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Crop Timing Using Thermal Units

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BACKGROUND

Precise crop timing is one of the most critical aspects of greenhouse production. Growers must target crops for lucrative seasonal markets. Crop timing, the manipulation of crops through physiological and environmental conditions, allows harvest and sale at specific dates. On the other hand, crop scheduling, the listing of times for organizing cultural practices, is only a part of the timing process. Timing is essential for crops that are grown only for specific holidays and it is important for: (1) crops grown during the season that have higher demands (and prices) at specific times (e.g., roses for Valentine's Day); (2) efficient space management, efficient sales and delivery planning and, as a consequence, efficient product marketing for the greenhouse crop. Hence, producing and improving methodology for crop timing has the potential of increasing grower profitability.

MATERIAL AND METHODS

Mini-rose plants of two cultivars (cv.), Candy Sunblaze and Red Sunblaze, were grown using standard cultural procedures and under a range of temperatures. Daily observations were conducted to determine the occurrence of pre-defined phenological events: bud break (BB), visible flower bud (VB), and open flower (OF). Environmental data were collected using thermocouples and data-loggers. Using these developmental events, rates of development were calculated and plotted as a function of air temperatures. These procedures allowed the determination of the base temperature (T_b) or temperature below which development does not occur. Using these T_b, average thermal units (TU with units of Degree Day) required to complete the developmental phases BB:VB, VB:OF and BB:OF for 120 and 85 flowering shoots of 'Candy Sunblaze' and 'Red Sunblaze' respectively plus 9 and 10 mini-rose crops of the same cultivars were calculated. These average TU allowed the prediction of dates of event occurrence, which were compared to the observed dates.

RESULTS

Rates of development (the inverse of the numbers of days to complete a given phenophase) increased with temperature. For two phenophases of 'Candy Sunblaze', rates of development increased with temperature up to a point (T_i) beyond which it increased, but at a lower rate. This temperature for the phenophases BB:VB and BB:OF of 'Candy Sunblaze' were 24.9 ºC (77 ºF) and 25.6 ºC (78 ºF), respectively. The base temperature for the developmental phase BB:OF for 'Candy Sunblaze' and 'Red Sunblaze' were 9.5 ºC (49 ºF) and 8.1 ºC (47 ºF) respectively.

The resulting discontinuity of rate of development versus temperature data prompted the modification of the traditional thermal unit formula. Using this modified formula, thermal units were calculated. 479 Degree Day (ºCd) and 589 Degree Day (ºCd) had to be accumulated to complete the phenophase BB:OF for 'Candy Sunblaze' and 'Red Sunblaze' respectively. Predicted dates of event occurrence were calculated and compared with the observed values. By subdividing the phenophase BB:OF into two (BB:VB and VB:OF) and using their respective T_b and thermal units, summations reduced the average error of prediction to 1.84 days from 1.91 days for 'Candy Sunblaze' and to 1.49 days from 2.35 days for 'Red Sunblaze'.

Phenological observations were also conducted on a population of plants and temperature summations for those populations were also calculated. The crop was considered to have reached a given event when 50 % -- or later when 75 % of the containers with plants had reached such event. Thermal unit summations for all phenophases of single shoots were similar to those for crops, whether calculated for the 50% or 75% levels of developmental event completion. Subdividing the phenophase BB:OF into two (BB:VB and VB:OF) and using their respective T_b and TU accumulations to predict the occurrence of OF at the crop level produced improvements in the prediction for 'Red Sunblaze". However, this methodology did not result in any significant reduction in the average error of pre-diction for 'Candy Sunblaze'.

CONCLUSIONS

We concluded that mini-rose development can be modeled using the traditional thermal units methodology. Thermal units can be used to predict certain stages of development (such as visible flower bud or open flower) with errors that are adequate for most miniature-rose growers.

IMPACT TO THE INDUSTRY

(1) Growers interested in precision timing of their crops can benefit from these results whether or not they have an environmental control computer. An example of how this model can be used : a grower wants to have 'Red Sunblaze' ready 60 days after pinching the plants. This means that the crop will have to accumulate 589 Degree Days over a period of 60 days -- or 9.8 Degree Days per day. At the end of each day, the grower calculates how many Degree Days have been accumulated and decides whether that total is greater or less than expected. Thus, the grower determines whether the crop is ahead or behind schedule. Based on that determination, plans can be made for the following day to either slightly increase or decrease the greenhouse temperature. By starting this corrective process early in the crop cycle, the grower can control temperatures to reach the required one in small increases or decreases without risking crop damage from excessive temperature changes. (2) This process can be done manually. However, ideally an environmental computer control system should be used. The computer not only would sense and record the greenhouse temperatures but also determine if the thermal units accumulation is on schedule and "decide" what actions should be taken. The computer's mechanisms can sense and correct the conditions at any time interval the grower desires.
(3) **Clearly, no technology will replace an experienced grower. This method is a tool that allows a good grower to become a better grower by reducing the subjectivity of the decision making process.**

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