Overview of the model. ALMOPOL is a computer-based simulation model written in Fortran 77, and is composed of four basic subroutines (BLOOM, FORAGE, CROSS-POLLINATION, NUT SET). The flow diagram illustrating how the components of ALMOPOL interact to predict nut set is shown in Fig. 1. Weather conditions are read into the ALMOPOL program hourly so that updates of open blossoms, foraging honey bees, and nut set per tree for each cultivar can be made hourly throughout bloom. Nut set predictions are made only when two or more cultivars are in bloom. To run ALMOPOL simulations, the user must enter information (Table 1) about the orchard to be analyzed.

After entering an orchard design, the user chooses a set of weather conditions, specifies the number of honey bee colonies to be introduced, and the number of potential foragers per colony. The number of blossoms that are visited by honey bees on a single foraging trip can also be specified. Other factors whose exact values are unknown can also be entered. For example, the number of blossoms cross-pollinated by a forager that has acquired compatible pollen can be varied, so that this factor’s influence on nut set can be assessed. One way honey bees acquire compatible pollen is by moving between trees of different cultivars. Movement between trees occurs if a forager repeatedly encounters previously visited (i.e., non-rewarding) blossoms. The number of non-rewarding blossoms that must be consecutively visited before a forager leaves a tree is not known. ALMOPOL permits the user to estimate this number and test its influence on nut set.

Materials and Methods

An orchard in Harquahala, Ariz. containing ‘Nonpareil’, ‘Price’, and ‘Carmel’ almonds was selected as the test site. Cultivars were arranged with two rows of ‘Nonpareil’ followed by alternating ‘Price’ and ‘Carmel’ rows. Test trees were selected on a diagonal line transecting the orchard. Temperature, solar radiation, wind velocity, and relative humidity were monitored hourly throughout the bloom period using an Omnidata EL-824 Easy Logger (Omnidata, Logan, Utah) with appropriate sensing probes.

The progression of bloom in each cultivar was determined by daily counts of open blossoms on selected limbs on the four sides (cardinal points) of trees of each cultivar. In addition, the length of time individual blossoms retained their petals following anthesis was determined for each cultivar throughout the bloom period. Five trees of each cultivar were also selected for estimates of foraging honey bees per tree. Estimates of honey bees per tree were made several times daily during suitable flight weather. Observers were stationed on the north and south side of a tree, and all foragers seen in a 20-sec interval were recorded. Twice daily 30 individual bees were observed during a blossom visit to determine the percentage that contacted the stigma.

Bloom was estimated by counting all the blossoms on 20 limbs per cultivar (four limbs at the cardinal points of five trees with an average of 105 blossoms per limb). Nut set on the same limbs was recorded 8 weeks after bloom and just before harvest. Finally, all nuts were removed from these trees and counted. The number of blossoms per tree was then estimated by dividing total number of nuts by the percentage of blossoms setting nuts. The height of each tree, canopy width, and length between the ground and lowest flowering branch were measured.

Results

The number of non-rewarding blossoms that must be consecutively visited before a forager leaves a tree is not known. ALMOPOL permits the user to estimate this number and test its influence on nut set.
After orchard design, weather conditions, and honey bee foraging parameters are entered, the number of open blossoms per cultivar is estimated hourly (BLOOM subroutine). Temperature strongly influences bloom phenology (Thorp, 1979), so time is expressed in accumulated degree days (DD) (Baskerville and Emin, 1969) for all bloom-related calculations in the ALMOPOL program. Following estimates of blossoms per tree, their probabilities of setting nuts are predicted based on age (i.e., time since anthesis) and time of opening during bloom. Nut set potentials decline as blossoms age and as bloom progresses.

After bloom phenology and blossom quality are updated, the size of the honey bee population foraging each cultivar is estimated as a function of weather conditions and blossom density per tree (FORAGE subroutine). The percentage of foragers (on each cultivar) carrying compatible pollen is then calculated (CROSS-POLLINATION subroutine) as a function of: 1) competition for floral resources (i.e., open blossoms containing nectar and pollen) and resultant movement of foragers between trees, 2) size of the foraging population on compatible pollen sources, and 3) the probability of acquiring compatible pollen in the hive from nestmate contacts (Betts, 1935, Karmo and Vickery, 1954; DeGrandi-Hoffman et al. 1984, 1986). Cross-pollinations occurring on each cultivar are then estimated using the equation:

\[
Y_i = \left[744\{0.103[\log (a \cdot b)]\} \cdot c\right] \cdot di
\]

where \(Y_i\) = blossoms per hectare of cultivar \((i)\), \(a\) = tree width \((m)\), \(b\) = tree height (distance begins at the first flowering limb), \(c\) = blossoms/m of branch, and \(di\) = number of trees of a cultivar \((i)\) per hectare.

