lesser response to the GA as the size of the phyllomorph which received the GA increases. The resulting homogeneity of slopes for the separate inflorescences within each cultivar serves to solidify the universality of the GA effect, by indicating that the 3 inflorescences react in a similar manner to the exogenously applied GA. The broad-based nature of this response is unusual for experimentation involving an exogenously applied growth regulator, and it is the first report for the genus *Streptocarpus*. Yet, this general correlation could be defined further. Was the late flowering, which typified the 1 cm phyllomorphs, actually an inhibition effect due to GA, while the relatively early responses of the 6 cm phyllomorphs representative of a GA-induced promotion of flowering? Unfortunately, the data were too variable to arrive at this conclusion unequivocally. Although it is true that 2 lines exhibited significantly delayed flowering when the 1 cm phyllomorph was treated with GA, and 2 other lines exhibited accelerated anthesis when the 6 cm phyllomorph was treated, no line exhibited both (Table 2). Even though GA has been shown to inhibit flowering of other species when applied to nonreproductive plants (11, 12, 15), and accelerate flowering when applied to plants possessing primordial flowers (8), the present study can only partially support these previous findings.

In pragmatic terms, this study has shown that if 25 µg GA/plant is to be used for the acceleration of *Streptocarpus* flowering, it should be applied when the phyllomorph is at least 6 cm in length. Early applications, especially at young seedling stages, when the reproductive status of the plant is unknown, could result in no effect at all, or risk the chance of flowering inhibition. Fears of excessively elongated flower peduncles and/or the possibility of GA only accelerating the first flower are unfounded with this treatment.

**Literature Cited**

2. Dubuc-Lebreux, M.A. and J. Vieth. 1976. Effets de quelques regulators de croissance sur la morphologie florale et inflores-


**Predicting the Dates of First Commercial Harvest of Selected Ontario Peach Cultivars**

Richard B. Smith

Horticultural Research Institute of Ontario, Vineland Station, Ontario, Canada L0R 2E0

*Additional index words.* equation, maturity, *Prunus persica*, degree days, heat units, bloom dates

**Abstract.** Multiple linear regression analysis was used to develop commercial harvest prediction dates for peach ‘Earlired’, ‘Redhaven’, and ‘Loring’. Prediction equations were developed using degree day summations and date of full bloom as variables. These equations were adjusted for geographic microclimatic variation and tested in 6 commercial peach orchards over 4 years. Predicted dates and actual first commercial harvest dates differed by 4 days or less for 100%, 96%, and 84% of the predictions for ‘Earlired’, ‘Redhaven’, and ‘Loring’, respectively.

Maturity prediction systems have been developed for a number of fruit crops, in particular, apple (3, 8), apricot (2), prune (5), and peach (15). Most prediction equations are not applicable to other climatic areas or other cultivars (1). In most prediction systems, growth and development are considered to be primarily a function of temperature (1, 2, 5, 8) and/or bloom date (3, 4). A number of prediction systems have been developed in which temperatures for a specific postbloom interval are considered to be the most important variable in determining when fruit matures (8, 9).

The objective of this study was to use historical bloom and harvest date data from commercial orchards to develop and evaluate a commercially feasible maturity prediction system for selected peach cultivars grown in the Niagara Peninsula of Ontario.
Materials and Methods

The peach cultivars used in this investigation were 'Earlired', 'Redhaven', and 'Loring'. Full bloom and first commercial-harvest dates were available from peach growing areas in the Niagara Peninsula of Ontario for the years 1970 to 1979. In this investigation, full bloom was the date when about 80% of the flower buds were fully open and was measured as days elapsed from 1 Apr. (11). Dates of full bloom were obtained from the records of 5 growers and verified for consistency with bloom date records at the Horticultural Research Institute of Ontario (H.R.I.O.). The first commercial pick made by the grower was recorded as the date of first commercial harvest. Climatological records were obtained from the Vineland Rittenhouse meteorological station (6), located within the peach growing area.

