Intermediate progress report to the International Cut Flower Growers Association

Calorespirometry: a novel approach to predicting energy requirements of greenhouse flower crops

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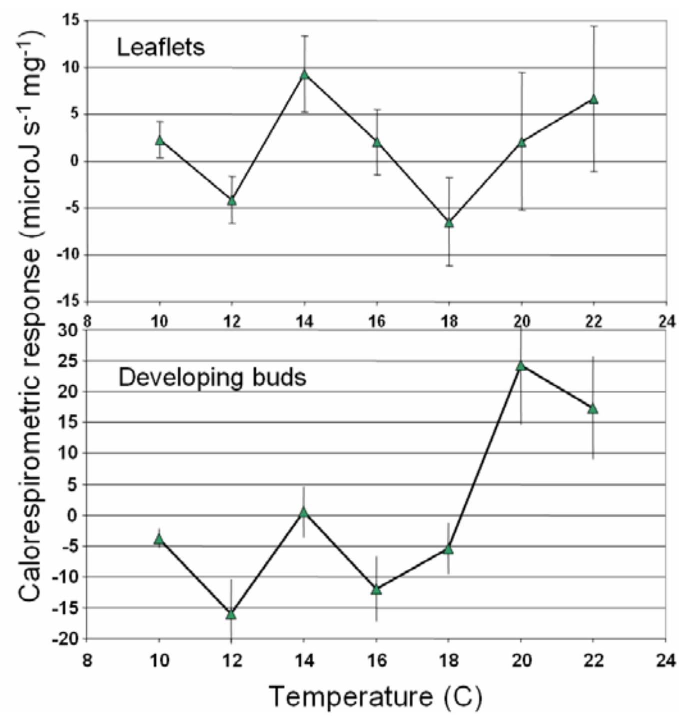
Introduction

Calorespirometry is a scientific technique where plant tissue is evaluated with regard to its energy utilization. By measuring metabolic rates, it is possible to determine the degree of various aspects of the plant's ability to grow. As such, this approach allows us to determine a potential growth rate for the tissue and to evaluate how various conditions (e.g. temperature) affect the tissue. In the past we found that this concept is valid for horticultural purposes (Raviv *et al*. 2001 a & b). That research found that: (1) tissues of different cultivars of rose have significantly different functional responses to temperature; (2) tissues from different organs of rose (e.g. leaves vs roots vs flower buds) have significantly different functional responses to temperature (Raviv *et al*. 2001b).

One of the interesting discoveries of this work was that the temperatures that result in the greatest potential growth were much lower than anticipated. For example, the following graph shows the calorimetric evaluation of the rose variety 'Milva':



Note in particular the fact that the response for leaflets at 14°C suggests metabolic activity of these tissues at temperatures that are generally accepted as being too low for rose production.

The project as proposed and funded by the Joseph Hill Foundation consists of two parts: (1) development of the response curves for metabolic activities in relation to temperature using calorimetry and (2) testing of resulting hypotheses with regard to temperature management in greenhouse cut flower rose production. The first part was completed in Israel by Dr. Raviv and his team and a previous progress report describes the results of that part. The second part was slated originally for UCDavis upon completion of the first phase. However, due to circumstances beyond our control, we were unable to get the second part started until this summer. The second part is currently underway and is the subject of this report.

In our earlier report (Raviv et al 2005) we showed results for roses which showed substantial differences between varieties, with some varieties showing metabolic activity at low temperatures, while other varieties do not.

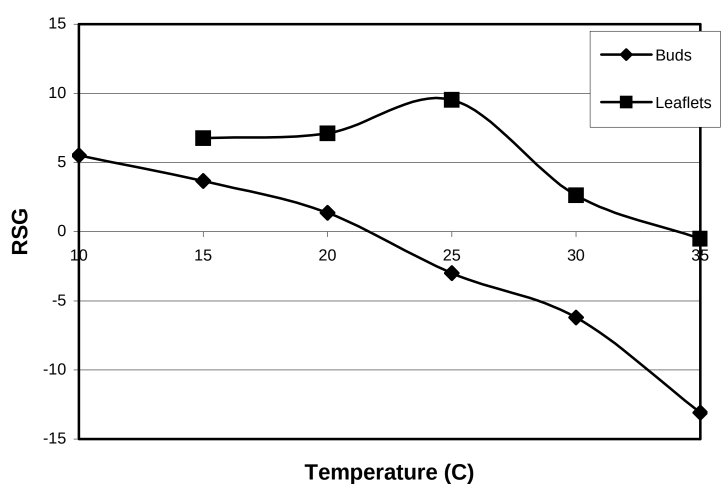
The objective of the project at this stage is to see whether we can exploit this low-temperature metabolic activity so as to reduce the night temperature in cut-flower rose production. It is well known that lowering either day or night temperature lengthens development time of the crop, but if flower development continues despite this, then it may be possible for growers to reduce energy costs. The fundamental objective of this work is to see if the findings from microcalorimetry can be used to identify varieties which can be used in a production program that involves low night temperatures, at least for part of the production cycle.

To carry out this work we have completed the calorimetry work and are now in the phase of the project where we are attempting to exploit the results to see if new horticultural methods can be developed; specifically to see if the low temperatures at which some varieties exhibited metabolic activity can be used to save energy in greenhouse production.

Materials and Methods

Two varieties that showed interesting patterns with regard to low temperatures were ‘Milva’ (see Fig 1) and ‘Kardinal’ (Fig 2).

Figure 2: Calorespirometric response of Kardinal leaflets and emerging buds.



The current phase of the trial is being carried out at the University of California, using the greenhouse for day-time conditions and cold-chambers for night conditions.

