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ONLINE MAGAZINE

Savage Stowaways Put Biocontrols to the Test

The Organic Edge... in Annual Color Programs

Guest Columnist: Nurseries Urged to Grow Region-Specific Trees

NEW! Plant Root Growth 101

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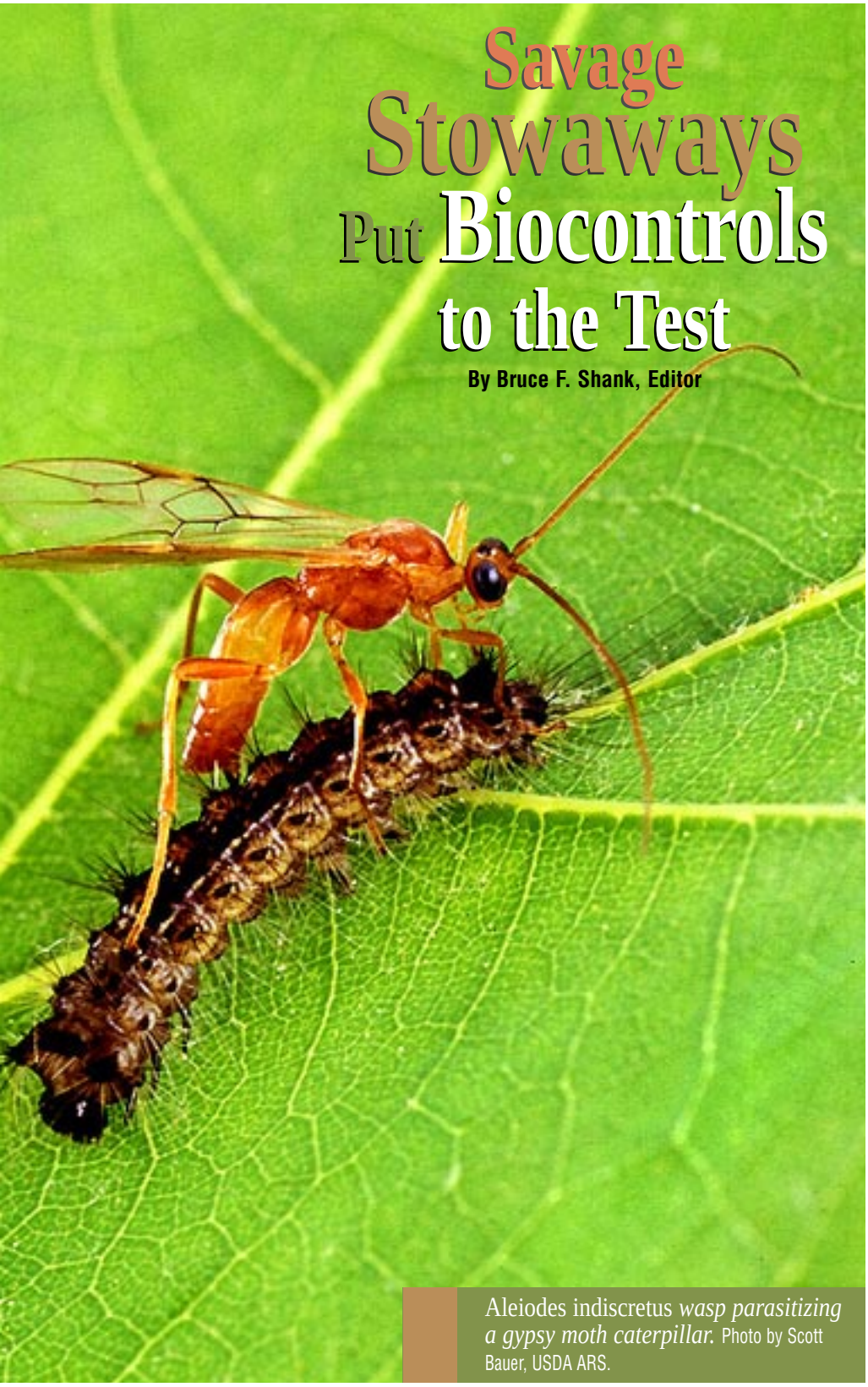
Savage Stowaways Put Biocontrols to the Test

By Bruce F. Shank, Editor



Aleiodes indiscretus *wasp parasitizing a gypsy moth caterpillar.* Photo by Scott Bauer, USDA ARS.

Imagine the discomfort early mankind had to tolerate from the onslaught of pests. Insects, spiders, snakes, bats and many more critters caused disease and had to be controlled by hunters and gatherers. When man learned he could cultivate crops to reduce his dependence on gathering, he was exposed to a new confrontation with pests. His options were limited to say the least.

Despite modern chemistry and advanced governmental intervention, we still find ourselves losing battles to pests hundreds of thousands of years later. Whenever a pest is transported out of its native habitat into a new one, trouble can erupt. These stowaways often don't have predators in their new location. They jump to the top of their food chain as soon as they find new hosts in a foreign land. Natural selection, as it relates to the pest, has to start all over again.

Armed with the knowledge of a pest's native habitat, we can fight back. We can give natural selection a shortcut by reproducing the same predator relationships in the pest's new location. Still, the process of reestablishing natural balance takes years, and in some cases decades.

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Widely disliked for their venomous, painful stings, fire ants have spread across much of the southern United States. Photo by Scott Bauer, USDA ARS.

Savage Stowaways CONTINUED

Faster solutions are needed to fill the gap. Prices based on supply and demand can't wait for a predator to increase in population. But, we are learning that temporary control measures are also subject to natural selection, that pests can develop resistance to synthetic chemicals. For long-term, natural balance of pest populations, priority must be given to restoring predators.

Admittedly, today we aren't facing life and death situations. However, we are at risk of losing a significant portion of our urban forest, many of our woody ornamentals, flowers, vegetables and even our pets. All these victims in the United States are threatened today by imported pests.

We have identified and increased populations of predatory wasps, fungi, viruses, and bacteria. We have fooled pests with sex attractants called pheromones to disrupt their reproduction. We have released sterile males to compete with normal males. By using natural controls in combination with synthetic ones that are timed for maximum impact, biological products have enabled us to decrease the amount of pesticides we apply.

Top Six Imported Pests

Depending upon where you live, these pests might be ranked in a different order. They should all be considered important.

Asian Longhorned Beetle, *Anaplophora glabripennis.* Chicago and New York have lost significant quantities of mature hardwood trees to this pest that hitchhiked from China on wooden shipping crates and pallets. They made the trip in tunnels they bored into the wood where they laid eggs that hatched after arrival in the States. They have been found on many maples, horsechestnut, poplar, willow, elm, mulberry and black locust in 14 states.

