ENERGY CRISIS

Timing Spring Crops

Learn how cooler greenhouse temperatures can influence crop timing.

by ***ERIK S. RUNKLE*** *and* ***ROYAL HEINS***

THE increase in natural gas prices in late 2000 has made growers sensitive to the cost of heating a greenhouse. To decrease structure heating costs, many growers have decreased the heating temperature setpoint. Lowering the heating setpoint will delay plant development. Cooler temperatures will mean plants will take more days to flower, or plants will be smaller (i.e., have fewer leaves) on a particular date compared with those grown at a warmer temperature.

Travel Analogy

The reason cooler temperatures delay plant growth and development can be compared to travelling in an automobile. For instance, the distance we travel in a car can be determined by multiplying your speed (a rate of distance traveled) by the time you drive. Similarly, lowering the temperature has the same effect as slowing down: either the distance one travels is less (less development) or it takes longer to travel the same distance (flowering takes longer).

To determine how much lowering temperature will affect crop timing, we must consider the usual greenhouse forcing temperature, how much temperature is lowered, and the plant species. To do this, assume you are the

Table 1. **Estimation Of Crop Timing Delay With Cooler Forcing Temperatures**

Base Temperature (°F)	New Cooler Air Temperature (°F)	Approximate Delay in Crop Timing		
		Percent	No. of Days	
		(%)	6-week Crop	8-week Crop
Normal Air Temperature of 68°F				
36 (cool-season crops)	64	11	5	6
	61	13	5	7
41	64	13	5	7
	61	15	6	8
45 (warm-season crops)	64	15	6	8
	61	18	8	10
Normal Air Temperature of 68°F				
36 (cool-season crops)	59	13	5	7
	55	15	6	8
41	59	17	7	10
	55	20	8	11
45 (warm-season crops)	59	20	8	11
	55	25	11	14

Plants with a relatively low base temperature (e.g., 36°F) are cool-season crops, and may include plants like alyssum, pansy, and petunia. Warm-season crops are those that are generally grown at warmer temperatures, such as celosia, impatiens, and vinca. Other plants might be considered to be between these two categories, and could include plants such as begonia, marigold, and tomato.

Figure 1.

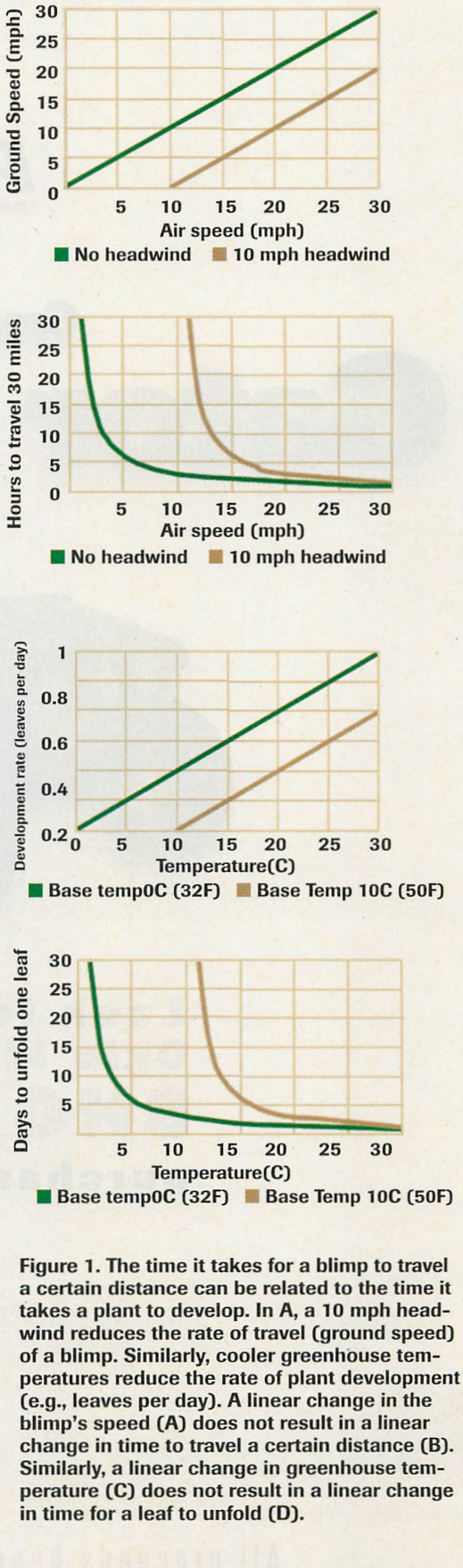

Figure 1. The time it takes for a blimp to travel a certain distance can be related to the time it takes a plant to develop. In A, a 10 mph headwind reduces the rate of travel (ground speed) of a blimp. Similarly, cooler greenhouse temperatures reduce the rate of plant development (e.g., leaves per day). A linear change in the blimp's speed (A) does not result in a linear change in time to travel a certain distance (B). Similarly, a linear change in greenhouse temperature (C) does not result in a linear change in time for a leaf to unfold (D).

captain of the Goodyear blimp, and your job is to move the blimp 30 miles. Figure 1A shows the effect of air speed on ground speed when the blimp travels either in calm air or with a 10 mile per hour (mph) headwind. With 30 mph airspeed, it takes one hour to cover the 30 miles in calm air (Figure 1B). Decreasing air speed by 10 to 20 mph (which is a 33% reduction) increases the travel time to 1.5 hours, which is a 50% increase.