The climatological data were used to develop variables which represented average daily heat unit summations, expressed as degree days [summations of (maximum temp. + minimum temp.)/2] in 5 day increments from full bloom to first commercial harvest only for 0° and 5°C (7, 11) threshold temperatures. These variables, calculated for each cultivar, year, and location were subjected to regression analysis using a Tektronix Statistics Volume 1, Plot 50 Program. Goodness of fit was determined for several potential curve forms. The best equation and time interval for degree day summations were selected by computer and by comparing the correlation coefficients (r).

A multiple linear regression analysis then was conducted using a Tektronix, Volume 3 — Plot 50 Program. Variables were degree days, rain (mm), sunshine (hours), degree days for the interval 1 Apr to bloom date, and date of full bloom. The variables rain, sunshine, and (degree days)^2 were summed for the same time intervals as the degree-day summations. The effect of each variable on the equations was determined by using the t test and observing changes in R^2 (multiple coefficient of determination) (12).

The first commercial-harvest prediction equations thus formulated were evaluated through 4 harvest seasons (1980–83) at 6 locations. During this evaluation period, full bloom was recorded each year by the staff of the H.R.I.O. Samples of peaches for laboratory studies were selected at each location on the date of first commercial harvest as determined by the grower and marketing board personnel. The stage of maturation was determined by analysis of ethylene production (13, 16) using a Hewlett Packard 7620A gas chromatograph. After 3 days in a 20°C ripening room, fruit quality was evaluated by a taste panel.

Since only one meteorological station was used in this study, correction factors had to be estimated and applied to the maturity prediction for the 6 locations. This correction factor initially was calculated using historical dates of first commercial harvest (unpublished data, Ontario Tender Fruit Producers’ Marketing Board) and later by temperature differences between locations. The predictions, modified for microclimates, were recorded as the adjusted predicted harvest dates. Consultation with peach marketing agencies indicated that an accuracy of ± 4 days for 90% of the predictions was commercially acceptable.

Results and Discussion

Preliminary simple regression analyses indicated that the variables which had a significant effect (t test, α = 0.05) on the development of peaches were bloom date and postbloom temperatures expressed as degree days for both 0° and 5°C thresholds. The highest correlation, r (Fig. 1), was obtained using a 0° threshold for 40 days past full bloom for ‘Earlired’, and 60 days for ‘Redhaven’, and a 5° threshold for 80 days past full bloom for ‘Loring’. The development of ‘Loring’ also was influenced by temperatures between 1 Apr. and bloom (0° threshold). No other variable evaluated had a significant effect on the number of days from full bloom to first commercial-harvest date.

The relationship between each of the independent variables and the number of days from full bloom to first commercial-harvest was linear (Fig. 1). The later the bloom date and the higher the temperatures after full bloom, the shorter the interval to first commercial-harvest. A negative correlation between high temperatures and number of days from bloom to harvest has been recorded for ‘Elberta’ peaches (15) and for apples (4, 8). Also, the negative correlation between date of bloom and number of days from bloom to harvest (Fig. 1) has been documented for apples (3). Although the linear model provided the best fit for the data, it does not preclude the possibility that the effects of temperature varied throughout the growing season (14). It is also possible that threshold temperatures other than 0° or 5°C may provide data for improving prediction accuracy. However, considering that there was little difference between 0° and 5° in the magnitude of r, a significant improvement was not expected, and thus, other threshold temperatures were not evaluated.

The multiple linear regression equations developed from the variables which had a significant effect on fruit development are found in Table 1. The multiple coefficient of determination (R^2) and the analysis of variance for regression (F test) indicate that there is a statistically significant relationship between the variables in the prediction equation and the number of days from full bloom to first commercial harvest.

The R^2 values were quite similar for degree day summations for intervals from 40 to 50, 60 to 70, and 80 to 90 days for ‘Earlired’, ‘Redhaven’, and ‘Loring’, respectively. The shortest time interval provided the highest R^2 and the earliest prediction. The respective time intervals are associated with the termination of pit hardening and the initiation of final growth swell which starts about 4 weeks before harvest (10). With a number of fruit crops, temperatures during one part of the growing season have more effect on fruit development than during another (2, 8, 9).