The only government-endorsed control method is prevention through a cooperative ban with China on untreated wooden shipping materials and removal of infested trees. A systemic insecticide (imidacloprid) can be injected into trees where permitted by special local needs labels [see www.mauget.com]. The adults fly from tree to tree but

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Leaf beetle Diorhabda elongata *is the first approved biological control agent for saltcedar in the U.S.* Photo by Bob Richard, APHIS.

Savage Stowaways CONTINUED

no traps currently exist with which to gauge populations. Dr. Jeff Aldrich with USDA in Beltsville, MD is lead researcher and can be contacted by calling (301) 734-8295 or visit the APHIS web site at http://www.aphis.usda.gov.

Sweet Potato Whitefly, *Bemisia tabaci.* Whiteflies are tiny (1 mm) white insects that suck plant juices from the bottom of leaves. You can detect whiteflies by shaking a branch and watching for flying adults. They seem so fragile that many people use insecticidal soaps to try to control them.

The unique characteristic about the sweet potato whitefly, according to David Byrne at the University of Arizona, is it attacks more than 400 plants, transmits plant viruses, and is resistant to some insecticides. The pest is thought to have entered the U.S. on shipments from the Sudan in the 1920s. A new strain of the whitefly was identified in the Southwest after large invasions in 1982 and 1986. While predators exist, including the lady beetle, minute pirate bug and big-eyed bug, the population of the predators does not grow as quickly as the whiteflies.

Byrne is evaluating a wasp, *Eretmocerus eremicus,* to make up where the current predators fall short. The wasps are bred by and made available from Novartis. Byrne said readers can contact the National Association of Biocontrol Producers at (315) 497-2063 for more information on wasps. Byrne can be reached at byrne@ag.arizona.edu.

There are a number of synthetic systemic and nonsystemic chemicals used for control of the whitefly on nonedible plants. Coverage is the critical element for best results with any of the pesticides. Read product labels carefully and follow all restrictions. When controlling any pest with synthetic chemicals, particularly the whitefly, apply the products within a solid resistance management program. Do not rely on any single pesticide family for multiple pesticide applications.

Red Gum Lerp Psyllid, *Glycaspis brimblecombei.* Many different types of eucalyptus trees in the Southwest are being defoliated by a psyllid imported from Australia, first identified in a suburb of Los Angeles in 1998. Of course, the

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The alfalfa plant bug, Adelphocoris lineolatus, *is a non-native plant pest.*
Photo by Scott Bauer, USDA ARS.

Savage Stowaways CONTINUED

eucalyptus tree was imported more than a century ago to produce wood for railroads in the West. The pest of the tree made it to the U.S. more than 100 years later.

The psyllid causes two problems, defoliation and massive amounts of honeydew. The sticky honeydew falls from psyllids feeding in trees onto homes, automobiles and outdoor furniture. Due to the size of the trees, spraying is impractical. Micro-injection with imidacloprid is possible and labeled. Be aware that some landscapers and arborists are concerned about the wounds caused by micro-injecting. Also, MycorTree Eucalypt Injectable is available from Plant Health Care, Inc. at 1-800-421-9051. This ectomycorrhizal fungal inoculant vitalizes damaged tree roots and reduces stress caused by the psyllid on eucalyptus trees. Apply this product with soil injection equipment.

Don Dahlsten, associate dean of agriculture at the University of California in Berkeley, has imported *Psyllaephagus* wasps from Australia and is increasing their population. The wasp is the natural predator for the psyllid in Australia. Continued defoliation of eucalyptus can deplete the carbohydrate reserves of the trees and cause them to die. "These are tough trees," Dahlsten said, "but the question is how many times they can be defoliated before they die." Dr. Dahlsten can be reached at donaldd@nature.berkeley.edu.

Africanized Honey Bee, *Apis mellifera Scutellata.* This aggressive honey bee can kill animals and people. It migrated to the U.S. from Brazil, where it was imported from Africa in the 1950s to improve pollination of agricultural crops. During its long journey north, the bee has been crossing with less aggressive species. Hybridization is the primary hope of resolving the spread of the bee, which has now reached Los Angeles and Phoenix.

On an optimistic note, the southward spread of the bee stopped in Argentina and it is expected that the northward spread will stop soon in the U.S. More information on the Africanized honey bee can be obtained from the University of California in Riverside at http://www.insects.ucr.edu.

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Asian longhorn beetles, male and female. Illustration courtesy of USDA Forest Service—St. Paul

Savage Stowaways CONTINUED

Gypsy Moth, *Lymantria dispar.* The larvae of gypsy moth can defoliate entire forests in less than a week. The moth first entered the country from Europe at Boston in 1869 and spread to defoliate more than a million acres in 17 states.

More recently, a hybrid of the European and Asian gypsy moth crossed the ocean from Germany to Wilmington, NC. Females of the Asian strain and the hybrids can fly to further spread damage.

Fortunately, larvae are highly susceptible to a strain of *Bacillus thuringiensis* (Bt), a biopesticide based on a naturally occurring beneficial soil bacteria. A nucleopolyhedrosis virus called Gypcheck is being used to contain the spread. Pheromones are being distributed over large areas as chips or beads to confuse adults. More information on the spread of the gypsy moth is available at www.gypsymoth.ento.vt.edu.

Aerial spray programs with malathion, carbaryl and synthetic insect growth regulators were tried to control some major infestations. But the synthetic chemical approach is discouraged because of the size of infestations and their proximity to people.

Japanese Beetle, *Popillia japonica.* The Japanese beetle is both a serious pest of more than 300 ornamental plants and turf. It entered the U.S. from Japan in New Jersey in 1916. The adults consume massive amounts of foliage in June and July. They can fly as far as two miles to eat and mate. After feeding, they lay eggs which hatch in late July and August. The eggs become larvae which feed on turfgrass roots.

The USDA has endorsed the use of pheromone traps to time control measures. Milky spore disease (fungus) has proven effective on grubs in the soil. The use of parasitic nematodes is also being studied for grub control. For more information on Japanese beetles check ipmwww.ncsu.edu and www.agcom.purdue.edu.

Fire Ants, *Solenopsis invicta.* Mobile, AL was the port of entry for the imported fire ant in the 1930s. It has steadily spread to the north, east and west from a shipment of sod and containerized nursery plants.

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Biological aide Kyra Williams prepares the beneficial insect, Encarsia formosa, *for studies of whitefly biological control.* Photo by Scott Bauer, USDA ARS.

Savage Stowaways CONTINUED

A single queen can produce 240,000 workers in less than three years. Mounds are unsightly in turf areas and disrupt maintenance practices. The bite from aggressive workers is extremely painful.

