Crop Phenology for Irrigated Spring Cantaloupes (Cucumis melo L.)

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Abstract

Field experiments were conducted in 2007 to evaluate a cantaloupe (Cucumis melo L.) plant development model as a function of heat units accumulated after planting (HUAP). Field experiments were conducted in 2007 in the Yuma Valley, Arizona (32° 42’ N, 114° 42’ W), about 150 feet (~ 32 m) elevation in four commercial cantaloupe fields managed by a cooperator-grower using four varieties. Plant measurements were made on regular 14-day intervals and the following growth stages were identified in relation to plant measurement data collection: pre-bloom, early fruit set, early netting, and physiological maturity (harvest). The model was evaluated by comparing the observed HUAP versus the predicted HUAP values using a repeated measures design. Mean differences within each sampling stage were separated using the Fishers’ protected least significance difference (LSD) test at $P \leq 0.01$. In addition, regression models were performed for all in-season data collected and the accuracy of the model was evaluated on the basis of the $R^2$ values with a specified level significance ($\alpha = 0.01$). No statistical differences were found between the observed phenological data and the predicted values from the model throughout the study period. Also, the model presented an overall accuracy of 54 ± 37 HUAP (2 ± 1 day) in predicting cantaloupe-harvesting time. It can be concluded that the model can be used as a useful tool to assist cantaloupe growers in predicting and identifying critical stages of growth for irrigated spring cantaloupe crops in Arizona and the desert Southwest.

Keywords
cantaloupe, Cucumis melo L., crop phenology, crop growth and development, heat units.

Introduction

Arizona cantaloupe (Cucumis melo L.) production ranks second to California in the United States. In 2006, approximately 23,000 acres of spring cantaloupes were harvested in Arizona, and yields averaged approximately 250 Cwt/acre (Arizona Agricultural Statistics, 2007). In 2006, total farm value of spring cantaloupes for Arizona amounted to more than $100 million dollars.
Harvest timing or seasonality of many vegetable crops, including cantaloupes, plays a major role in determining produce prices in the marketplace (Tronstad, 1995). We can often monitor and predict development based on measuring the thermal conditions in the plants environment. Various forms of temperature measurements and units commonly referred to as heat units (HU) or growing degree units (GDU), have been utilized in numerous studies to predict phenological events for both agronomic and horticultural crops (Baker and Reddy, 2001).

Wurr et al. (2002) stated that to describe crop growth and development there is first the need to determine rate functions for various processes. These include the identification of distinct stages and phases of growth and development, as well as the duration of developmental phases for given temperature regimes. Marcelis et al. (1998) stated that the most straightforward models in this field are based on heat sums. The uses of HU accumulation methods are efficient techniques for modeling and predicting growth stages in crops (such as cantaloupes) as compared with the traditional days after planting (DAP) method since variations among seasons and locations can be better normalized by the use of HU calculations rather than days after planting (DAP).

Soto-Ortiz et al. (2006) developed a cantaloupe plant development model as a function of HUs accumulated after planting (HUAP) that could be extended as a crop management tool for growers. However, this model is lacking sufficient validation. Similarly, there are no reports as to the accuracy of any other similar models to predict developmental stages and the harvest time of cantaloupes. Therefore, the objective of this study was to evaluate the accuracy of the Soto-Ortiz et al. (2006) model for cantaloupe plant development and its ability to predict crop developmental stages and harvest dates of irrigated spring cantaloupes in Arizona.

**Materials and Methods**

The time line of the Arizona cantaloupe phenological model (Soto-Ortiz et al., 2006), as well as the regression equations to predict some growth and development parameters are shown in Figure 1 and Table 1. To provide in field-testing and validation of this model and to provide additional data for the model, a set of field experiments were conducted in the Yuma Valley, Arizona (32° 42’ N, 114° 42’ W, about 150 feet elevation) with four commercial cantaloupe fields managed by a cooperator-grower. These four sites employed four different cantaloupe varieties. The general description of the sites and some experimental methods are described in Tables 2 and 3. In all fields, melon seeds were dry planted...
on 80-inch beds and furrow irrigated. Each field was thinned to approximately 12-inch plant spacings (6,450 plants per acre). General fertilization at all sites included 145 lb. N/acre, 30 lb. P/acre and 15 lb. S/acre. Twenty five percent of the total N and all of the P fertilizers were applied pre-plant using liquid ammonium phosphate (10-34-0). Fifty percent of the total N and all of the S fertilizer was side-dress injected before the first irrigation using a mixture of UAN-32 and sulphuric acid (20-0-0-5). The remaining 25% of the fertilizer N was water-run applied on the second irrigation, using UAN-32 (32-0-0). Water and pest control procedures were managed throughout the season on an as-needed basis. In addition, all crop management decisions were made in conjunction with the grower-cooperator.

An automated Arizona Meteorological Network (AZMET) station located close to the experimental sites monitored weather conditions on a daily basis throughout the growing season. The AZMET station is used to determine a complete series of meteorological measurements including the hourly maximum and minimum temperature values. Consequently, the HU accumulations (86/55 °F thresholds) are calculated by a method presented in Baskerville and Emin (1969) and modified by Brown (1989). The daily HU accumulations are summed from the time of planting and reported as HUAP.