The plants being used in this trial are mounted on movable carts so that they can be transferred to growth chambers at various temperatures during the night. The Milva plants were obtained from California Pajarosa and were repotted into coir from their hydroponic buckets. Kardinal plants were available to us as small plants. Both sets of plants were repotted into 3-gallon containers filled with coir. The first few weeks were acclimation periods.

Experimental plan

Eighteen plants of each cultivar are used for the experiment. The plants stayed in the greenhouse, under standard conditions, for an adaptation period of 6 weeks. On August 14, 2006 the plats of each cultivar were divided into 9 pairs of apparently uniform plants. The experiment started after pruning/pinching all plants, in order to synchronize their developmental stage as much as possible.

Kardinal

The interesting element of the calorimetric results for Kardinal is the high metabolic activity of small buds at temperatures between 10 and 15°C (see Fig 2). This is extremely surprising because all models for rose physiology developed in the past indicate that development rate declines with temperatures below 15°C. Thus our objective for Kardinal is to determine if this aberration can be used to our advantage by using low night temperatures during the period of bud break. It should be noted that this is completely opposite of what growers practice since the general trend in the industry is to raise temperatures during this period.

Three to five uniform shoots per plant were tagged and serve now for detailed measurements. All other flowering buds/stems will also be harvested and recorded. Half the plants stayed in the greenhouse both day and night at around 20-25°C day and 16-19 °C night; the other half of the Kardinal plants were in the same daytime temperature conditions in the greenhouse, but were transferred nightly (around 4:45 pm) to the cold conditions (14±1°C) from August 15 until bud break had occurred for most of the tagged shoots (August 23). The carts were rolled back from the cold storage to the greenhouse every morning, as early as possible (between 7:00 and 7:30 am). Full bud break was determined as a 5 mm long bud.

Currently (as of Aug 31 2006) all plants are remaining in the greenhouse at the pretreatment conditions until the shoots are harvested. At that point this procedure will be repeated for 2-3 flushes.

Milva

The calorimetric results for Milva showed an unusual pattern for leaflet metabolic activity with a peak at 14°C. Again, this is completely unexpected since no grower would consider this temperature to be conducive to any aspect of rose plant growth or development. Our objective for Milva is to test whether we can use this low temperature during the part of the production period where the leaves are forming and unfolding.

Three to five uniform shoots per plant were tagged and serve now for detailed measurements. All other flowering buds/stems will be harvested and recorded as well. All Milva plants were initially left in the greenhouse, under 18-20°C night conditions, until unfolding of the first leaflet of the majority of the newly developed shoots (August 28, 2006). At this point one plant of each pair was transferred each night into a cold chamber (14°C, 57°F), while its counterpart remains in the greenhouse during the night. The carts are rolled back from the cold storage to the greenhouse every morning, as early as possible (between 7:00 and 7:30 am). This procedure will be repeated until the stage of visible flower bud is reached in most of the tagged shoots. From this stage on, and until harvest, the plants will stay in the greenhouse. After all shoots are harvested, this procedure will be repeated for the next 2 – 3 flushes.

Measured parameters

The main developmental stages to be used during the experiment are: bud emergence, unfolding of the first leaflet, visible flower bud, attaining full leaf size and harvest. The duration of each of these stages will be recorded for all tagged shoots. The length of all tagged shoots will be measured three times per week. At harvest, flower length, fresh and dry weight will be measured, as well as the number of petals.

Data loggers were installed on representative carts so that exact temperature trajectory for each treatment is recorded. Thermal units will be calculated from these data and used during data analysis.

Nightly greenhouse temperatures were kept at 62-68°F (16.7-20°C) from the beginning of the experiment and until August 25. At this day the range was narrowed to 65-68°F (18.3-20°C).

Results and Discussion

Clearly it is too early to discuss any results since the first set of treatments were just started a few days ago (as of Aug 31 2006).

It should be noted that the quest here is to improve our understanding of how rose plants behave under low temperature conditions. It is well known that one aspect of rose development benefits from low temperatures: petal count in the flowers (i.e. lower temperatures result in larger, more-massive flowers). But there is always a price in that the production period is extended. When energy costs were lower than they are now, it was economically feasible to grow plants at higher temperatures; currently growers are interested in anything that will let them reduce energy costs. Doing so may well require a change of varieties. In fact, the reason South American growers typically use a different set of varieties is for this very reason: they prefer varieties that can be produced at colder temperatures, even if it means much longer production cycles. As growers with heated greenhouses seek ways to reduce energy costs by shifting varieties, they will need to know which of their varieties stay productive under cooler temperatures and which will not.

We are hopeful that microcalorimetry can be used to test plant tissues to obtain an indication of how specific rose varieties may respond to various types of low temperature patterns. In the case of Kardinal we are testing whether calorimetry gives us the needed information about bud break; for Milva we are testing whether leaf development will continue well at low temperatures.

We recognize that this is a fairly high gamble and that there are many more plant processes that combine to form a harvestable flower shoot than just the metabolic activity of buds or leaflets. Yet if we can use this tool to learn how to use low temperatures to our advantage in cut-flower rose production then this will be a major advance. Also, if we find that we can use calorimetry as a tool to test varieties, then this will be a very important tool for breeders since this gives them a tool they can use even before varieties are scaled up into commercial testing or released to the public.

Literature cited

Raviv, M., J.H. Lieth, D.W. Burger and R. Wallach (2001a). Optimization of Transpiration and Potential Growth Rates of ‘Kardinal’ Rose with Respect to Root-zone Physical Properties._ *J. Amer. Soc. Hort. Sci.* 126: 638-645.

Raviv, M., D.W. Burger and J.H. Lieth (2001b). Microcalorimetry: A novel approach to decision making in cut rose production. *Acta Hort.* 547: 105-110.