No natural control has been devised at this time. Baits and chemical drenching of mounds are the primary control methods for existing mounds. Rootball treatment with chlorpyrifos is used prior to shipping container stock. Clemson University has one of the largest research programs on the fire ant in the country. It can be contacted at http://entweb.clemson.edu/fireant.

You can see that it takes years to develop natural control methods once a pest sneaks into the United States. As the earth get smaller as travel gets faster and commerce is multinational, cross-infestation is more likely to occur. Until natural predators can be established in all ranges of a particular pest, chemical intervention will be necessary. But the ultimate weapon in preventing devastating infestations is the development of comprehensive biocontrol programs. Nature has already done the development work. We need to find it, accept it, and apply it.

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The Organic Edge—in Annual Color Programs

by Felicia Gillham, Managing Editor

By adopting more organic approaches, Duke-Weeks Landscape reduced fungicide use in its flower bed program by 70 percent. Post Landscape Group cut its annual color maintenance costs by as much as 40 percent, and its flowers last about 30 days longer at the end of the season.

It's time to judge organic approaches by their performance and by the bottom dollar.

Angie Mueller is seasonal color designer for the Post Landscape Group (PLG), a large Atlanta-based firm that generates $3.5 million a year handling the landscape programs for residential and commercial clients. PLG's clients have some prestigious properties—the Atlanta Financial Building, the Capital City Golf Club and the Avenues at East Cobb, all in Atlanta. Mueller is responsible for renewing all seasonal color accounts, which means she works directly with clients and ensures their satisfaction. She's also involved in the new accounts, most of which invariably call for color.

Seasonal color programs have become big business in Southeast landscaping. Attractive, well-maintained seasonal color become roadside advertisements that draw new clients into this highly competitive market. "Color sells" is not a saying in this region, it is a fact.

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Cutting Costs With Organics CONTINUED

Flower beds, therefore, would seem to be the riskiest of all landscaping endeavors in which to try new products and approaches. By their very nature, flowers are fragile and they are highly visible to competitors and potential customers.

Mueller began seasonal color work about 10 years ago while working for another firm. It was a time when the basic bed designs consisted of one row of light-colored plants in the forefront of the bed with an additional row of dark-colored plants in the back of the beds. “Along with the ‘lovely’ design work went lots of chemicals,” Mueller says. “We did preventative sprays with fungicides, going at night on a regular basis to make sure the flowers didn’t come down with disease. Of course, over time, nothing worked,” she says, because the diseases built up resistance to the spray materials. “Even the begonias were getting diseases. The whole system was breaking down.”

Mueller says she just didn’t want to use large amounts of chemicals anymore. She wanted grow plants differently, to concentrate first on preventing problems rather than just curing them. It was an attitude change, she says. Mueller started by working to repair her soils, trying different amendments and liquid feeds. And she tried to keep an open mind. “A lot of people have tried biological approaches, but if they don’t get immediate results, they don’t use them again,” she says, acknowledging that organics are not cure-alls and that building good soil takes time.

Four years ago, Mueller was introduced to a soil-based organic bedding program using products from Plant Health Care, Inc. (Plant Health Care is the publisher of this magazine.) Mycor™ Flower Saver™ provides the soil with endomycorrhizal fungi, growth-promoting bacteria, and biostimulants. According to Mueller, the endomycorrhizal or vesicular-arbuscular fungi (VAM) colonize the roots of plants to provide their hosts with more essential elements and water. A mycorrhizal plant, one that has been colonized by mycorrhizae, is able to better resist stress. The beneficial bacteria make the soil more productive and the biostimulants stimulate growth, naturally. Healthy Start™ for Flowers is a biofertilizer that provides plant nutrition and more beneficial bacteria. Particularly liked by Mueller was the PHC™ Yuccah product, a natural wetting agent and soil penetrant.

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Cutting Costs With Organics CONTINUED

After a season of using the organic program, Mueller believed that her newly productive soils were building better, longer lasting plants. She could see the results. But Mueller is also a realist. She knew she needed a response from the program that would alleviate the skepticism of the financial managers.

Mueller got the dollar response she needed in fewer plant replacements, lower maintenance costs, and an almost complete elimination of fungicides. She was able to duplicate her results during each of the four years she used the organic program.

Last year, Mueller joined PLG. “I didn’t think I was going to get them to use the organic program because I was new, and PLG would risk a lot on this decision,” Mueller says. There was another factor involved, as well. Organic products can, on a square footage basis, cost almost twice the initial investment usually devoted to traditional programs. Some companies try to trim costs by just using a biofertilizer or just a biostimulant. Mueller cautions, however, that regardless of what products you use or which manufacturer produces them, you must “let the whole natural system work.” You must use enough products to make your particular soils productive, and you must use them consistently.

Mueller sold PLG on the organic program in two ways: Through dollars and through timing. Her past experience told her that she could cut maintenance costs in half, but to play it safe, she budgeted a 40 percent reduction in maintenance costs into the PLG bids. Then last year’s drought forced the replanting of several beds during the summer. Those beds were redone organically.

“It was so hot here during August, but the flowers we used Plant Health Care products on looked gorgeous. We got drought stress relief, hardly any fungus disease, and when everybody else’s flowers started to peak, our beds held up right through to the planting season,” Mueller says.

It’s in the winter that the cost-efficiency of an organic program really pays off, she says. Maintenance can be especially high in the winter when pansies, the color flower of choice, must be dead-headed. The longer the bloom, the fewer the dead heads.

Another organic convert is Lee Padgett, floriculture manager of Duke-Weeks Landscape. With approximately $30 million in sales last year, Duke-Weeks is the

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Cutting Costs With Organics CONTINUED

largest Atlanta-based landscape company. The corporation is a real estate investment company, "so obviously we know what is involved in creating a pleasant, vibrant environment for tenants, their employees and their prospective customers," Padgett says. "That's our number one goal—to create a nice, friendly atmosphere that makes people want to come in." Hence Padgett's interest in organic approaches.

Padgett directly supervises the flower programs of the Atlanta and South Carolina offices of Duke-Weeks, a responsibility that covers about 140,000 square feet of flower beds. Four years ago, Padgett also began using the Plant Health Care flower bed program. "When we initially started, it was actually a little more expensive than what we were putting in our beds previously," he says.

Those costs are shaved, Padgett says, in both bed preparation and maintenance during the growing season. Instead of putting as many as five different amendments into the soil, Padgett now uses as few as two, including those that contain endomycorrhizal fungi, beneficial bacteria, and biofertilizers. "It actually saves us money, because the crews are spending less time in preparing the beds," he says.