Derivation of this equation \((r^2 = 0.72)\) was based on the assumption that blossoms per tree are a product of canopy volume and blossoms per meter of branch and that the canopy is >1.0 m wide and 1.0 m high.

ALMOPOL simulates the bloom phenologies of the three almond cultivars Nonpareil, Price, and Carmel. Equations expressing the progression of bloom for each cultivar were derived from daily field counts of open blossoms made under monitored weather conditions. Length of the bloom period varies inversely with temperature (Thorp, 1979). To simulate this, the progression of bloom is expressed as a function of DD. The base temperatures for DD accumulation were derived from field data by plotting daily counts of open blossoms over time to determine the general shape of the bloom phenology curve. Various base temperatures were then tested to determine those producing equations giving the best fit of the field data. In the ALMOPOL model, base temperatures for ‘Nonpareil’, ‘Price’, and ‘Carmel’ are estimated to be 2.2°C, 4.4°C, and 5.6°C, respectively. Bloom periods are divided into pre- and post-peak bloom periods. Pre- and post-peak bloom equations are:

\[
Y = 5.71a^2 + 0.0805a \text{ ‘Nonpareil’ pre-peak bloom (}r^2 = 0.98\text{)}
\]

\[
Y = 3.53 + 4.18a^2 - 7.67a \text{ post peak bloom (}r^2 = 0.98\text{)}
\]

\[
Y = -14.53a^3 + 12.17a^2 \text{ ‘Price’ pre-peak bloom (}r^2 = 0.96\text{)}
\]

\[
Y = 7.35 - 25.5a + 28.7a^2 - 10.89a^3 \text{ post-peak bloom (}r^2 = 0.99\text{)}
\]

\[
Y = 1.81a^2 + 0.507a \text{ ‘Carmel’ pre-peak bloom (}r^2 = 0.99\text{)}
\]

\[
Y = 1.34 - 1.32a^2 \text{ post-peak bloom (}r^2 = 0.99\text{)}
\]

where \(Y\) = the proportion of total blossoms that is open and \(a\) = total accumulated DD at time \((t)\)/total DD in the bloom period. In all bloom equations, when \(a = 1\), \(Y = 0\). Actual and
predicted bloom progressions for each almond cultivar are compared in Fig. 2.

Bloom phenology equations are integrated and used to estimate the number of blossoms opening hourly. The length of the hour interval is a function of the average temperature for that hour and the DD that have accumulated. Hourly DD are calculated using the equation:

$$DD = \frac{(a - b)}{24};$$  \hspace{1cm} [8]

where \(a\) = average temperature for that hour and \(b\) = the base temperature for a given cultivar (if \(b < a\), then \(DD = 0\)).

The number of blossoms opening each hour is estimated by integrating the bloom equations over the interval \([\text{accumulated } DD \text{ at time } (t) \text{ to } (t + 1)]\), and multiplying that value by the total blossoms per hectare for each cultivar [Eq. 1]. Values for the length of time \((\text{in } DD)\) that blossoms remain open are estimated to be 73.2 DD\(_{2.2}\) for 'Nonpareil', 61.8 DD\(_{4.4}\) for 'Price', and 58.3 DD\(_{5.6}\) for 'Carmel'. These values were estimated based on field measurements of the length of time blossoms retained their petals following anthesis, and the DD that had accumulated during that interval.

Initial nut set probability on the day of anthesis is predicted to decline as bloom progresses (Thorp, 1979). Following anthesis, a blossom’s probability of setting decreases as it ages (Griggs, 1970). In the ALMOPOL program, bloom length and the time \((\text{in } DD)\) that individual blossoms remain open is divided into 10 periods. Because the exact rate of decline in a blossom’s nut set potential is not known, users can assign nut set probabilities. Blossom nut set potentials are calculated as compound probabilities of a blossom’s age and period of opening during bloom. An example of these calculations is shown in Table 2.

