GROWING KNOWLEDGE

Series content is coordinated by Dr. Lloyd Nackley, associate professor of nursery production and greenhouse management at Oregon State University in Corvallis, Oregon.

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The hottest 30 minutes

Young red maple trees growing in an Oregon nursery. Unlike their native forests of the eastern United States, where summer rainfall, higher humidity, and partial canopy cover help moderate heat stress, nursery trees in Oregon are grown in full sun and must cope with hot, dry summers while establishing relatively small root systems and developing canopies. PHOTO COURTESY OF OREGON STATE UNIVERSITY

Researchers explore how to best help plants and trees through days of high heat

BY LLOYD NACKLEY, DALYN MCCAULEY AND CLINT TAYLOR

By the middle of a hot summer afternoon, most of us make the same decision. We look for someplace cool.

It might be the shade of a porch, beneath the canopy of a favorite tree, or the comfort of an air-conditioned office. At a nursery, crews naturally shift the day's work toward the cooler morning hours, often retreating to the shop or tackling indoor tasks once the afternoon heat settles in.

Plants don't have that luxury.

Once rooted in a container, plants spend the entire afternoon exactly where they were placed. They can't move into the shade or wait for cooler weather. Every hot day, they simply stand there, absorbing sunlight, moving water from their roots to their leaves, and trying to keep photosynthesis running despite temperatures that continue to climb.

As growers, we've become very good at measuring heat. We know the daily high temperature. We know the weekly average. Some of us even monitor canopy temperatures with infrared sensors.

In many ways, modern horticulture is built on averages. We schedule crops using average greenhouse temperatures, predict flowering with growing degree days and thermal time, and estimate production schedules based on how warm a season is expected to be.

Those tools have served growers remarkably well.

But as growers, we're increasingly »

During extreme heat events, some Oregon field nurseries use overhead hand-line irrigation to provide temporary evaporative cooling. While effective at lowering canopy temperatures during the hottest part of the day, this approach requires careful irrigation management to avoid overwatering while maintaining adequate cooling. PHOTO COURTESY OF OREGON STATE UNIVERSITY

challenged by temperature extremes. We may see a record-breaking summer heat wave or an unexpected spring frost. One begins to wonder: do plants experience those events the same way we measure them? Were they responding to average temperatures? Or did they remember something else entirely?

Walk through a nursery during a hot afternoon and you'll notice something interesting. Black nursery containers become almost too hot to touch. Heat shimmers above the gravel. Irrigation cycles become more frequent.

Imagine carrying a heavy bag of potting media. Most of us could carry it across the nursery without much trouble. But carry that same bag up three flights of stairs, and you'll quickly discover there is a point where your body simply says, "That's enough."

Leaves behave in much the same way.

During much of a summer day, photosynthesis hums along efficiently, converting sunlight into the sugars that ultimately become roots, stems, and leaves. But as leaf temperatures climb into the upper 80s and above, the enzymes responsible for photosynthesis begin to lose efficiency.

The tree doesn't stop growing because the entire day was hot. It slows because, for a relatively brief period, the machinery inside the leaf shifts from growth to self-preservation.

How much heat can a nursery tree tolerate? That question had been simmering in our research program for several years — but in the summer of 2021, it suddenly became much more than academic.

The Pacific Northwest Heat Dome pushed temperatures well beyond what nurseries across Oregon, Washington, and British Columbia were accustomed to. Those extraordinary days felt unlike anything we had experienced before. Afternoon temperatures climbed well beyond what our nurseries were accustomed to. Shade trees scorched. Leaves crisped and dropped. Even established landscape trees in cities and towns showed signs of severe heat injury.

Walking nurseries afterward, it was obvious something unusual had happened.

Our research group had already been studying how container production responds to hot weather. Earlier work with Dr. Carolyn Scagel at the USDA showed that controlled-release fertilizers released nutrients much more rapidly under extreme heat, potentially leaving crops under-fertilized later in the season.

Graduate student Sadie Keller's work had also demonstrated something equally surprising: keeping roots well irrigated wasn't always enough. Even with adequate soil moisture, young red maples could still suffer severe canopy injury during periods of extreme heat. Irrigation alone wasn't solving the problem.

At the time, many people described the Heat Dome as a once-in-a-century event. Perhaps they were right. But each summer seemed to bring another record-breaking day, another unusually warm

week, another reminder that nursery production was being asked to operate under conditions it hadn't experienced before.

Rather than asking whether another Heat Dome would occur, we found ourselves asking a different question. If another exceptionally hot afternoon comes is there anything we can actually do to help a tree through it?

That simple question became the beginning of this project.

The obvious answer seemed straightforward. Cooler trees should grow better than hotter trees. At least, that's what we thought. So we decided to throw just about everything we could think of at a crop of young red maples.

Some treatments attempted to cool the canopy directly, including evaporative mist and reflective kaolin clay. Others, including paclobutrazol, propiconazole, and phosphite products, asked a different question: could subtle changes in plant physiology help trees tolerate heat more effectively?