"During the maintenance season, the products cut our labor because we're getting a quicker start to the plants. The plants are filling in quicker, which reduces the weed growth, and that also helps reduce moisture loss because there's less evaporation from the soil.

"The biggest result we really see is in the reduced use of our fungicides," Padgett says. "We've reduced our fungicide use by approximately 70 percent."

Although both Padgett and Mueller have seen the reduced need for fungicides, it is critical to point out that none of the Plant Health Care products mentioned are fungicides. So how can Padgett and Mueller say they have reduced their need for fungicides?

There are two primary reasons, and both form the basic premise of organic gardening. First, healthy plants have more natural defenses against soil-borne disease pathogens. They are stronger, so they can ward off an attack better. Second, good, healthy soils or those made productive with the addition of mycorrhizal fungi and beneficial bacteria, help plants resist pathogens in the soil. How? Mycorrhizal fungi can form barriers

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Cutting Costs With Organics CONTINUED

around plant roots, thereby keeping pathogens from infecting the plant. Bacteria can out compete soil pathogens for food, they can antagonize pathogens and make them go elsewhere, and some species actually produce natural antibiotics that kill the disease organisms.

The bottom line in organic gardening is to think "soil" first. Nurture it with beneficial soil microorganisms. Provide it with organic matter to improve tilth and to give the beneficial bacteria the material to convert to plant nutrients. Provide adequate water. In short, use products and practices that, as much as possible, recreate a natural, healthy and sustainable soil setting in your urban environment. Then, let your healthier plants work in concert with beneficial organisms to reduce your need for added inputs, such as fungicides.

Padgett does not want to be misunderstood. He does not believe that the overall goal of a bedding program—organic or not—should be the use of fewer pesticides. "I want to work better with what we do use," he says.

"The further we can get away from solving problems by finding a chemical and just spraying it, the better off we all are," Padgett says. "Generally everybody in the horticulture and landscape industry is looking for new ways that are more organic, more environmentally friendly, and more labor- and cost-conscious.

"That's the good part. Most of the organics are more economical to use than most of your previous chemicals," he says. "We'll definitely continue to see more organic or biological controls being used."

Snail Mail:

Post Landscape Group
2971 Atlanta Road
Smyrna, GA 30080

Duke-Weeks Landscape
4275 Shackleford Drive
Suite 225
Norcross, GA 30093

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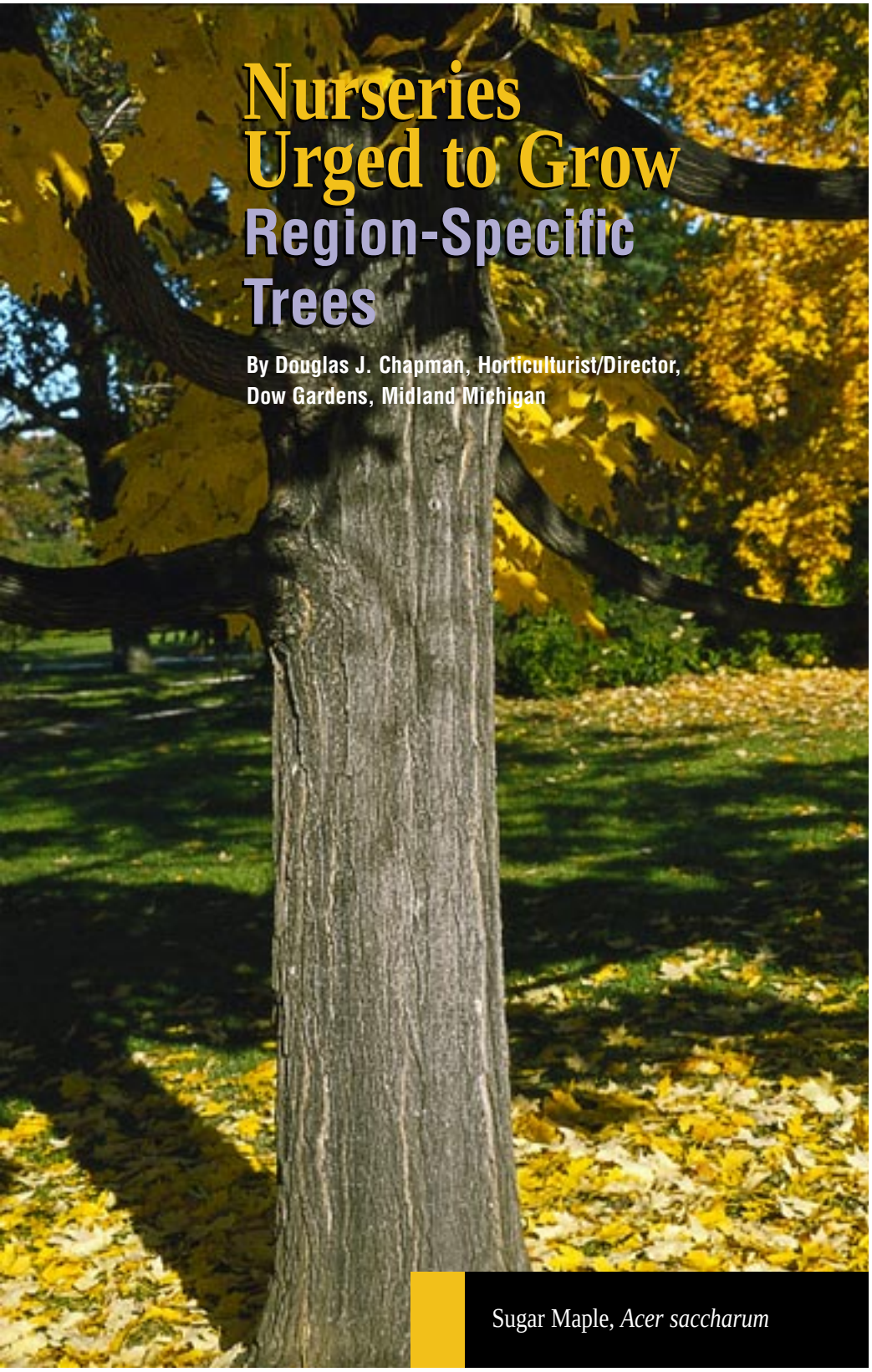

Nurseries Urged to Grow Region-Specific Trees

By Douglas J. Chapman, Horticulturist/Director, Dow Gardens, Midland Michigan

Sugar Maple, *Acer saccharum*

Local Ecotype Trees and Provenance Are Major Factors in Increased Longevity

Wherever we go on this earth we like to bring along our favorite plants. It's been happening for millennia. Whether the plants are spices, tea, tobacco, meadow grasses, tulips, or azaleas, we make room in our luggage for seeds, cuttings or bulbs.