**FORAGE subroutine.** During the interactive portion of the ALMOPOL model, users enter the number of potential foragers per hectare (PFP). The size of the population foraging on each almond cultivar is estimated hourly based on weather conditions and the number of open blossoms per tree.

The percentage of the PFP that leaves the hive each hour is referred to as the active foraging population (AFP), and is predicted to be a response to temperature, wind velocity, and solar radiation. Flight is predicted to occur only during daylight hours when temperatures are >10°C and wind velocity is <40 km-hr\(^{-1}\) (25 mile/hr) (Burrill and Dietz, 1981; Lundie, 1925). Response equations to weather factors were derived from field data of counts of honey bees leaving the hive and foraging on almond trees under monitored weather and bloom conditions. Because the foraging response to solar radiation apparently differs in the early afternoon (i.e., solar noon period 1200-1400 h) from that during the rest of the day (Frisch, 1967; Burrill and Dietz, 1981), separate responses were derived. The honey bee foraging response to temperature, wind, and solar radiation are predicted to be:

$$Y = \left[ \log \left( a \cdot 0.699 \right) \right] - 0.27;$$  \hspace{1cm} [9]

where \(Y\) = proportion of the PFP that is actively foraging \((Y \leq 1.0)\) and \(a\) = temperature \((^\circ C)\);

$$Y = 1.0 - \left( 0.0249 \cdot b \right);$$  \hspace{1cm} [10]

where \(b\) = wind velocity \((\text{km-hr}^{-1})\); and

$$Y = \left[ c \left( c + 0.5 \right)^{-1} \right] \cdot 1.50;$$  \hspace{1cm} [11]

or for the solar noon period \((1200-1400 \text{ h})\):

$$Y = 0.60 \cdot c;$$  \hspace{1cm} [12]

where \(c\) = solar radiation \(\text{(kW-m}^{-2}\text{)}\).

The AFP is predicted by multiplying the PFP by the percent reduction for each weather factor as determined by the conditions that hour. During rain, the AFP is predicted to be zero, regardless of the values for the other weather conditions.

After estimating the AFP, the percentage that forage almond trees is predicted based on stage of bloom. Stage of bloom is predicted as a function of accumulated DD using the base temperature for the predominant cultivar. The length of the bloom period is estimated as the interval from the time the first blossom opens until blossoms no longer exist on any cultivar in the

<table>
<thead>
<tr>
<th>Table 1. Information a user must enter (underlined) to run ALMOPOL, and resulting nut set predictions generated by the model.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. OWNER’S NAME</strong> .......................................................... GDhoff</td>
</tr>
<tr>
<td><strong>2. LOCATION NAME</strong> .......................................................... Harquahala Valley</td>
</tr>
<tr>
<td><strong>3. ENGLISH (E) OR METRIC (M).</strong> ...................................... M</td>
</tr>
<tr>
<td><strong>4. TOTAL ORCHARD SIZE (HECTARES)</strong> .................................. 1166.4</td>
</tr>
<tr>
<td><strong>5. CULTIVAR NAME</strong> .......................................................... ‘NONPAREIL’, ‘PRICE’, ‘CARMEL’</td>
</tr>
<tr>
<td><strong>6. TREE HEIGHT</strong> ............................................................. 2.75 2.39 2.06</td>
</tr>
<tr>
<td><strong>7. BRANCHING WIDTH</strong> ..................................................... 2.51 2.17 2.26</td>
</tr>
<tr>
<td><strong>8. # FLOWER BUDS PER METER OF BRANCH</strong> .......................... 157.00 90.00 125.00</td>
</tr>
<tr>
<td><strong>9. # TREES PER HECTARE</strong> ................................................ 16 8 8</td>
</tr>
<tr>
<td><strong>10. % BLOSSOMS THAT ARE VIABLE</strong> ..................................... 0.99 0.99 0.99</td>
</tr>
<tr>
<td><strong>11. FIRST DAY OF BLOOM</strong> ................................................ <em>7 Feb. 1986</em></td>
</tr>
<tr>
<td><strong>12. FIRST HOUR OF BLOOM</strong> ................................................ 9:00</td>
</tr>
<tr>
<td><strong>13. POTENTIAL FORAGING POPULATION PER HECTARE.</strong> ............... 2500</td>
</tr>
<tr>
<td><strong>14. NUMBER OF NON-REWARDING FLOWERS A BEE MUST VISIT BEFORE MOVING TO ANOTHER TREE</strong> .......................... 3.0</td>
</tr>
<tr>
<td><strong>15. NUMBER OF FLOWER VISITS PER HOUR</strong> ............................ 100.0</td>
</tr>
<tr>
<td><strong>16. AVERAGE NUMBER OF CROSS-POLLINATIONS PER CROSS-POLLINATOR</strong> ............................................................... 5.0</td>
</tr>
<tr>
<td><strong>17. CHOICE OF WEATHER TAPE</strong> ........................................... Cool Weather with Little Wind</td>
</tr>
</tbody>
</table>
The accuracy of the weather and bloom response equations was tested by comparing actual and predicted almond foragers per hectare (Fig. 3). Predictions were generated by first estimating the PFP at the study site. During the first 3 days of bloom, honey bees were counted on five trees of each cultivar. The average number of bees per tree of each cultivar was estimated, multiplied by the number of trees of each cultivar per hectare, and totaled to approximate almond foragers per hectare at time (t). The PFP was then estimated using the equation:

