Native to South Asia, cucumbers are adapted to growing under conditions of high light and moderate to warm temperatures.¹² For the long English, seedless cucumber varieties commonly grown in greenhouses, fruit are typically 12 to 14 inches long at the time of harvest. USDA standards for U.S. Fancy, U.S. No. 1, and U.S. No. 2 fruit state that “Unless otherwise specified, the minimum length shall be not less than 11 inches.”²³ Unofficially, cucumber fruit can be classified as large, medium, and small, with fruit under ten inches long falling in the less marketable and less valuable “small” category.⁴ The sizing specifications for Long English greenhouse cucumbers in Canada are shown in Table 1.⁵

**Table 1. Size standards for greenhouse cucumbers in Canada.**⁵

<table>
<thead>
<tr>
<th>Grade</th>
<th>Minimum Diameter (mm)</th>
<th>Length Range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada No. 1</td>
<td>41</td>
<td>≥280</td>
</tr>
<tr>
<td>Small</td>
<td>41</td>
<td>280 to 317</td>
</tr>
<tr>
<td>Medium</td>
<td>41</td>
<td>318 to 368</td>
</tr>
<tr>
<td>Large</td>
<td>41</td>
<td>369 to 419</td>
</tr>
<tr>
<td>Extra Large</td>
<td>41</td>
<td>&gt;419</td>
</tr>
</tbody>
</table>

**THE SHORT FRUIT PROBLEM**

In northern regions of North America, greenhouse cucumber growers often experience problems with short fruit on cucumber crops grown during the winter months with low light conditions.⁴ Low light conditions occur when the levels of natural light are less than 600 joules/cm²/day. Under these conditions, some fruit can abort. The time to harvest increases resulting in a shorter shelf-life once harvested.⁶ The low light levels result in reduced levels of photosynthesis, which affects the energy balance within the plants. Under low light conditions, cucumber plants tend to switch from generative growth (fruit production) to vegetative growth (stem and leaf production) to create more leaf area for photosynthesis. This reduces the amount of resources going to fruit production, resulting in lower fruit production and shorter fruit. Fruit cells form but fail to elongate, and shorter, fatter fruit are produced (Figure 1).

**VARIETY SELECTION**

One way to address the problem of short fruit in winter months is to select varieties that do well under low light conditions. These varieties tend to have more generative growth habits and can better tolerate low light conditions. They also set fewer flowers, therefore they have more photosynthates (food) per developing fruit. Lower planting densities and fruit pruning also help prevent problems with short fruit. Mini cucumber varieties also tend to be less susceptible to fruit elongation problems, although these varieties are susceptible to the problem to some extent. Some cucumber growers switch to growing only mini varieties during the winter because of the fruit elongation problem.⁶

**ENCOURAGING GENERATIVE GROWTH**

**Supplemental lighting:** An obvious solution to the problem of short fruit caused by low light levels is to use supplemental lighting. Overhead lighting with high-pressure sodium (HPS) lamps or LEDs is good. The use of overhead lighting along with inter-lighting (in-canopy lighting) is even better, and the added light can help reduce problems with short fruit. This lighting should be thought of as supplemental, rather than as a replacement for natural light. The total of natural and supplemental light should provide at least 800 joules to reduce short fruit problems.⁶

A problem with supplemental lighting is that it can be expensive, not only for the initial set up but also for the continued energy-use costs. Some growers have tried to lower energy costs by turning on the lights at night, when the cost of electricity is lower. However, this can result in additional problems. In areas with cold winter climates, the vents of the greenhouse need to be closed at night to prevent the loss of heat, and some greenhouses use energy screening to help prevent the loss of heat at night. These measures can increase humidity levels in the greenhouse, lowering the plants ability to transpire and move water and nutrients from the roots to the foliage and fruit. Turning on the lights at this time can cause problems for the plants, including edema, the bursting of cells from too much internal water pressure.⁶⁷

[Continued on page 2]
Fruit Length in Winter-Grown Cucumbers

[Continued from page 1]