The presumption that plants from one location will thrive in another location is naive. Equally presumptuous is the thought that plants, which are produced in a nursery in one particular part of the country, will thrive everywhere. Yet we have managed to do both by fussing over our imported plants, increasing the amount of care we provide to keep them healthy.

Now is the time to consider use of regional native trees. Arboretums have recently spearheaded plant conservation and use of native trees. We have known for many years native plants are better adapted to local conditions, yet we continue trying to use the same several hundred tree cultivars throughout all of North America.

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Paper Birch, *Betula papyrifera*

Focusing on Regional Trees CONTINUED

I recently visited Salt Lake City, UT and noted the home and street landscape was comprised of many trees we grow in the Midwest. I could say the same about many dissimilar parts of the country.

However, this observation was not true as I drove through Provo Canyon on the way to Park City, UT. The native plants in the landscape were unique to the area and were thriving as you'd expect with a minimal amount of care.

A Nation of Differences

How similar are our continental and marine environmental conditions? Should we consider growing a Sugar Maple (*Acer saccharum*), which is native to Vermont, in Denver, CO because they both have mountains?

We can reduce maintenance by planting the right tree for any area of the country. For example, we should plant Blue Spruce (*Picea pungens*) to grow in well drained soils at 6,000-10,000 feet elevation. In Michigan, Blue Spruce starts declining at 20 years of age and frequently contracts Cytospora Canker. Not so in the western Rockies. White Spruce (*P. glauca*) can be planted in cold climates from Northern Michigan to Northern New England.

Focusing on regional trees has begun in earnest. The University of Minnesota introduction program is based upon good plant science. One can cite Harold Pellet's plant introduction program, which is focused on selecting, developing, and introducing trees for COLD continental climates.

Many northern natives are cold temperature hardy, i.e. White Pine (*Pinus strobus*), Paper Birch (*Betula papyrifera*), and White Spruce, but are not warm temperature tolerant. It has been proven that native White Birch will decline if the mean July temperature is above 70 degrees F. Furthermore, it should be noted that entomologist David Neilson, who studied white bark birches at the Ohio Agricultural Research and Development Center (OARDC) in Wooster, reported native *Betula papyrifera* showed

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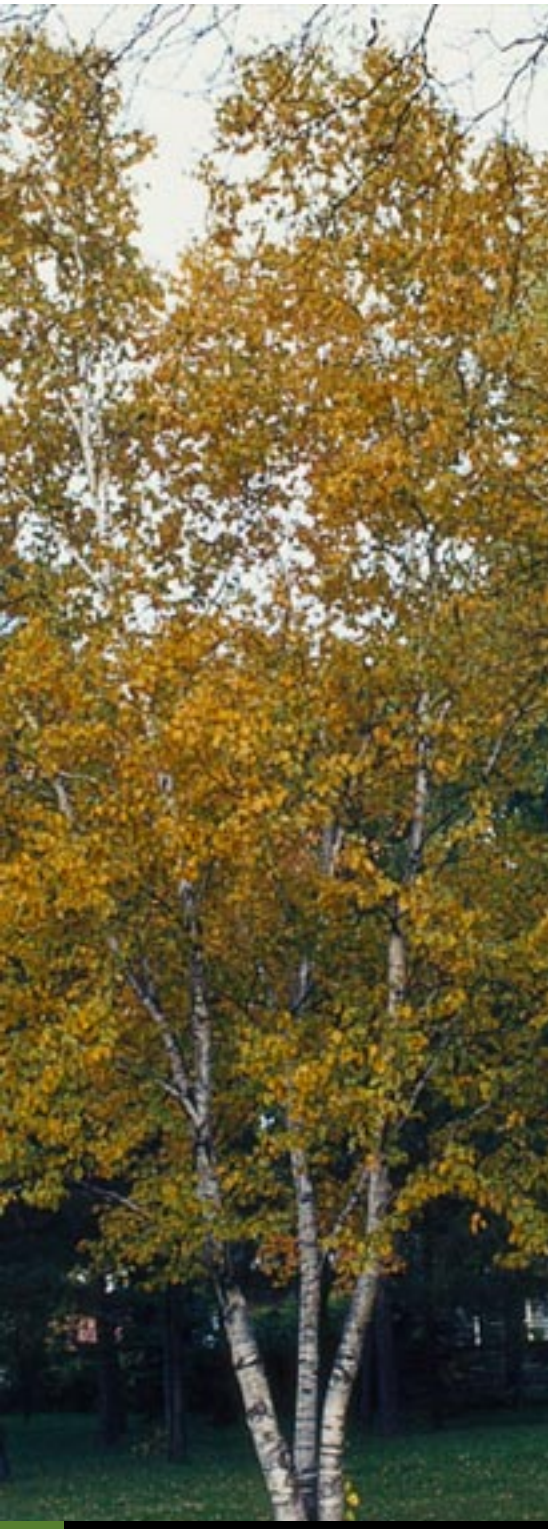

Paper Birch, *Betula papyrifera*

Focusing on Regional Trees CONTINUED

less susceptibility to Bronze Birch Borer than some Asian species. Others reported native birch from the southern range of *B. papyrifera* were more tolerant of higher temperature than plants from a more northern provenance.

Provenance and Ecotypes

Provenance is when trees within their native range exhibit local adaptation. In other words, a range can be large and trees within that range exhibit special adaptation in their particular location. Many of our favorite tree species have a wide North/South native range, but plant provenances from northern latitudes can't survive high temperatures in the south and conversely southern provenance trees within the same species are not cold temperature hardy.

It has been shown that plant selections in northern latitudes of the species' native range are more photoperiod responsive and cold-temperature hardy. These northern provenances respond to day length and go dormant earlier. Red Maple (*Acer rubrum*) is native from Upper Michigan to Northern Florida and Red Oak (*Quercus rubra*) is native from New England to the southeastern states. However, local ecotypes might not be hardy 200 miles north or south of their seedling origin.

When Pellett (University of Minnesota) introduced his first selected Red Maple cultivar Northwoods, he found it growing in Northern Minnesota. As I said, East/West conditions don't have as pronounced impact on photoperiodic responses.

Regional native trees that are based upon provenance would mean that every part of the country could again be unique. The same tree can have slight variations that make it locally special. For example, the designers of McDonalds' restaurants realize the value of provenance and adapt the company's Golden Arch architecture to fit each region. The Big Mac looks and tastes the same, but the environment has hometown appeal.

