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Peach Fruit Abscission by Shading and Photosynthetic Inhibition

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Abstract. **Shading of nectarine [*Prunus persica* (L.) Batsch] scaffold limbs 45–58 days after full bloom caused seed discoloration and fruit abscission. Shading of peach [*Prunus persica* (L.) Batsch] scaffold limbs from 31–41 days after full bloom caused greater fruit adscisson than shading from 11–21 or 21–31 days after bloom. The photosynthetic inhibitor, 3-tert-butyl-5-chloro-6-methyluracil (terbacil), applied to whole trees 35 days after full bloom induced fruit abscission. Terbacil at 500 ppm or higher caused excessive thinning. Fruit size was larger than hand thinned fruit, since overthinning occurred. Fruit color, soluble solids, and firmness of fruit from the 500 ppm treated trees were similar to fruit from hand thinned trees. No leaves abscissed, but marginal chlorosis occurred on less than 30% of the leaves at harvest. Flower bud numbers per cm of terminal length were similar to the hand thinned trees, but much greater than unthinned trees. Residue analysis of fruit at harvest from the 500 ppm terbacil treatment revealed 0.07 ppm in the fruit.**

The work of Abbott (1) and Quinlan and Preston (8) suggests that apple fruit abscission after fertilization and during "June drop" is due to a competition for essential metabolites between individual fruitlets, and between fruitlets and vegetative shoots. Schneider showed that naphthaleneacetic acid (NAA) thinning sprays decreased the amount of reducing sugars in young apple fruitlets (9, 10), and that one week of black cloth shading potentiated natural "June" drop in apples (11). In our preliminary experiments in peach, however, black fabric cloth caused burning of foliage which was due to high temperatures in the enclosures. For this reason, nursery-polypropylene shade material was used in experiments reported in this paper. Weinbaum and Simons (14) also showed reduced starch deposition in maternal seed tissue, and this, reduction was correlated with impending seed abortion in NAA-treated apples. Peach fruit pretreated with ethylene-releasing-chemicals at rates sufficient to cause fruit abscission showed a reduced translocation of ^{14}C-photosynthate (6), reduced ^{14}C-sucrose (11, 15), and ^{14}C-IAA translocation in excised peach pedicel segments (15). These data are consistent with the concept that natural or chemically-induced fruit abscission might be accentuated by limiting photosynthesis.

The objectives of these experiments were to investigate the amount and time of shading required to cause fruit abscission and to demonstrate that a photosynthetic inhibitor, terbacil, applied at this time could be used as a fruit thinner by temporarily limiting photosynthesis.

Five scaffold limbs of similar size and vigor were selected and tagged on each of 4 mature 'Nectared 5' nectarine trees in a randomized complete block design in 1981. One limb on each 'Nectared 5' tree was shaded from 45 to 58 days after full bloom with 0%, 73%, 82%, or 92% black polypropylene shade material (E. C. Geiger, Harleysville, Pa.), and a 5th limb was hand thinned 47 days after bloom. These shade materials were measured to give 70%, 79%, and 90% shade on an overcast day using a LI-COR Model LI-85 light meter with a quantum sensor. Fruit circumference and number were measured on uniformly sized sample limbs, 2.5–4 cm limb diameter, located within the shaded scaffold limb. Fruit size was determined during the slow growth stage (stage II) of fruit development which has been shown to correlate well with final fruit size (2).

On each of 4 'Redhaven' peach trees in 1982, one scaffold limb was shaded from 11 to 21 days, 21 to 31 days, or 31 to 41 days after full bloom with 90% polypropolyene shade material in a randomized complete block design. One additional limb on each tree was hand thinned 21 days after full bloom. Forty seven days after full bloom, the trees, including shaded limbs, were hand thinned in order to prevent limb breakage. Fruit number per branch and fruit size was determined at FB + 54 days as in 1981.

An evaluation of several photosynthetic inhibitors on greenhouse grown 'Redhaven' peach trees or limbs of field grown 'Madison' peach trees indicated that terbacil strongly inhibited net photosynthesis (Pn) for varying lengths of time at concentrations from 200–1500 ppm (4). Based on these preliminary data, 500, 1000, and 1500 ppm of terbacil (Sinbar 80% a.i.) were applied in 1, 2, or 3

Table 1. Effect of 13 days of shading and hand thinning on fruit set and fruit size of 'Nectared 5' nectarine (1981).