\[ \text{PFP} = a \times b \]  \[ \text{[15]} \]

where \( a = \) almond foragers per hectare observed at time (t) and \( b = \) the predicted reduction in the almond foraging population due to weather (Eq. 9-12) and bloom stage (Eq. 13 and 14) at the time of the honey bee per tree count. The PFP used to validate the weather and bloom response equations was determined by averaging the PFPs estimated for each sampling interval (predicted PFP). Actual almond foragers per hectare were estimated by repeating the honey bees per tree counts throughout bloom and comparing them with predicted almond foragers per hectare (\( Y \)) generated by the equation:

\[ Y = a \times b \]  \[ \text{[16]} \]

Honey bees foraging almond blossoms are distributed among the different cultivars according to the equation:

\[ Y_i = \left( \frac{a_i}{b} \right) \times c \]  \[ \text{[17]} \]

where \( Y_i = \) number of foragers visiting trees of a given cultivar (i), \( a_i = \) total open blossoms on a given cultivar (i), \( b = \) total open blossoms on all cultivars, and \( c = \) almond foraging population at time (t) from Eq. 13 and 14.

During the interactive portion of the simulation, users enter the number of almond blossoms a bee visits on a single foraging trip. The number of blossoms visited on each cultivar every hour is totaled so that the ratio of visited (non-rewarding) and non-visited (rewarding) blossoms can be determined. This information is used in the CROSS-POLLINATION subroutine to partially determine the cross-pollinating population (Eq. 18).

CROSS-POLLINATION subroutine. Although the number of foragers on each cultivar is predicted in the FORAGE subroutine, only those carrying compatible pollen can potentially cross-pollinate blossoms. In the CROSS-POLLINATION subroutine the size of the almond foraging population carrying compatible pollen relative to the cultivar being foraged is predicted hourly. This subroutine is used only when two or more cultivars are in bloom. Honey bees can acquire compatible pollen by two methods; movement between two different cultivars, or contact with nestmates in the hive (Betts, 1935; Free and Williams, 1972; Karmo and Vickery, 1954; DeGrandi-Hoffman et al. 1984, 1986).
Table 2. Estimates of blossom nut setting potentials based on their age and time of opening during bloom (underlined numbers are entered by the user).

<table>
<thead>
<tr>
<th>Blossom age periods</th>
<th>Probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>0.95</td>
</tr>
<tr>
<td>3</td>
<td>0.85</td>
</tr>
<tr>
<td>4</td>
<td>0.75</td>
</tr>
<tr>
<td>5</td>
<td>0.65</td>
</tr>
<tr>
<td>6</td>
<td>0.55</td>
</tr>
<tr>
<td>7</td>
<td>0.45</td>
</tr>
<tr>
<td>8</td>
<td>0.30</td>
</tr>
<tr>
<td>9</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Blossom age periods are determined for a cultivar by the equation: DD accumulated since anthesis/total length of blossom life; DD = degree days; 1 = anthesis, 10 = all petals abscised.

Bloom period is determined for a cultivar by the equation: DD accumulated since the beginning of bloom/total DD in the cultivar's bloom period; 1 = start, 10 = end of bloom period.

---

Fig. 3. Actual estimates of almond foragers per hectare and ALMOPOL predictions using weather and bloom response equations. Each sample count represents a separate estimate of the almond foraging population taken early (1.0) to late (10.0) in the bloom period. The correlation coefficient between actual and predicted almond foragers is 0.80.