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Crabapple, *Cornus florida*

Focusing on Regional Trees CONTINUED

Quality Over Quantity

The selection and introduction of regional native trees could lead to a boom for the nursery industry. No longer would the same cultivars be offered for use across the entire North American landscape. Regionally seedlings and/or cultivars could lead to increased longevity of trees in our urban landscapes. The rootstock and scion would be of the same provenance avoiding the incongeniality reported by Davidson with Red Maple cultivars. Lastly, using regional native trees based upon provenance would mean that every part of the country could again be unique. The aesthetic qualities of regional native trees might display some unique characteristics, but the genetics would definitely be locally adapted with greater diversity.

Today, we generally use 40 tree species comprised of some 500 cultivars, but all 500 are clones. Consequently, of the millions of trees planted annually it is possible that 85 percent are cultivars. This means, in layman's terms, that of the many thousand individual trees being planted annually across the country, the composition consists of simply 500 clones.

Picture crabapple cultivars when many were first introduced, i.e. Malus Radiant, M. Dorothea, and M. Snowdrift. They exhibited resistance to fire blight and/or apple scab. But, after a number of years and many plantings, these cultivars no longer possess resistance to these diseases. We had to develop new cultivars.

Professor Lester Nichols from Pennsylvania State University spent a professional career testing and reporting on disease-resistant cultivars of crabapples. A situation that was in a continuously dynamic state requiring a new report every few years. This fact alone favors seedling selection to increase diversity. Yet, we should be able to produce seedlings as well as some superior regional cultivars. No one technique is perfect but an emphasis on multiple solutions should lead to a healthier, lower-maintenance landscape that is based upon good science.

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Sugar Maple, *Acer saccharum*

Focusing on Regional Trees CONTINUED

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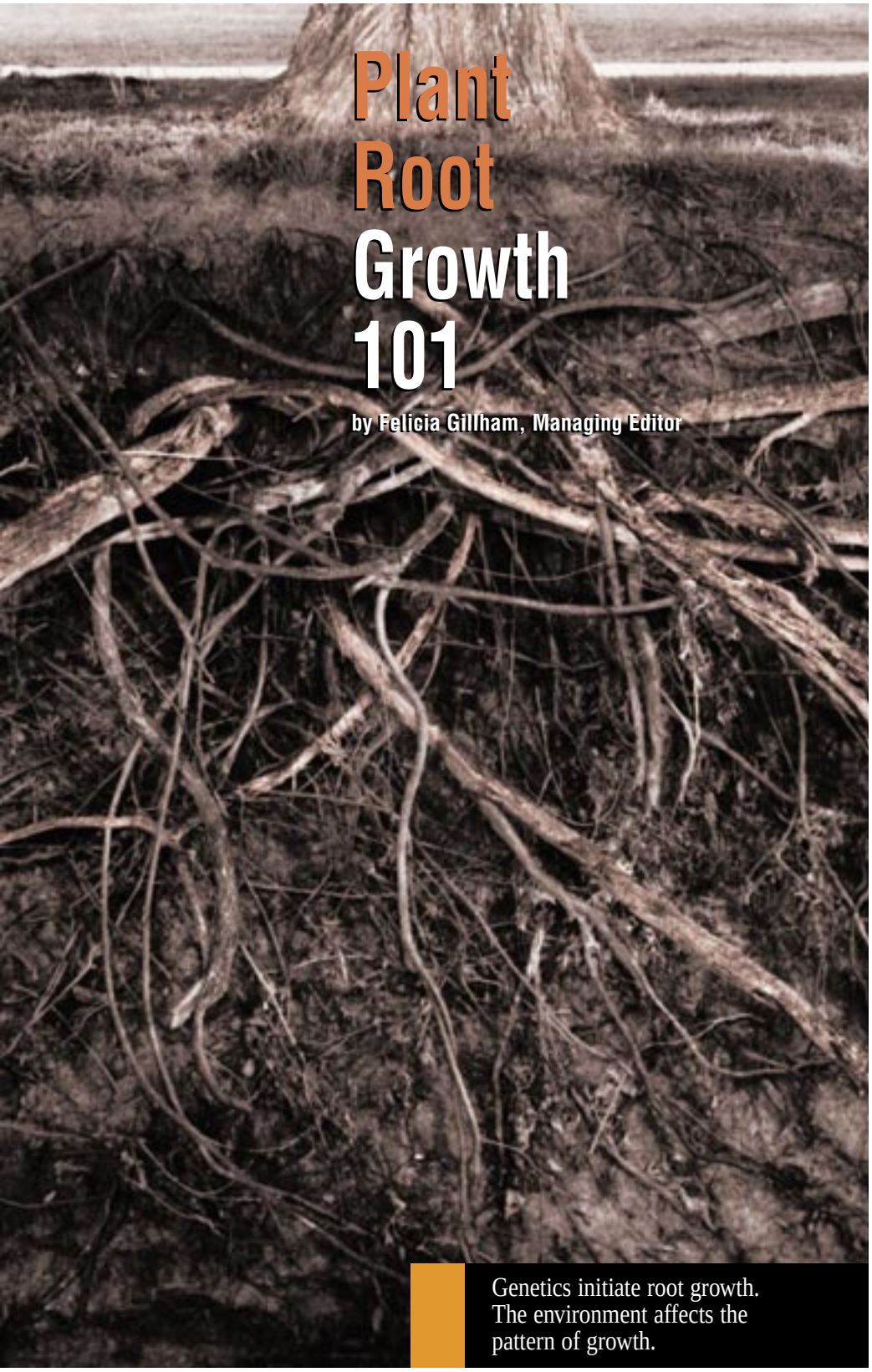

Plant Root Growth 101

by Felicia Gillham, Managing Editor

Genetics initiate root growth. The environment affects the pattern of growth.

We appreciate plant roots, because as professionals we understand roots are the vital underpinnings of the plants we maintain and nurture. We also hate plant roots, because their often exacerbating growth can make our jobs frustrating.

Research into the growth and development of roots began in the late 1800's. Because roots are difficult to study (we're above ground, and they are below ground), basic research is still far from complete. There has been a resurgence in root studies, not because technology allows us to do more research, but because many of the basic questions about roots have never been answered. Scientists still argue about which of eight terms should be used for the common tap root.

In the future, we can expect more new answers to old questions. In the meantime, we can absorb this decade's largesse, the increased understanding of the plant root's interaction within the rhizosphere (root zone). While the scientific community argues the fine art of terminology, we can apply what we do know about roots to avoid root-related problems.

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Elongation of the radicule signals a seedlings emergence.

Roots 101 CONTINUED

Roots in Their Infancy

Let's take a little refresher course on how roots begin. In general, root growth and development is the same for all plants except that dicotyledons (trees, shrubs and bedding plants) form secondary vascular tissues and monocotyledons (grasses) don't.