Treatment[z]	Timing (days after bloom)	Fruit/cm^2 cross sectional area (FB + 110 days)	Wt of fruit/limb (kg) (FB + 110 days)	Fruit diameter (cm) (FB + 110 days)
Control	---	33 a[y]	7.3 a	2.0 b
70% shade	45–58	21 ab	4.5 ab	2.0 b
79% shade	45–58	15 b	3.6 bc	2.0 b
90% shade	45–58	7 b	1.8 c	2.1 b
Hand thinned	47	16 b	5.0 ab	2.3 a

[z]One scaffold limb on each of 4 trees was shaded or thinned. Full bloom occurred 10 Apr. Ovule length was 11.4 ± 0.3 at 47 days after full bloom.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 2. Effect of shading on fruit set and fruit size of 'Redhaven' peach (1982).

Treatment[z]	Timing (days ater bloom)	Fruit/cm^2 cross sectional area (FB + 54 days)	Fruit diameter (cm) (FB + 54 days)
Hand thinned	21	4.8 a[y]	3.1 ab
92% shade	11–21	5.2 a	3.0 b
92% shade	21–31	4.0 a	3.2 ab
92% shade	31–41	0.7 b	3.4 a

[z]One scaffold limb on each of four trees was shaded at times indicated or hand thinned at 21 days. All limbs were thinned at 47 days to prevent tree breakage leaving fruit at about 10-15 cm intervals.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

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Table 3. Effect of rates and time of terbacil on 'Cresthaven' peach fruit abscission, fruit circumference, photosynthesis, and flower bud production (1983–84).

Rate[z] ppm	Timing (FB + days)	Total dose (ppm)	Fruit/cm² limb cross sectional area (FB + 71 days)	Fruit circumference (cm)	Leaf injury rating (0–5)	Photosynthesis (mg CO_2 dm^{-2} hr^{-1}) FB + 39	FB + 52	Terminal length (cm) (FB +320)	Flower buds per cm (FB +320)
Control	---	---	13.0 a[y]	5.1 c	0	11.6 a	24.3 a	35 ab	0.06 c
Hand thinned	---	---	5.6 b	6.2 b	0	---	---	33 ab	0.65 a
500	35	500	2.4 c	6.7 ab	0.5	0.5 b	13.3 ab	32 ab	0.67 a
500	33, 35	1000	1.4 cd	6.5 ab	2	2.1 b	13.3 ab	40 a	0.64 a
1000	35	1000	1.7 cd	6.6 ab	2	0.9 b	13.2 ab	44 a	0.58 a
500	31, 33, 35	1500	0.6 cd	6.8 a	3	−0.4 b	7.7 b	40 a	0.41 b
1500	35	1500	1.3 cd	6.4 ab	3	0.8 b	6.7 b	33 ab	0.32 b
1000	33, 35	2000	0.9 cd	6.5 ab	4	−1.3 b	7.7 b	29 ab	0.31 b
1000	31, 33, 35	3000	0.6 cd	5.6 c	5	−0.8 b	7.9 b	18 b	0.01 c
1500	33, 35	3000	0.9 cd	5.5 c	4.5	−0.5 b	6.5 b	33 ab	0.04 c
1500	31, 33, 35	4500	0.1 d	---	5	−0.1 b	3.4 b	21 b	0.01 c

[z]Treatments were applied when ovule lengths were 10.4 mm ± 0.3, 11.3 ± 0.3, 11.3 ± 0.4, and 12.6 ± 0.3 which corresponded to full bloom (FB) + 31, 33, and 35 days. Full bloom occurred 29 Apr.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

