Every year millions of grafted seedling tomato plants are loaded into refrigerated trucks and shipped to greenhouses in Arizona, Texas and other states. Grafted seedlings combine high-producing tomato varieties with disease-resistant rootstocks. Although the demand is high, the production of these high quality transplants is not yet widespread in the United States. Rather, greenhouse producers purchase them from specialty propagators in Canada.

The drawback is that the stress of the long-haul trip can weaken the plants and cause them to yield poorly after they are transplanted into hydroponic systems (where plants are grown in nutrient solutions). Their maturity may be delayed, affecting the size and number of fruit produced. Not only has the production of high quality transplants become a critical technology that supports the success of the final crop, the way they are transported makes a difference as well.

Two researchers at the UA’s Controlled Environment Agriculture Center (CEAC) in Tucson are working with a Canadian transplant propagator and an Arizona greenhouse producer to learn more about how to reduce the failure rate in transporting tomato seedlings over long distances. Although these grafted transplants, which cost $1.00 to $1.50 per plant, are considerably more expensive than the bare-root seedlings typically used for field-grown tomatoes, the researchers say not much information is available on the best conditions for transporting them. The Arizona Department of Agriculture has funded the research.

“The goal was to understand how to optimize transportation conditions,” says Chieri Kubota, associate professor of plant sciences. “We wanted to minimize or eliminate the negative impact of transportation on the transplants and thereby on the early yield.” Kubota and research specialist Mark Kroggel would eventually discover that the temperature in the trucks can make a big difference in the survival and health of the seedlings.

The scientists began collecting information in 2003 from the Canadian propagator, Bevo Farms, Ltd. in Milner, British Columbia, and from the greenhouse operation Eurofresh Farms, Inc., in Willcox, Arizona. Eurofresh is the largest producer of greenhouse tomatoes in the United States.

“The first time I visited Eurofresh was when I was interviewing for this job and the grower mentioned the seedlings were not doing well,” Kubota recalls. “I thought it might be related to transportation.” The Eurofresh growers had observed that the stresses of long distance transportation, greenhouse planting conditions and the timing of flower development could all directly cause flower drop or abnormal fruit development on the first truss of the plant. The truss is the section where the fruit sets after the flowers bloom.

“The first truss generally produces the highest yield of tomatoes, compared to subsequent trusses,” Kubota says. “Shortening the duration from transplanting to the first truss harvest is crucial to assure high annual yield of greenhouse tomatoes.” Not only is it important to get the transplant into the growing medium as quickly as possible, it’s also critical to make sure the transplant hasn’t already been delayed in development before it’s even unloaded from the trailer. Significant yield delays and losses result in part because the mechanisms that cause flower
Chieri Kubota
tomato transplants from Canada.

To get some baseline data, Kubota and Kroggel shipped temperature, humidity, and light sensors to Bevo Farms, which were put inside trailers full of transplants (14,500 per truck; three to four trucks per delivery) on several runs from B.C. to Willcox, a 3,000 km. run (1900 miles). The condition of the seedlings was checked on arrival and after transplanting. On campus, simulation experiments were set up in growth chambers to examine combinations of air temperature and light intensity that could occur during transportation.

Over a four-day period, the researchers placed “Durinta” tomato seedlings with visible flower buds under various air temperatures — 6°Celsius, 12°C, or the conventional transportation temperature of 18°C (or 43, 54 and 64°Farenheit). They also varied the light intensity, including conventional darkness or dim light, to simulate transportation conditions. Plants were evaluated for visual quality, photosynthetic capacity, growth and ultimately fruit yield.

“We found that lower temperatures and illumination significantly maintained visual quality and photosynthetic capacity of the seedlings,”Kubota says. The simulated transport at 6°C under light initially showed the best transportability without negative impact for the four-day simulated transportation, but later trials resulted in chilling damage. Holding the seedlings at 10°C seemed to create a problem with pathogen growth, so this temperature was not recommended either. Seedlings held at 12°C under light and in darkness showed satisfactory transportability.

But seedlings at 18°C, the current standard transportation temperature, showed serious quality deterioration of seedlings, delay in early growth and development, loss of flower buds on the first truss, and yield reduction. This agrees with the fact that conventional transportation is currently limited to three days. The delay in maturity was estimated to be one week.

Based on these results, Eurofresh conducted a two-level temperature trial on actual two-day deliveries from B.C. to Arizona. Temperature sensors were placed among the seedlings during loading in Canada and collected at the site of unloading in Arizona. Temperature settings of 12°C and 18°C were tested inside different trailers, and an immediate analysis of the transplant quality and early fruit development was conducted by the CEAC researchers upon arrival. The seedlings were immediately interplanted between rows of mature plants inside the greenhouses, a conventional practice in a continuous truss, high-wire tomato system. These seedlings were monitored through maturation by Kubota and Kroggel.

The results show that lowering air temperature to 12-14°C from the conventional 18°C for transplants during transportation significantly improved the development of flower and fruits of the first truss.

“It was so obvious,”Kubota says. “Two weeks after transplanting we visited the greenhouse to evaluate the truss development of the plants. On the ones held at 18°C, more than 95 percent of the plants were showing an abnormal truss — either the flowers had aborted or there was delayed development of fruits. Of those we saw that were transported at 12°C, most had beautiful, perfect trusses with no abnormal development. About 33 percent still showed some damage, but that was still a 65 percent reduction from the damage shown in the seedlings transported at 18°C.”

The researchers concluded that transportation at 18°C created a significant reduction and delay of the first truss yield and thus would significantly reduce the annual yield. Temperatures of 12 -14°C were recommended inside the trailers.

By adopting this strategy, Kubota says the profit to the largest Arizona greenhouse operation, by improving the transport conditions for transplants and thereby assuring normal first truss development without causing delay, is roughly estimated as a half million dollars per operation, or $3,100 per acre of greenhouse per year.

There is also a significant potential benefit for transplant propagators who could extend the transportable distance and therefore the market by improving the transportability of their seedlings.

“All grafted seedlings used at Eurofresh Farms are now transported at a lower temperature than they used to be,” says Damian Solomon, Eurofresh industry research collaborator. “Also, propagators pay more attention to the seedling quality during transportation. With these improvements, it seems that we almost eliminated the problem.”

**CONTACT**

Chieri Kubota
(520) 626-8833
ckbota@ag.arizona.edu

Controlled Environment Agriculture Center
cals.arizona.edu/ceac/

Damian Solomon, industry research collaborator at Eurofresh Farms, inspects recent delivery of tomato transplants from Canada.