Root growth begins in the embryo. When the radicle (tap root or seminal root) elongates, we know that germination has occurred. Root hairs appear and the first lateral roots emerge within three days, or depending upon the plant species, seminal roots emerge which later develop root hairs and eventually lateral roots.

In dicots, secondary vascular tissues then develop on lateral roots. The roots enlarge and increase their capacity to transport water and the mineral elements carried in that water to the shoot. The more the roots grow in diameter, the more soluble material they can transport.

Plants must continue to produce new roots to explore new volumes of soil to acquire the soil resources they need to grow. It is the young root with root hairs that is responsible for absorption of water and mineral nutrients. Root hairs are projections that increase the absorptive surface of the young root. As older roots die, are eaten by soil organisms or lose their functionality, they are replaced by new fine absorbing roots. In trees, shrubs and other plants, fine roots lose their ability to absorb minerals and become woody as they age. These larger woody roots become important for the absorption and transportation of water and transport of mineral elements to the stem. They also become the tree's anchorage and food storage area. The direct mineral uptake is relegated to the new, young roots that emerge. In trees and shrubs therefore, in general, older roots are close to the base of the tree with newer root growth extending outward. The plant will contain main transport roots that extend out and divide into smaller roots with each ending in a mass of fine absorbing roots. The root systems of grasses and annual plants tend to have soft, fine roots for mineral gathering. They do not develop woody transport roots.

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Recreating forest conditions in the rhizosphere help produce healthy roots.

Roots 101 CONTINUED

Up to this point, plant roots grow in the pattern dictated by their genes. Beyond this point, and beyond some physical norms, growth can be shaped and altered by the environment in which they are grown.

Root System Maturity

Most of us would agree that old growth forests represent the ideal situation for plant growth. Because these forests are largely not altered by man, the plant growth within them can be considered the "norm."

Trees and other plants have a natural imperative to survive. This means that each individual tree attempts to out-compete other plants for available resources. Competition between trees occurs first between their root systems. The most competitive trees are those with the largest expanses of root systems. Many mature forest trees have diameters of root spread that are four to five times the height of the tree. The nonwoody, absorbing roots on large, mature lateral roots can occupy as much as 150 cubic yards of soil.

Roots grow where the physical and chemical environment is most ideal. In general, the moisture, soluble mineral elements, temperature, oxygen, pH and soil structure are best in the top 10 to 12 inches of soil. As a result, this is where plant roots proliferate creating an area on and surrounding plant roots called the rhizosphere.

Plants evolved from forest ecosystems where they were faced with the natural stresses of extreme temperature changes, fluctuating levels of available water, soil infertility, catastrophic fires and storms, poor soils and competition. To survive these stresses, plants formed partnerships with specific soil microorganisms. These include beneficial bacteria or rhizobacteria that live on absorbing root surfaces. The rhizobacteria solubilize mineral elements, such as phosphorus, that are essential for plant growth. Since plant roots cannot absorb insoluble (solid) materials, the rhizobacteria make mineral nutrients soluble that might not otherwise be available to plants. Some rhizobacteria fix gaseous nitrogen from the air in soil. Others decompose organic

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Root variations among species are under study.

Roots 101 CONTINUED

matter, produce plant growth regulators that affect plant growth, and still others deter many root diseases.

Other organisms, including actinomycetes, algae, protozoa, arthropods and worms, feed on organic matter, increase the aeration of soil, and the penetration and movement of water through the soil.

The most critical of the soil microorganisms to plant root growth is mycorrhizal fungi. These fungi form beneficial partnerships with more than 95 percent of the land plants of the world. Mycorrhizal fungi either colonize the inside of plant roots (endomycorrhizae) or the outside (ectomycorrhizae) to attain simple carbohydrates (sugars), vitamins and amino acids. In return, some of the fungi extend vegetative strands (feeding tubes) far into the soil thereby increasing the surface area of the roots. This improves the absorption of water and essential mineral elements which are shared with their plant hosts.

Mycorrhizae are able to absorb, accumulate and transfer all of the major and minor mineral elements and water to trees more rapidly and for longer periods of time than nonmycorrhizal absorbing roots. Ectomycorrhizae can increase the absorptive surface area of root systems by more than 700 percent when compared to nonmycorrhizal roots. From an energy perspective, a tree would use approximately 100 times more photosynthate (sugars) to form enough nonmycorrhizal roots with the same absorptive surface area equal to that provided them by the mycorrhizal associations. In healthy forest soils, root colonization by mycorrhizal fungi can exceed 80 percent of the absorbing roots.

Nurturing Urban Plant Roots

With these basics facts in mind, how can they be applied to benefit the trees, shrubs and plants grown and maintained in urban soils?

Provide Organic Matter: Urban soils are widely deficient in organic matter, which provides soil microorganisms with a food source and a natural slow-release of

(continued)

Plant roots established partnerships with soil microbes in primordial forests.

Roots 101 CONTINUED

essential minerals to plant roots. To ensure survival of plants in organically deficient soils, large amounts of fertilizer must be applied, which can lead to leaching, water contamination, etc. The addition of organic matter, such as compost, humus, and mulch, maximizes the utility of fertilizers, supports soil organisms and improves the tilth of the soil.

Promote Plant Health: Regularly supplement soils with beneficial soil microorganisms and inject or vertimulch with mycorrhizal fungi. This helps keep soils productive for plant roots, as well as provide the roots with support against the natural stresses of the urban environment.

Compaction of Soil: Soil compaction restricts water and oxygen uptake by roots. Without oxygen, roots can die or not form at all. If soils are firmly packed, plant roots cannot find pores to grow through. Growth can become constricted and limit the plant's ability to absorb water and essential minerals. Stress can follow, leaving the plant open to attack by pests and disease.

Covering Tree Roots: Adding fill soil on top of an existing grade surrounding a plant reduces oxygen to the roots. Inadequate oxygen interferes with metabolic processes and root growth. Further, the added soil can alter the pH of the soil.

Watch the pH: Soil pH affects the solubility of mineral elements, and therefore, their availability to the plant. A soil with a pH range of 6 to 7 is the ideal and is the range where most plant-essential mineral elements are available. Acid soils decrease the solubility of calcium, magnesium, potassium, phosphorus and molybdenum and may cause deficiencies. Acid soils of pH 5 or lower can also increase the solubility of aluminum and manganese producing toxic levels. Alkaline soils of pH 7.5 and higher can make zinc, copper, manganese, boron and phosphorus less soluble, opening the door to deficiencies of these elements.

Deep Feeding Trees: The practice of applying fertilizer deeply beyond the root zone (top 12 inches of soil) has little or no benefit. Young nonwoody absorbing roots lie above the application and cannot access the fertilizer.