applications to 2 whole tree replicates per treatment in a randomized complete block design on 'Cresthaven' peach in 1983. Treatments were applied 31–39 days after full bloom with a hand gun sprayer at 10.5 kg/cm² (150 psi) to drip. Three limbs per tree were tagged prior to treatment. Fruit were counted 71 days after bloom (31 days after the last chemical treatment). Fruit circumference was determined with a band caliper on 10 fruit sampled from the periphery of each tree. Foliar injury was rated from 0 (none) to 5 (severe). Pn was measured at 4 and 17 days after the last treatment on 2 detached shoot samples per replicate. Shoots were cut in air, their basal ends placed in water, and transported to the lab where Pn determinations were made the following day on a young, fully expanded leaf. The shoot portion distal to the test leaf was cut off, and all but the test leaf removed. A fresh basal cut was made under water, leaving about 4 cm of shoot below the test leaf. The leaf chamber was a modification of one described by Syvertsen and Smith (12). Air flow rate was 3 liters min^{-1}, air temperature 28 ± 2°C, and relative humidity was 55 ± 5%. Photosynthetically active radiation was 900 $\mu mol\ m^{-2}s^{-1}$ and was supplied by four 500 w reflector flood lamps located 2 cm above an 18 cm deep flowing water bath (4). Fruit firmness was measured with a Magness-Taylor penetrometer with a 11.1 mm tip; the percentage of soluble solids was determined from a composite sample of 10 fruit using a Bausch & Lomb hand refractometer. Red color was estimated visually as the percentage of the fruit surface showing red, and ground color was rated from 1 (green) to 5 (yellow). A 2.5 kg sample of fruit from the 500 ppm and control treatments at harvest were analyzed for terbacil using standard liquid chromatographic methods described by Pease et al. (7). Five terminal shoots were collected from the periphery of each tree at a height of 2.2 m in March 1984. Terminal length, number of flower buds, and number of nodes were determined.

'Nectared 5' scaffold limbs under 79% and 90% shade frome 45 to 58 days after full bloom had reduced fruit numbers and fruit weight at harvest (Table 1). The regression analysis of fruit numbers per cm² cross sectional area gave a significant quadradic component ($y = 33 + 0.24\times - 0.0058\times^2$, $R^2 = 0.99$). Fruit from shaded limbs were smaller than hand thinned fruit, but as large as unthinned controls. Maximum air temperature of 33°C during the period was similar inside and outside the shade treatment.

Table 4. Effect of terbacil on 'Cresthaven' peach fruit quality near harvest (1983).

Rate[z] ppm	Timing (FB + days)	Total dose (ppm)	Firmness (newtons)	Soluble solids (%)	Red color (%)	Ground color (0–5)
Control	---	---	66 ab[y]	7.8 e	63 ab	3.7 ab
Hand thinned	---	---	44 b	10.3 bcd	65 a	4.3 a
500	35	500	60 ab	10.9 abc	73 a	3.9 ab
500	33, 35	1000	80 ab	11.3 ab	59 abc	3.2 bc
1000	35	1000	80 ab	10.9 abc	61 abc	3.4 abc
500	31, 33, 35	1500	84 ab	12.4 a	66 ab	3.3 abc
1500	35	1500	105 a	10.3 bcd	50 bc	2.6 cd
1000	33, 35	2000	85 ab	11.6 ab	62 abc	3.2 bc
1000	31, 33, 35	3000	---	---	---	---
1500	33, 35	3000	105 a	8.8 de	40 c	2.2 d
1500	31, 33, 35	4500	---	---	---	---

[z]Treatments were applied when ovule lengths were 10.4 mm + 0.3, 11.3 ± 0.3, and 11.3 ± 0.4, which corresponded to full bloom (FB) + 31, 33, and 35 days. Full bloom occurred 29 Apr.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Shading of 'Redhaven' scaffold limbs from 31 to 41 days after bloom led to greater fruit abscission than limbs shaded from 11 to 21 days, or from 21 to 31 days after bloom (Table 2). Fruit from limbs shaded from 31 to 41 days after bloom was of similar size to hand thinned fruit. This period also corresponds to the beginning of the natural "June" drop period in peach (3).

Upon removal of the shade cloth, no leaf yellowing or leaf abscission was noticed. Fruits that were visibly shrivelled or yellow in color exhibited significant browning of the seed tissues. Some small fruit that seemed normal also had brown seeds, and these abscissed. At harvest, fruit remaining from shaded limbs appeared normal.

Since shading was most effective from 31 to 41 days after bloom the application of terbacil in the 1983 test was timed 30–35 days after bloom. Terbacil inhibited Pn for several days after treatment (Table 3). Rates were too high, and overthinning occurred with all treatments. Treatments that received a total dose of 2000 ppm or above caused defoliation, inhibition of leaf size, and a reduction of flower buds per cm of shoot. In addition, the unthinned control produced only 10% of the flower buds for the subsequent season in comparison to the hand thinned or the 500 or 1000 ppm treatments. A total dose of 500 ppm caused some marginal leaf chlorosis on 30% or less of the leaves at harvest and no leaf drop. With this concentration, fruit numbers per cm² cross sectional area of limb were reduced to one-half that of the hand thinned trees. Fruit size was greater than the control and hand thinned treatments at harvest. Residue analysis of fruit from the 500 ppm treatment showed a terbacil concentration of 0.07 ppm in the fruit. The legal tolerance set by the Environmental Protection Agency is currently 0.1 ppm for terbacil when used as a herbicide in peaches. Very high rates (a total dose of over 3000 ppm) caused a significant increase in fruit firmness, and decreases in fruit size, red color and ground color when compared to the hand thinned control or the 500 ppm terbacil treated fruit (Table 4). Since rates lower than 500

ppm would likely be adequate for thinning, these effects are not expected to be of importance.