The peach growing areas of the Niagara Peninsula are affected by many microclimates due to the proximity of Lakes Ontario and Erie, the Niagara escarpment, the Niagara River, and the Welland Canal (Fig. 2). The difference in actual harvest dates between the warmest and coldest area studied was 10 days in some seasons (Table 2). Differences of 6 to 8 days are considered normal (unpublished data, Ontario Tender Fruit Producers’ Marketing Board). The equations developed were based in part on bloom dates representative of the climatic areas; thus, the bloom date coefficients in the prediction equations compensate for differences among locations. Date of bloom varied in excess of 30 days between years (Fig. 1), but seldom exceeded 2 days for a cultivar in any one year. Based on the latter fact, the growers assessment of date of full bloom, when consistent with those recorded at the H.R.I.O., provide a sound data base for developing the prediction equations.

Since there were insufficient data within zones, and temperature records were not available for all microclimates, climatic data from Vineland Rittenhouse (Fig. 2) were used to determine the relationship between temperature and development. Thus, the prediction dates are biased toward an average. An adjustment factor therefore was used to compensate for temperature differences among locations. This factor initially was calculated from historical harvest dates (Ontario Tender Fruit Producers’ Marketing Board). However, climatic data do show that the
Fig. 1. The relationship between full bloom (days elapsed from 1 Apr.) and heat units (0°C threshold, summed for 60 days past full bloom) on the number of days from full bloom to the date of first commercial harvest of 'Redhaven' peaches (**significant at 0.01) for the years 1970 to 1979.

Table 1. Equations for predicting the date of first commercial harvest for the peach 'Earlired', 'Redhaven', and 'Loring' grown in the Niagara Peninsula of Ontario.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Equation</th>
<th>$R^2$</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earlired</td>
<td>$Y = X_{bd} (-0.2038) + X_{040} (-0.0498) + 114.2$</td>
<td>0.77**</td>
<td>41**</td>
</tr>
<tr>
<td>Redhaven</td>
<td>$Y = X_{bd} (-0.3805) + X_{060} (-0.0232) + 134.9$</td>
<td>0.74**</td>
<td>62**</td>
</tr>
<tr>
<td>Loring</td>
<td>$Y = X_{bd} (-0.3402) + X_{04ab} (-0.0214) + X_{580} (-0.0222) + 153.1$</td>
<td>0.95**</td>
<td>216**</td>
</tr>
</tbody>
</table>

Y is the interval in days from full bloom to first commercial harvest, $X_{bd}$ is full bloom date and $X_{040}$ is a heat unit summation for 40 days past full bloom using 0°C as the threshold temperature.

$X_{040}$

$X_{060}$

$X_{04ab}$

$X_{580}$

** $\alpha = 0.01$ for both $R^2$ and F.

** $\alpha = 0.01$ for both $R^2$ and F.

Virgil Brights meteorological station (Fig. 2) has an average daily temperature 1°C warmer than Vineland (6). Virgil Brights is near the warmest (locations 1 and 2) (Fig. 2), and Vineland is near the coolest (location 6) climatic areas. The temperature differences between the warmest and coolest areas would result in at least 40 ('Earlired'), 60 ('Redhaven'), and 80 ('Loring') degree days of heat accumulation during the prediction interval. Regression analysis showed that for every 100 degree days, there was an 8.6, 6.5 (Fig. 2), and 5.1 day change in the interval from bloom to harvest for 'Earlired', 'Redhaven', and 'Loring', respectively. On a proportional basis, this degree day difference would account for 3.4, 3.9, and 4.1 days in the respective correction factors ('Earlired': $\frac{40}{100} \times 8.6 = 3.4$, 'Redhaven': $\frac{60}{100} \times 6.5 = 3.9$, 'Loring': $\frac{80}{100} \times 5.1 = 4.1$). Temperature differences between locations during the latter 4 to 5 weeks of the growing season, which are not a part of the degree day summations used in the prediction equations, would contribute sufficiently to fruit development to accommodate the remaining portion of the 5 day correction factor.