With a 10 mph headwind, ground speed at 30 mph airspeed is now only 20 mph (Figure 1A), and travel time is 1.5 hours (Figure 1B). A similar 10 mph decrease in air speed (now a 50% decrease in ground speed) increases travel time to three hours (30 miles at 10 mph), a 100% increase in travel time.

This example shows that the same absolute change in speed (10 mph) can have dramatically different effects on time to travel a certain distance. In fact, an additional 10 mph decrease in air speed (now 10 mph airspeed) causes the blimp to travel the 30 miles in three hours in calm air, but with the 10 mph headwind, ground speed falls to zero and the blimp never gets there.

The message here is that changing speed in a linear fashion (as in Figure 1A) does not result in a linear change in time to travel a certain distance (Figure 1B). As speed approaches zero, travel time changes dramatically with small changes in speed.

A Good Comparison

Plant maturity is exactly comparable to distance traveled: it is a function of plant development rate (Figure 1C) multiplied by time. As temperature increases, development rate increases in a linear fashion above the base temperature. The base temperature is the temperature above which plant development occurs as temperature increases.

Examples of two different base temperatures are shown in Figure 1C, 0°C (32°F) and 10°C (50°F). The 0°C base temperature is similar to ground speed of the blimp without any headwind, while the 10°C base temperature is similar to the ground speed of the blimp with the 10-mph headwind. The relative development rate for any temperature above 10°C is greater for a plant with a base temperature of 0°C compared to a plant with a 10°C base temperature.

As with changes in air speed, changes in temperature have a different effect on maturity, depending on

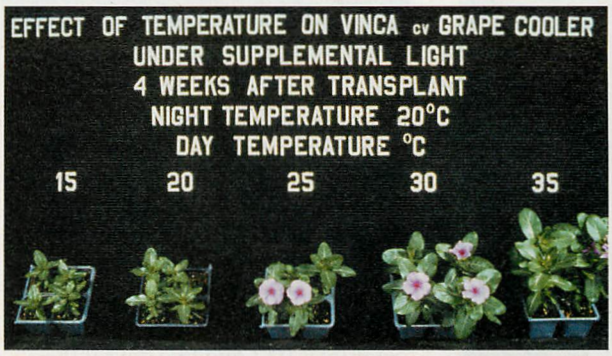

Figure 2. Growth and development of the warm-season annual vinca is slow at cool temperatures. Plants were grown with a 20°C (68°F) night temperature and a day temperature ranging from 15°C (59°F) to 35°C (95°F). *Photo courtesy of Grace Pietsch.*

the actual temperature as well as the base temperature for the plant. The closer one is to the base temperature, the greater the effect a change in temperature will have on maturity.

Using the example shown in Figure 1D, the time it takes to unfold a leaf at 20°C (68°F) is 1.5 days if the base temperature is 0°C, and two days if the base temperature is 10°C. Decreasing the temperature to 15°C (59°F) increases the time to unfold a leaf to two days for the plant with a 0°C base temperature, an increase of 0.5 days. For the plant with a 10°C base temperature, lowering the temperature from 20° to 15°C increases the time to unfold a leaf to six days, an increase of three days. These responses are identical to those observed with the blimp traveling in still air versus a headwind.

Table 1 estimates how reducing the temperature could influence crop timing. We arbitrarily chose two "normal" air temperatures that growers might use when growing spring crops (63°F and 68°F) and when energy costs are relatively inexpensive. Then, we determined how a 4°F or 7°F temperature reduction would affect crop timing.

Let's look at an example of how reducing the temperature influences crop timing. One grower of celosia (a warm-season crop) normally grows at 68°F, but this spring her greenhouse is only heated to 64°F. As Table 1 indicates, the crop will be delayed by approximately 15%. Thus, if a crop normally took eight weeks (56 days) at 68°F, it would take roughly eight days longer at 64°F (64 days). Assuming a cool-season crop (base temperature assumed to be 36°F) was treated similarly, the delay would be less (i.e., 11%, or six days).

As the table indicates, reducing the temperature would generally delay warm-season crops more than that of cool-season crops. For example, let's say that another grower normally grows a warm-season crop at 63°F. If he lowered the temperature by 4°F, the crop would be delayed by about 20%. Therefore, a crop that normally takes eight weeks (56 days) at 63°F would be delayed approximately 11 days at 59°F.

These estimates are provided to give growers a general idea how cooler air temperatures will influence their crop timing. It is intended as a guide only, as the responses will vary by plant, light intensity, and stage of plant growth. But it will at least give you an idea of what type of delay to expect if you have turned down the thermostat to reduce energy consumption this spring. **GG**

About the authors: Erik S. Runkle is an assistant professor and extension specialist and Royal Heins is a professor, Department of Horticulture, Michigan State University, East Lansing, MI 48824.