Since fruit, vegetative growing points, and other plant organs are competing sinks for several energy requiring mechanisms, the effect of shading or photosynthetic inhibitors could alter several essential physiological and biochemical functions significantly. Previous work suggests the 1st step in the ethylene-releasing-compound induction of peach fruit abscission is a reduced translocation rate of ^{14}C photosynthate (6) and ^{14}C-sucrose (11, 15). Additional effects of limiting Pn could be production, transport, and function of plant hormones, carbohydrates, proteins and lipids, enzyme synthesis, RNA and DNA synthesis, phloem loading, maintenance of concentration gradients and several other energy requiring processes (5, 13).

Data presented here demonstrate that limiting photosynthesis by shading or by applying terbacil (a chemical photosynthetic inhibitor) caused fruit abscission in peach and nectarine. Further, the period when 'Redhaven' peach trees seemed most susceptible to shading was about 31–41 days after full bloom, and terbacil was an effective [fruit abscission] agent at this period. Terbacil and/or other photosynthetic inhibitors may have potential for post bloom thinning of stone fruit, and should be investigated to potentiate other chemical thinning agents such as carbaryl or NAA in apples.

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Soil and Foliar Application of Magnesium Compounds for the Control of Magnesium Deficiency in 'Shamouti' Orange Trees

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Abstract. **Band application of $MgCl_2 \cdot 6H_2O$ under the tree canopy of 'Shamouti' orange [*Citrus sinensis* (L.) Osbeck] trees significantly increased leaf Mg and Cl concentration. $MgSO_4$ and MgO were not effective. Fertigation with $MgCl_2 \cdot 6H_2O$ was less efficient than band application and was not superior to foliar application of $Mg(NO_3)_2 \cdot 6H_2O$ for increasing leaf Mg concentrations. In spite of high Cl concentration of the leaves, no visible toxicity symptoms were observed.**

Magnesium deficiency, well-known in Israel, is especially widespread in the Mediterranean coastal region characterized by light sandy soils. This problem has become of increasing concern to citrus growers and, in recent years, has been encountered in previously unaffected orchards. The causes vary, but among them may be the increasing use of potassium in both soil and foliar fertilization. Additionally, the widespread use of commercial fertilizer materials free of Mg and trace elements may be a factor contributing to the increasing occurrence of Mg deficiency in citrus trees (8).

No direct relationship has been found between moderate Mg application to orange trees and yield. Furthermore, yield increase was obtained only after the 5th successive year of Mg sprays in trees severely Mg deficient (11).

Using leaf Mg deficiency symptoms rather than yield as a guide to the Mg level may lead to the application of insufficient quantities of Mg. Pratt and Harding (13) theorized that in California, soils of low cation exchange capacity and the use of high Ca and low Mg irrigation water was most likely to produce Mg deficiency. This finding followed an earlier work by Heymann-Herschberg (9) showing that applications of $MgCl_2$ and $MgSO_4$ were not effective in correcting Mg deficiencies in sandy soils along the coastal plain of Israel. The latter salts were applied in quantities ranging from 0.25 to 2 kg per tree annually for 2 successive seasons. Jacoby (10) concluded that an exchangeable Ca/Mg ratio in the soil greater than 4:1 impaired Mg uptake by citrus seedlings. Lack of success in achieving adequate control of Mg deficiency by use of Mg fertilizer materials and only partial success with application of $MgSO_4$ sprays led to the use of $Mg(NO_3)_2 \cdot 6H_2$ as foliar spray material (2). Jones et al. (11) pointed out, however, that only a small fraction of the Mg from foliar sprays is translocated from old to young foliage, necessitating a program of annual sprays.

The site of the experiments was the major producing area of 'Shamouti' orange in the central coastal strip of Israel, which is characterized by light sandy soil of 7 to 8 pH. Four experiments were conducted at different growers' orchards. In all locations, 'Shamouti' orange trees, grafted on sweet

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