The adjusted predicted harvest date was within 4 days of actual first commercial harvest date 100%, 96%, and 84% of the time for 'Earlired', 'Redhaven', and 'Loring', respectively. In only 4 of 59 predictions did the actual and predicted harvest
Table 2. Comparison of adjusted predicted and actual, first commercial harvest dates of ‘Earlired’, ‘Redhaven’ and ‘Loring’ peaches.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Prediction date adjustment</th>
<th>‘Earlired’</th>
<th>‘Redhaven’</th>
<th>‘Loring’</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>-2</td>
<td>22 July -1</td>
<td>11 Aug. 0</td>
<td>24 Aug. +4</td>
<td>24 Aug. +2</td>
</tr>
<tr>
<td></td>
<td>-2</td>
<td>21 July +2</td>
<td>11 Aug. +2</td>
<td>28 Aug. +4</td>
<td>23 Aug. +2</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>29 July 0</td>
<td>16 Aug. +2</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>28 July +4</td>
<td>17 Aug. +2</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>27 July +3</td>
<td>18 Aug. -4</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>-</td>
<td>18 Aug. +1</td>
<td>29 Aug. +6</td>
<td>29 Aug. +6</td>
</tr>
<tr>
<td>1981</td>
<td>-2</td>
<td>18 July -1</td>
<td>9 Aug. -3</td>
<td>21 Aug. 0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-2</td>
<td>20 July 0</td>
<td>8 Aug. -2</td>
<td>21 Aug. 0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>24 July -4</td>
<td>13 Aug. -5</td>
<td>25 Aug. -3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>24 July -3</td>
<td>14 Aug. -2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>24 July -3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-2</td>
<td>23 July -4</td>
<td>13 Aug. -1</td>
<td>26 Aug. -3</td>
<td>30 Aug. +2</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>28 July 0</td>
<td>18 Aug. +1</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>29 July 0</td>
<td>19 Aug. +1</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>29 July 0</td>
<td>19 Aug. -1</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>-</td>
<td>19 Aug. +2</td>
<td>31 Aug. +6</td>
<td>31 Aug. +6</td>
</tr>
<tr>
<td>1983</td>
<td>-2</td>
<td>23 July +2</td>
<td>-</td>
<td></td>
<td>24 Aug. +3</td>
</tr>
<tr>
<td></td>
<td>-2</td>
<td>-</td>
<td>24 Aug. +1</td>
<td>24 Aug. +1</td>
<td>28 Aug. +2</td>
</tr>
<tr>
<td></td>
<td>+2</td>
<td>27 July 0</td>
<td>14 Aug. +1</td>
<td>28 Aug. +3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>28 July -2</td>
<td>15 Aug. 0</td>
<td>29 Aug. +4</td>
<td>29 Aug. +4</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>28 July 0</td>
<td>15 Aug. +2</td>
<td>29 Aug. +2</td>
<td>29 Aug. +2</td>
</tr>
</tbody>
</table>

* Grower location as shown in Fig. 1.

+ ‘Adj. pred.’ is predicted date adjusted for location, and ‘Act.’ is commercial harvest days before (−) or after (+) predicted.

x Negative = predicted date advanced, positive = predicted date delayed.

w No data for year or no trees of that cultivar.

dates differ by more than 4 days. Harvest dates for ‘Loring’ were more variable than expected, considering the magnitude of $R^2$. Late harvesting and excessive crop load for the size and vigor of the trees could have been factors. Ethylene analysis and firmness of the fruit indicated fruit from location 6 were considerably more mature than fruit from other locations in 1980. In 1982, the crop yield at locations 5 and 6 may have been excessive for the vigor of the trees because of tree injury, a result of excessively cold midwinter temperatures, or insufficient thinning following the loss of the 1981 crop. If these extremes were excluded, the equation for ‘Loring’ would have functioned within the preset limits. The equation for ‘Loring’ still was considered to have commercial acceptability.

The range in harvest dates was not due to differences in calendar date of full bloom between locations. In 2 of the 4 years in which the equations were evaluated, the calendar date of full bloom had a range of 2 days across locations within cultivars, and only a 3 day variation among cultivars. The first commercial harvest of all fruit in 1981, when there was a light crop, was on or before the adjusted predicted harvest date. A further shortening of 1 to 2 days may be justified in the adjusted predicted harvest date when crop load is reduced by 50% or more.