In-season data collection for each variety was taken at five randomly selected locations in each field on regular 14 day intervals and they include the following basic plant growth and development measurements: number of mainstem nodes, number of fresh flowers on each vine, and length (cm) of each fruiting vine. Also, the number of melons larger than “golf ball” size in two meter row segments were counted. Also, the following growth stages were identified: pre-bloom, early fruit set, early netting, and physiological maturity (time of first harvest). The model was evaluated by comparing the predicted HUAP values versus the observed HUAP values using a repeated measures design. Mean differences within each stage of sampling were separated using the Fishers’ protected least significance difference (LSD) test at P ≤ 0.01. In addition, regression models were performed for all in-season data collected and the accuracy of the model evaluated on the basis of the R² values using a designated significance level for testing (α = 0.01). Statistical procedures were consistent with those outlined by Steele and Torrie (1980) and SAS (SAS Institute, 1999a and 1999b).

Results and Discussion

Figure 2 presents the observed phenological stages for all varieties as expressed in terms of HUAP and calendar days, versus the projected by the model. Despite the natural variation among varieties, planting dates, and sites the observed phenological stages matched the projected from the model.
relatively well. The Tuscan and Ocotillo varieties were better described by the model than the Olympic Gold and Esteem varieties (or sites). The HUAP and calendar day deviation from the model averaged 21 HUAP and 1.5 days for Tuscan, and 26 HUAP and 1.5 days for Ocotillo. The greatest deviation from the model was observed in Olympic Gold, with an overall deviation of 71 HUAP and 4 calendar days. The model presented an overall accuracy of $54 \pm 37$ HUAP in predicting the time of cantaloupe harvesting. Expressed in terms of calendar days, the predicted time of harvest had an accuracy of 1 to 3 days.

Figure 3 presents the overall statistical comparisons among the observed and predicted phenological stages. No statistical differences were found between the observed and the predicted data throughout the study period.

The model was also able to accurately predict some cantaloupe growth parameters (Figure 4). The corresponding $R^2$ values for the number of nodes, main vine length, and number of melons per 2m$^2$ were highly significant ($\alpha = 0.01$), and corresponded to 0.91, 0.88 and 0.88 respectively. The $R^2$ value for the regression between the observed numbers of blooms versus the model predictions was significant ($\alpha = 0.05$) with a value of 0.58.

The Arizona model demonstrated a reasonable level of accuracy and precision as a management tool for commercial spring cantaloupe growers under irrigated conditions common to Arizona and the desert Southwest.

**Acknowledgements**

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References


Table 1. Cantaloupe growth models, 2007.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Equation</th>
<th>$R^2$</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vine length</td>
<td>$y = -44.9 + 0.3x$</td>
<td>0.8</td>
<td>31.9</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>$y = -2.9 + 0.05x$</td>
<td>0.8</td>
<td>5.1</td>
</tr>
<tr>
<td>Blooms</td>
<td>$y = -0.2 + 0.01x - 1.3 \times 10^{-5}x^2$</td>
<td>0.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Melons per 2 meter</td>
<td>$y = -6.1 + 0.03x$</td>
<td>0.6</td>
<td>3.8</td>
</tr>
</tbody>
</table>

$R^2$.- coefficient of determination, SE.- standard error.

Table 2. Cantaloupe experimental sites and basic agronomic information, 2007.

<table>
<thead>
<tr>
<th>Field</th>
<th>Wet date</th>
<th>Variety</th>
<th>Soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barkley Ranch</td>
<td>8 March</td>
<td>Tuscan</td>
<td>Gasden Clay (Fine, montmorillonitic [calcareous], hyperthermic Typic Torrifluvents)</td>
</tr>
<tr>
<td>Amigo Ranch Block 2</td>
<td>30 January</td>
<td>Ocotillo</td>
<td>Gasden Clay (Fine, montmorillonitic [calcareous], hyperthermic Typic Torrifluvents)</td>
</tr>
<tr>
<td>Amigo Ranch Block 25</td>
<td>18 March</td>
<td>Esteem</td>
<td>Gasden Clay (Fine, montmorillonitic [calcareous], hyperthermic Typic Torrifluvents)</td>
</tr>
<tr>
<td>Richardson Ranch</td>
<td>1 March</td>
<td>Olympic Gold</td>
<td>Kofa clay (Clayey over sandy or sandy skeletal, montmorillonitic [calcareous], hyperthermic Vertic Torrifluvents)</td>
</tr>
</tbody>
</table>
Table 3. Weather conditions at the Yuma Valley throughout the cantaloupe phenology study period (January-June), 2007.

<table>
<thead>
<tr>
<th>Average air temperature at planting dates</th>
<th>Maximum and minimum mean air temperature</th>
<th>Maximum and minimum mean relative humidity</th>
<th>Cumulative precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>64 ± 11 oF</td>
<td>85 – 52</td>
<td>43 - 29</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Figure 1. Spring cantaloupe developmental stages predicted by the model, 2007.
Figure 2. Observed phenological development (HUAP and calendar days) versus projected (model) development, 2007.
Figure 3. Observed versus predicted phenological stages (HUAP), 2007. (NS.- not significant)
Figure 4. Observed number of nodes (a), main vine length (b), number of blooms in main vine (c), and number of melons per 2 m² (d) versus predicted values from the Arizona model, 2007. * 0.05 and ** 0.01 levels of significance for R² values.