Honey bees are predicted to leave a tree if they repeatedly encounter non-rewarding blossoms (Thorp, 1979; Waddington, 1980). The number of non-rewarding blossoms that must be visited consecutively before a bee leaves a tree is estimated by the user at the beginning of the simulation. The size of the population of foragers moving between almond trees of each cultivar (Yi) (wanderers) is determined using the equation:

\[ Yi = \left(\frac{ai}{bi}\right) \cdot d \]  \[ 18 \]

where ai = non-rewarding blossoms on cultivar (i), bi = total open blossoms on cultivar (i), c = number of non-rewarding blossoms that must be consecutively visited before a forager leaves a tree, and d = number of foragers visiting trees of a given cultivar (from Eq. 17).

After a wanderer from a particular cultivar leaves a tree, the number moving to a different cultivar (Yi) is determined using the equation:

\[ Yi = ai \cdot \left(\frac{bj}{c}\right) \]  \[ 19 \]

where ai = number of foragers from cultivar (i) moving between trees, bj = open blossoms on a compatible cultivar (j), and c = total open blossoms on all cultivars. Only those bees moving between compatible cultivars are included in the second cultivar's cross-pollinating population.

In apple orchards, honey bees can acquire sufficient compatible pollen from nestmate contact to cross-pollinate blossoms and set fruit (DeGrandi-Hoffman et al., 1986). Since honey bees collect large amounts of almond pollen, it is assumed that in-hive pollen transfer contributes to the formation of the cross-pollinating population.

The percentage of almond foragers acquiring compatible pollen through in-hive pollen transfer is determined by: 1) the proportion of the PFP leaving the hive at time (t), and 2) the size of the foraging population on compatible pollen sources relative to the total population foraging during that time. Because pollen probably loses viability in the hive overnight (Kraai, 1962), the contribution of in-hive pollen transfer to the cross-pollinating population is assumed to begin only after the second hour of flight each day.

The proportion of foragers acquiring pollen from nestmate contacts (Y) is predicted using the equation:

\[ Y = 0.739a^2 + 0.261a \]  \[ 20 \]

where a = proportion of the PFP foraging the previous hour. This equation is based on the assumption that pollen transfer in the hive increases with foraging activity, and was derived from ALMOPOL simulations of orchards with known amounts of nut set.

The number of almond foragers obtaining pollen in the hive is estimated by the equation:

\[ Y = a \cdot b \]  \[ 21 \]

where \( a \) = the number of almond foragers (from Eq. 13 and 14) and \( b \) = the percentage of AFP acquiring pollen in the hive (from Eq. 20).

The number of foragers on a particular cultivar obtaining compatible pollen in the hive is then estimated using the equation:

\[
Y_i = a \times (b/c);
\]  

[22]

where \( Y_i \) = the number of foragers on a cultivar (i) obtaining compatible pollen in the hive, \( a \) = the number of almond foragers obtaining pollen in the hive at the time (t) (from Eq. 21), \( b \) = the number of foragers on all compatible cultivars at time (t), and \( c \) = the total number of bees in the AFP at time (t).

The size of the cross-pollinating population on each cultivar is the sum of foragers acquiring compatible pollen by tree-to-tree movement, and those obtaining compatible pollen in the hive. All cross-pollinators do not transfer pollen to blossoms, because some fail to touch stigmas during a visit (Thorp, 1979). Our field data in Arizona orchards indicate that 80% (\( n = 540 \) bees, \( s_d = 1.8 \)) of the honey bees contact stigmas while foraging almond throughout bloom. Consequently, only 80% of the estimated cross-pollinators are considered to be functional.

The number of blossoms cross-pollinated during one flight by a bee carrying compatible pollen can be entered at the beginning of a stimulus. The number of blossoms cross-pollinated on a cultivar (\( Y_i \)) each hour is determined by the equation:

\[
Y_i = a_i \times b_i;
\]  

[23]

where \( a_i \) = cross-pollinating population foraging cultivar (i), and \( b_i \) = the number of blossoms a forager can cross-pollinate after acquiring compatible pollen as entered by the user (see Fig. 2).

