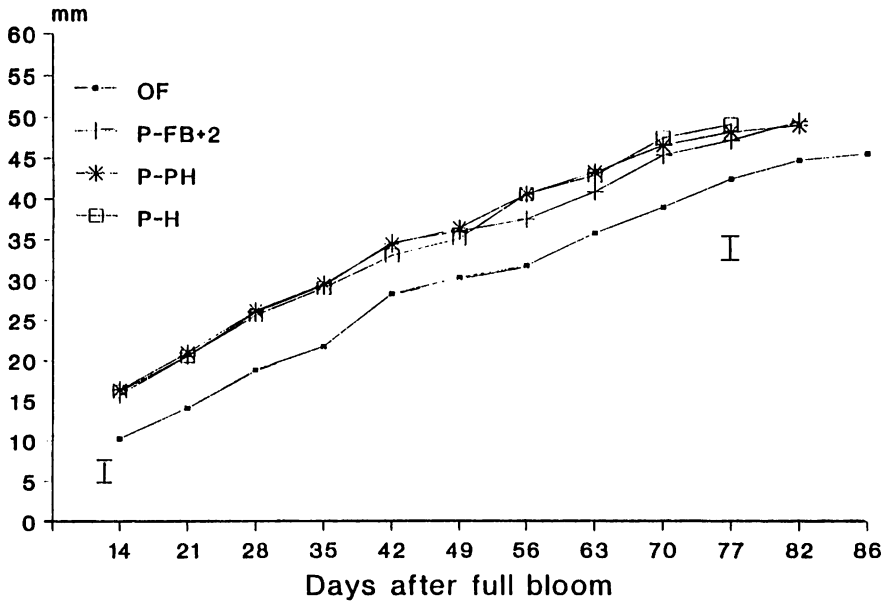



Figure 7. Fruit growth in terms of suture diameter (mm) of 1-year old 'Maravilha' peach trees growing for different periods within a greenhouse and in the field. OF = open field; P-FB + 2 = in greenhouse from pink-bud until two weeks after full bloom; P-PH = in greenhouse from pink-bud until pit hardening; P-H = in greenhouse from pink-bud until harvest. Bars denote L.S.D. at P = 0.01.

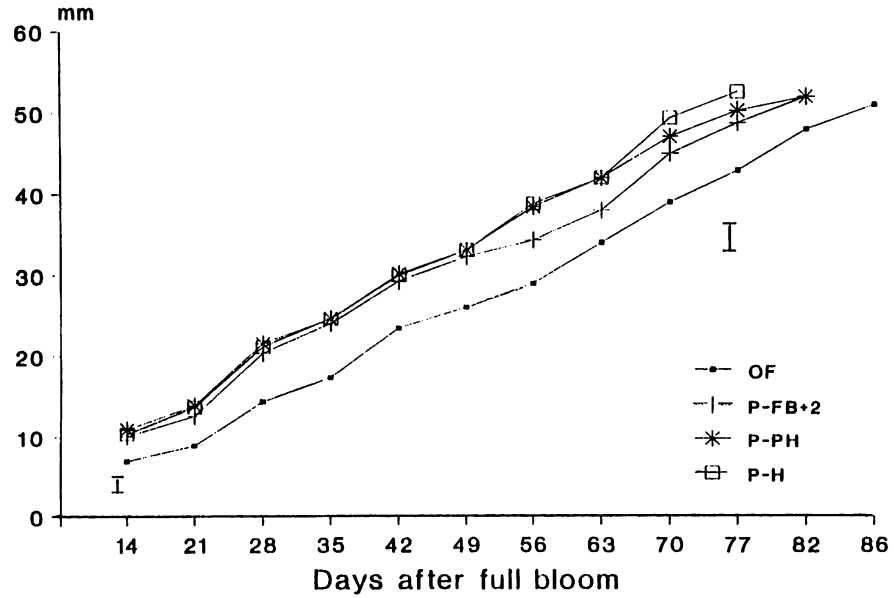



Figure 8. Fruit growth in terms of polar diameter (mm) of 1-year old 'Maravilha' peach trees growing for different periods within a greenhouse and in the field. OF = open field; P-FB + 2 = in greenhouse from pink-bud until two weeks after full bloom; P-PH = in greenhouse from pink-bud until pit hardening; P-H = in greenhouse from pink-bud until harvest. Bars denote L.S.D. at P = 0.01.

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## Fingerprints for 'Delicious' Sports

Isozyme electrophoresis has been used successfully to characterize and separate apple cultivars but closely related cultivars are difficult to separate. A new technique using DNA fingerprints was tried on 15 different sports of 'Delicious.' These sports exhibited almost identical fingerprints. Thus this technique may be successful in differentiating between cultivars devised through genetic recombination but not useful for differentiating vegetative sports.

From: Nybom, H. 1990. DNA Fingerprints in Sports of 'Red Delicious' Apples. *HortScience* 25(12):1641-1642.