Samples of peaches selected from each orchard on the first harvest date were, in all instances, producing ethylene, indicating that the fruit was physiologically mature (16). Individual fruit which had been monitored for ethylene production was held for 3 days at room temperature. When subjected to organoleptic evaluation, the quality of those fruit producing ethylene was characteristic of fruit harvested at the proper stage of development. In some instances, particularly for ‘Earlired’, 20% to 30% of the harvested fruit were not producing ethylene and did not have the quality associated with a mature ripe peach. This harvesting problem was not due to limitations in the equation, but to picker’s subjective assessment of fruit maturity.

Predictions also were made for ‘Earlired’, ‘Redhaven’, and ‘Loring’ produced in the experimental orchards of the H.R.I.O. These data were not included in this investigation, as the fruit is traditionally harvested at a stage of development which would be considered too mature for the commercial trade.

The equations developed in this study function within acceptable commercial tolerance limits. They provide marketing strategists with reliable estimates of first commercial harvest dates of peach cultivars which mature in early, early midseason, and late midseason. These equations should provide the peach industry with the means to help plan the marketing of Ontario’s peach crop.

**Literature Cited**


Effects of Growth Regulators on Abscission of Young Macadamia Fruit

Mike A. Nagao
Hawaii Agricultural Experiment Station, University of Hawaii, Hilo, HI 96720

William S. Sakai
College of Agriculture, University of Hawaii at Hilo, Hilo, HI 96720

Abstract. The abscission of young *Macadamia integrifolia* Maiden & Betche fruit was investigated in vitro with explants consisting of a single fruit attached at the distal end of a segment of the peduncle. A 30% reduction in fruit removal force (FRF) of explants incubated in distilled water was evident within 48 hr after excision and was correlated with increased ethylene production. Pretreatment of explants with 5 and 10 mM ethylene accelerated FRF reduction. Pretreatment with increasing concentrations of silver nitrate (AgNO₃) to 1.47 mM or AOA to 0.05 mM, inhibited the reduction in FRF. FRF reduction also was inhibited by 1000 μM NAA and 100 μM 2,4-D. GA₃ and BA had no effect. Chemical names used: (2-chloroethyl)phosphonic acid (ethephon); 1-naphthaleneacetic acid (NAA); 2,4-dichlorophenoxyacetic acid (2,4-D); gibberellic acid (GA₃); N-(phenylmethyl)-H-purin-6-amine (BA); (aminooxy)acetic acid (AOA).

The use of explants has demonstrated an auxin-ethylene interaction during abscission of young and mature orange fruit (6, 7, 8). Ethylene applied to fruit explants promotes abscission by stimulating synthesis of cellulase and polygalacturonase, whereas auxins such as 2,4-D delay abscission by inhibiting appearance of these wall degrading enzymes. Control mechanisms in explant abscission are similar to those within intact plants. For example, studies with cotton (10), cherry (2, 16), and apple (2) showed increased ethylene production by fruit during periods of high abscission frequency. In addition, postbloom applications of aminoethoxyvinylglycine reduced ‘June drop’ of apples by lowering endogenous ethylene production (14). The reduction of preharvest abscission in oranges treated with 2,4-D was attributed to reduced activity of cellulase and polygalacturonase in the abscission zone (18).

Observations of macadamia fruit development indicated that nearly 90% of the initial number of fruits abscised prematurely by 15 weeks after anthesis, with the highest frequency of drop occurring at 4-5 weeks (13). The involvement of growth regulators in premature fruit drop of macadamia has not been investigated thoroughly. Nakata et al. (12) reported a 10% increase in yield following daminozide treatment of trees; whether the effect was related to greater initial set, a reduction in premature drop, or a combination of these 2 factors is not known. An understanding of the role of growth regulators in macadamia abscission could provide insight into the control of premature drop in this crop. The purpose of this study was to assess the effect of ethylene, auxin, and other growth regulators in abscission of young macadamia fruit on explants.

Materials and Methods

All experiments were performed on racemes taken from 20-year-old *Macadamia integrifolia* ‘Kakea’ trees growing near Hilo, Hawaii. In 1980, 1981, and 1983, racemes (4 to 6 weeks after anthesis) bearing fruit between 3.0 and 6.5 mm in diameter were harvested, immediately immersed in distilled water for 1 to 2 hr and sectioned into 1.5 to 2.0 cm segments with a single fruit attached near the distal end.

NAA, 2,4-D, GA₃, BA, and ethephon were applied by im-