(continued)

Turf and trees compete for the same soil resources.

Roots 101 CONTINUED

Herbicide Exposure: Improper application or placement of herbicides, as well as other chemicals, can harm roots. Treatment of grasses and weeds within the canopy area of a tree or shrub can accidently harm the roots lying below the surface of the soil.

Root Disease Prevention: The most common root diseases, *Phytophthora*, *Pythium* and *Fusarium*, attack and kill nonwoody absorbing roots. If infection by these diseases are extreme, the tree loses its ability to absorb water and essential minerals. Other fungi can promote decay in large, woody roots, which suppresses growth, destroys the root's ability to transport food, reduces food storage and ultimately decays the tree's structural support. Soil-borne diseases are best prevented through selection of resistant root stock and through maintenance of high populations of rhizobacteria (that compete with or antagonize disease-causing organisms). Also important is to ensure that plants are well colonized by mycorrhizal fungi, which can form a barrier around plant roots making it more difficult for soil-borne disease organisms to penetrate. Avoid mechanical injury to roots, which can open sites for disease infection.

Sadly, although we may learn more about plant roots and their growth, we are probably never going to solve the sidewalk—root battle that generates the most root-related complaints. Plant roots require room for growth. They will take the space they require in the urban landscape, just as they learned to compete for valuable resources in the forests in which they evolved.

If you would like more in-depth information about plant physiology, consider attending the PHC Plant Biology Workshop. See www.planthealthcare.com.

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About Planthealthcare.com Online Magazine

PlantHealthCare.com Online Magazine is posted at www.planthealthcare.com for professionals who produce, design and maintain plant material in the arbor, landscape architecture/design, landscape maintenance, nursery/greenhouse, and parks and recreation industries. Published as an educational service by Plant Health Care, Inc., the PlantHealthCare.com Online Magazine is designed to engage, educate and inform professionals about new technologies that promote the health of plants, specifically those that create "sustainable" landscapes that cost less, provide more value and last longer. The magazine also seeks to open discussion about issues that impact the many businesses that serve the plant health industry.

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Meet Your Editors

Editors

Bruce F. Shank
Editor

Bruce Shank is owner of BioCOM, a horticultural communications company based in Palmdale, CA. He is the editor of *Irrigation Business & Technology*, managing editor of *TurfGrass Trends*, and former editor of *Landscape & Irrigation*, *Landscape Management* and *sportsTURF* magazines. He was graduated by the University of Missouri—Columbia with a degree in agricultural journalism in 1973. He is a past president of the American Society of Business Press Editors and a member of the Turf & Ornamental Communicators Association.

Felicia L. Gillham
Managing Editor

Felicia Gillham is owner of Gillham & Associates Marketing Communications, a San Diego, CA firm she established in 1989 to service the needs of turf and ornamental, agricultural and biotechnology companies. Articles written by Gillham on behalf of her clients have appeared in more than 100 Green Industry and farm trade publications. She is a 1980 graduate of the University of Missouri—Columbia with a degree in agricultural journalism. Gillham is a member of the Turf & Ornamental Communicators Association, American Agricultural Editor's Association and the National Association of Farm Broadcasters.

Meet Your Editors

Doug Chapman
Guest Columnist

Douglas J. Chapman has been the administrator and horticulturist for Dow Gardens in Midland, MI for 25 years. The large garden, which is part of the Herbert H. and Grace A. Dow Foundation, is renowned for its training programs for professionals, the general public and children. Chapman is a Massachusetts native and was graduated by the University of Massachusetts. He earned advanced degrees in plant physiology and horticulture from Ohio State University and Michigan State University. He is widely published as an expert in plant selection, broadening the plant palette, and matching plants to the right locations. During his career Chapman has been honored by American Association of Nurserymen, the International Society of Arboriculture, the Michigan Forestry and Park Association and the Michigan Association of Nurserymen. He is credited with running "one of the most beautiful gardens in America."

Calendar of Industry Events

April

5

New York State Turfgrass Association Adirondack Regional Conference, Lake Placid. (800) 873-8873.

26

Massachusetts Arborists Association Arbor Day Celebration, Worcester. (508) 653-3320.

May

5-11

American Society of Golf Course Architects Annual Meeting, Ireland. (312) 372-7090.

9-11

Using Conservation Buffers in Urbanizing Landscapes National Conference, Nebraska City, NE (402) 474-5655

17-18

Tree and Shrub Fertilizer Conference, Akron, OH. (440) 632-5299.

18

Recycled Water for Turf and Landscape Irrigation, Davis, CA. (800) 752-0881.

June

14

Scouting for Pests and Problems of Woodyt Ornamentals in the Landscape, Pittsfield, MA. (413) 545-0895

15-16

Warm-Season Turfgrass Research Tour, Maricopa, AZ. (520) 783-2050.

21

University of Massachusetts Turf Research Field Day, South Deerfield. (413) 545-3066.

Calendar of Industry Events

CONTINUED

July

11-16

American Nursery and Landscape Association Annual Convention, British Columbia, Canada. (202) 789-2900.

13-16

American Landscape Contractors Association Summer Leadership Meeting, San Diego, CA. (800) 395-2522.

22-24

International Lawn, Garden and Power Equipment Expo, Louisville, KY. (800) 558-8767.

26

Massachusetts Nursery and Landscape Association Summer Meeting, Boyleston. (413) 369-4731.

31

Kansas and Missouri Joint Landscape and Nursery Summer Meeting and Trade Show, Kansas City, MO. (816) 233-1481.

August

4-6

Southern Nurseryman's Association Conference and Trade Show, Atlanta, GA. (770) 953-3311.

15

Cornell University Field Day, Ithaca, NY. (607) 255-1792.

16-19

Golf Course Builders Association of AmericaSummer Meeting, Louisville, KY. (919) 942-8922.

18-21

Texas Association of Nurserymen Nursery and Landscape Exposition, Houston. (512) 280-5182.

Calendar of Industry Events

CONTINUED

24-27

Ornamentals Northwest Seminar and Farwest Show, Portland, OR. (800) 342-6401.

September

15-16

Tennessee Nursery & Landscape Association Trade Show, Nashville, TN. (615) 889-1000.

21-23

Florida Nursery and Allied Trade Show, Orlando. (407) 295-2994.

October

13-14

Plant Biology Workshop, Plant Health Care, Inc. Education Center, Frogmore, SC.

November

3-4

Plant Biology Workshop, Plant Health Care, Inc. Education Center, Frogmore, SC.

4-7

Green Industry Expo, Indianapolis, IN. (770) 973-2019.

12-14

International Irrigation Show, Phoenix, AZ. (703) 573-3551.