Regulating humidity: As mentioned, keeping vents closed in the winter often results in higher humidity levels in the greenhouse. Higher humidity levels tend to push plants toward more vegetative growth, adding to the short fruit problem. High humidity levels lower the vapor pressure deficit (VPD), the difference in the water content of the air inside and outside of the plant. Proper VPD is needed for adequate transpiration, the process which drives the movement of water and nutrients within the plant. At high humidity levels (low VPDs), the stomates on the plant close, slowing transpiration and reducing photosynthesis because of lower CO₂ levels in the leaf. Passive ventilation is used in many greenhouses, with heating pipes at the bottom of the house and ridge-vents at the top. Convection moves the warm air up through the house and out the vents. In freezing conditions, the vents can ice up, lowering the air exchange rate in the house and increasing humidity levels. Some operations use active dehumidification systems to mix drier air from outside the house with more humid internal air. Some houses also use active circulation systems to bring the warm air from the top of the house down to the bottom to better mix the air in the house. Using dehumidifiers, proper venting, and active circulation to prevent icing of vents can keep humidity levels low and VPD levels in the proper range for plant transpiration. Keeping VPD levels between 0.4 and 0.8 kPa helps maintain active transpiration and minimizes problems with water condensation on plant surfaces that can favor the development of foliar diseases.

CO₂ enhancement: Elevating CO₂ concentrations in the greenhouse can help push generative growth and increase fruit production. CO₂ concentrations between 800 and 900 ppm are recommended for low light conditions once plants start to produce fruit. However, the source of the CO₂ can be a factor in the problem of short fruit length. In mid-tech greenhouses, using on-site boilers to elevate CO₂ levels can increase problems with short fruit for two reasons. One reason is that flue gases can add humidity to the greenhouse, resulting in the problems discussed above. Incomplete combustion can also result in flue gases contaminated with nitrogen dioxide (NO₂) and ethylene. Both of these contaminants can exacerbate the problem with short fruit, and NO₂ can damage leaf and fruit surfaces. When using on-site boilers as a source of CO₂, growers should monitor levels of NO₂ and ethylene in the flue gases. Increased humidity is not a problem when off-site boilers are used in higher-tech greenhouses. Using liquid CO₂ to elevate CO₂ levels in the greenhouse eliminates both the humidity and flue gas contamination problems. However, liquid CO₂ can be expensive.

Effect of temperature: Temperature in the greenhouse (both the 24-hour average and the day/night temperature difference) has a strong influence on fruit length. Optimum fruit production of greenhouse-grown cucumbers is usually achieved with a 24-hour average of 70°F (21°C). The day/night temperature difference can be used to alter the vegetative-generative growth balance. A small difference [or no difference] in day and night temperatures often results in more vegetative growth with thinner stems, longer internodes, and shorter fruit. Lowering the nighttime temperature results in more generative growth with thicker laterals, stronger flower formation, slower plant growth, and longer fruit. A standard recommendation is to have a daytime temperature of 73°F (23°C) and a nighttime temperature of 62-70°F (17-21°C).

On cloudy days, or during low light conditions in the winter, the 24-hour average can be lowered to 69°F (20.5°C). During low light periods, the day/night temperature difference should be increased to about 9°F (5°C). Use light-dependant temperature increases, higher temperatures during periods with the most light. The effect of the day/night temperature differential is most pronounced during the initial stages of fruit growth. Once the fruit reaches a length of 8 inches, the temperature difference has less of an effect. Avoid quick changes in greenhouse temperatures. Rapidly raising the temperature can cause water condensation on plant surfaces, resulting in increased amounts of foliar disease. Rapidly cooling the house can result in chilling injury to leaves and fruit. The temperature in the house should be raised or lowered at a rate of about 2°F (1°C) per hour.

Nutrient solution concentration: Some research has evaluated the relationship between fertility and fruit length, and, at least in the case of nitrogen in one study, there was no effect of N concentration in the nutrient solution on fruit length or diameter. However, there is an effect of the electrical conductivity (EC) level of the nutrient solution on fruit growth, quality, and shelf-life. Elevating the EC level of the solution helps push the plants toward more generative growth. Under normal conditions, feed-EC values of 2.5 to 3.0 mS/cm are recommended for the beginning of the harvest period, and values of 2.1 to 2.8 mS/cm are recommended for the period of full harvest. Under low light conditions, increasing the feed-EC value to between 3 and 4 mS/cm can help plants maintain a pattern of generative growth. Watering levels will need to be adjusted as well, as plants do not transpire as much in low light conditions, so they will not use as much water.

Sources:

For additional agronomic information, please contact your local seed representative.

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