**NUT SET subroutine.** Nut set predictions are made by combining hourly updates of blossom quality from the BLOOM subroutine with estimates of the number of cross-pollinations occurring on each cultivar from the CROSS-POLLINATION subroutine. Cross-pollinators are evenly distributed to blossoms of each age class and period of opening in each cultivar. The number of nuts setting each hour (\( Y_i \)) is then predicted for each cultivar by the equation:

\[
Y_i = (a \times b);
\]  

[24]

where \( a \) = blossom probability of nut set based on age and period of opening during bloom, and \( b \) = the number of cross-pollinations occurring on blossoms of a given age and period of opening during 1 hr.

Initial nut set, expressed as the percentage of blossoms setting nuts per cultivar (\( Y_i \)), is estimated using the equation:

\[
Y_i = a_i/b_i;
\]  

[25]

where \( a_i \) = the total number of blossoms setting nuts at time (t) for cultivar (i), and \( b_i \) = the total number of blossoms of cultivar (i) that will open during bloom. Initial set is reported daily.

Almond trees have several nut-drop periods after bloom, and the percentage of nuts that drops varies inversely with initial set (Kester and Griggs, 1959a, 1959b). In ALMOPOL, final set in each cultivar (\( Y_i \)) is predicted from the initial percentage of blossoms setting nuts using the equation:

\[
Y_i = \exp\left[-(a_i \times 0.5) + 0.057\right] \times a_i;
\]  

[26]

where \( a_i \) = the proportion of blossoms initially setting nuts on a given cultivar (i). This equation was derived from our data for the initial and final percentage of blossoms setting nuts (\( r^2 = 0.94 \)).

At the end of the bloom period, the initial and final percentage of blossoms setting nuts and the final weight of nuts/ha (high and low values) are predicted for each cultivar. The final weight of nuts is estimated by multiplying the total number of blossoms on a tree by the final nut set percentage. The number of nuts/kg is dependent on their size. A range of 145 to 180 nuts/kg is used for 'Nonpareil' and 'Carmel,' and 180 to 222 nuts/kg for 'Price' (Almond Board of California, 1985). The weight of nuts per hectare for each cultivar (\( Y_i \)) is estimated by the equation:

\[
Y_i = (a_i/b_i) \times c_i;
\]  

[27]

where \( a_i \) = the final number of nuts set per tree of cultivar (i), \( b_i \) = the number of nuts of cultivar (i) per kg (the high and low values are used), and \( c_i \) = the number of trees of cultivar (i) per hectare. An example of ALMOPOL output is shown in Table 3.

**Discussion**

Almond cross-pollination and nut set predictions are products of the dynamic interactions of weather, foraging population size and behavior, compatible pollen availability, and blossom nut set potentials. ALMOPOL simulates the interactions of these biotic and abiotic factors, and generates nut set estimates.

Data compilation leading to the development of ALMOPOL indicate that cultivars may have specific threshold temperatures for bloom progression, as found for apple (DeGrandi-Hoffman et al., 1987), causing the period of bloom overlap between cultivars with different threshold temperatures to be temperature-dependent. Since cross-pollination occurs only when two compatible cultivars are in bloom simultaneously, the influence of temperature on nut set extends beyond its effects on pollinator foraging activity.

Foraging data collected in developing ALMOPOL indicate that honey bees respond in a relatively predictable manner to weather and bloom conditions. Temperature and wind velocity response equations are identical to those used in the REDAPOL model (DeGrandi-Hoffman et al., 1987). Solar radiation response equations required modification, as did those for the foraging response to bloom. Apple bloom response equations underestimated the foraging population on almond. Apparently, a greater proportion of the honey bee foraging population visits almond than apple, especially during full bloom. Stigma contact occurs in a majority of these visits, particularly if foragers are collecting pollen.

Table 3. Example of nut set predictions generated by the ALMOPOL model.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Nonpareil</th>
<th>Price</th>
<th>Carmel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prediction</td>
<td>Start hour of bloom</td>
<td>Total hours of bloom</td>
<td>Total hours of faring</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>825</td>
<td>825</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>726</td>
<td>718</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>800</td>
<td>690</td>
</tr>
</tbody>
</table>

* Nut set range is dependent on nut size and number per kilogram.
ALMOPOL functions as a research tool that can simulate the interaction of weather, bloom, and honey bee foraging components that lead to nut set. The model can identify areas where more information is needed (e.g., changes in blossom nut set potential and the source and size of the cross-pollinating population over time). Finally, ALMOPOL can aid in determining either individual factors or combinations thereof that strongly impinge on nut set.

Literature Cited