We partnered with scientists from **Bartlett Tree Experts**, like Dr. Drew Zwart, who were also interested in preserving urban tree canopies.

Looking back, we weren't really testing products. We were testing an idea. Could helping a tree through the hottest part of the afternoon meaningfully change its growth?

Over the next two summers, sensors distributed throughout the nursery quietly recorded temperature and moisture every few minutes while nearby weather stations tracked the environment, and we monitored tree growth, irrigation demand, and soil moisture.

Every tree experienced the same Oregon summer, but under a different management strategy.

Then came the part every researcher looks forward to. We downloaded the data and began making graphs.

At first, the results were almost disappointing. Average canopy temperatures looked ... ordinary. Mist cooled leaves slightly. Kaolin reflected a little more sunlight. A few treatments appeared a fraction of a degree warmer or cooler than others.

But once those temperatures were

averaged across entire days, and eventually across two growing seasons, the differences nearly disappeared. The lines on the graph tracked one another so closely that you could almost convince yourself nothing interesting had happened.

Had we just spent two summers proving that none of these treatments really mattered?

If the story had ended there, it probably never would have become a paper. Fortunately, plants don't read graphs. While the temperature curves looked remarkably similar, the trees themselves told a different story.

Some treatments consistently produced larger trees. Others increased stem caliper. More importantly, several treatments reduced the amount of time leaves spent at the hottest temperatures, even though their average canopy temperatures changed very little.

That was the moment our thinking changed. Perhaps average canopy temperature had never been the right question. Perhaps what mattered wasn't how hot a tree became over the course of an afternoon. Perhaps what mattered was how often, and for how long, it crossed temperatures where photosynthesis begins to struggle.

Instead of looking at averages, we began looking at moments.

What the trees were really telling us

The treatments that performed best shared something else in common. They reduced a tree's thermal exposure, either by shortening the amount of time leaves spent above stressful temperatures or by reducing the dramatic swings between cool mornings and scorching afternoons.

That may sound like a subtle distinction, but biologically it's a very different way of thinking about heat. Once temperatures moderate, photosynthesis resumes, but those lost minutes add up.

One hot afternoon may not matter very much. Two weeks of hot afternoons become hours of lost carbon gain. By the end of a summer, those small interruptions can become the difference between a tree that simply survives and one that puts on another flush of growth.

That realization changed how we interpreted our experiment.

The best treatments were the ones that helped trees avoid crossing damaging thresholds, or helped them spend less time there. In other words, it was impractical to create a cooler summer, but with a targeted approach it was possible to create fewer stressful moments.

That distinction has enormous implications.

Growers don't have much control over tomorrow's weather forecast. Nobody can order an overcast afternoon before a heat wave or ask for temperatures ten degrees cooler next Tuesday. But many growers already have tools that influence how crops experience those hottest hours of the day: a short mist cycle during peak heat, strategic shade, reflective particle films, well-timed irrigation that keeps substrates from becoming limiting, or even thoughtful crop spacing that improves air movement around the canopy.

Viewed through the lens of average daily temperature, those practices may not appear to accomplish very much. Viewed through the lens of thermal exposure, they may be doing exactly what the plant needs.

Our work also reinforced another lesson experienced growers have known for years: no single product is a silver bullet.

Kaolin didn't solve heat stress. Mist didn't solve heat stress. Plant biostimulants didn't solve heat stress. Each influenced the plant differently, and each came with tradeoffs.

What mattered was understanding when a particular management tool might be useful, and why. That is why experiments like this matter. They don't produce recipes nearly as often as they produce better questions.

Instead of asking, *"Which product lowers temperature the most?"* we can ask, *"Which management practice helps my crop avoid the most stressful part of the afternoon?"* That shift in thinking may prove more valuable than any individual treatment we tested.

As new products, sensors, and automated cooling systems continue to emerge, they all point back to the same biological principle.

Young red maples at the North Willamette Research and Extension Center treated with a reflective kaolin clay film. Widely used in orchards and vineyards to reduce sunburn and heat stress while helping deter some insect pests, kaolin was evaluated as one strategy for reducing canopy heat during summer production. PHOTO COURTESY OF OREGON STATE UNIVERSITY

Trees don't experience averages. They experience moments.

Every grower has walked a nursery after a heat wave and wondered why one block came through better than another. Sometimes the answer is irrigation. Sometimes it's fertility. Sometimes it's genetics. But sometimes the difference may come down to a handful of stressful minutes on an otherwise ordinary afternoon.

We can't make July cooler, and we may not have to. Sometimes helping a tree through the hottest thirty minutes of the day is enough to change the trajectory of an entire growing season.

Lloyd Nackley, Ph.D., is a ***professor*** *at the Oregon State University North Willamette Research and Extension Center (NWREC) in Aurora, Oregon. He can be reached at* **Lloyd.Nackley@OregonState.edu**. *Dalyn McCauley if faculty research assistant at NWREC. She can be reached at* **Dalyn.Mccauley@OregonState.edu**. *Clint Taylor is faculty research assistant in nursery, greenhouse and irrigation at NWREC. He can be reached at* **Clint.Taylor @OregonState.edu**.