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110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315
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MULCH

Organic Mulches Enhance Overall Plant Growth

By John E. Lloyd, Daniel A. Herms, Benjamin R. Stinner and Harry A.J. Hoitink

Nutrient cycles have been studied thoroughly in forested and agricultural ecosystems (Facelli and Pickett 1991; Wardle 1992; Attiwell and Adams 1993; Mary et al. 1996). In contrast, nutrient cycling has received little attention in ornamental landscapes, and the effects of mulch on soil fertility have been largely ignored.

Organic matter such as leaves and grass clippings are often collected and removed from ornamental landscapes, which disrupts nutrient cycles and can increase reliance on inorganic fertilizers. Mulches are used widely to suppress weeds, conserve soil moisture, direct traffic flow and enhance the beauty of landscapes (Robinson 1988). Depending on their composition, some mulches may also have substantial effects on soil fertility and plant growth.

Because these products vary widely in their C:N ratios, we predicted that they would have dramatically different effects on nitrogen availability and plant growth.

Mulches with a high carbon-to-nitrogen (C:N) ratio, such as recycled wood pallets, hardwood bark, straw and sawdust, are thought by some to induce nutrient deficiencies in plants by stimulating microbial growth, which depletes underlying soils of available nutrients.

On the other hand, mulches such as composted yard waste, or wood/bark blended with composted manure or sewage sludge may increase soil fertility and plant growth because their low C:N ratio resembles high-quality forest litter. Mulches derived from the bark of mature softwood trees, such as cypress and pine, are quite resistant to decomposition by microbes, and thus have little effect on nutrient availability. The key to understanding how different mulches affect soil-nutrient availability lies in understanding the role of soil microbes in nutrient cycling, and how they respond to addition of organic matter.

Organic matter, microbes and the cycling of nutrients

As with plants, soil microorganisms (fungi and bacteria) require energy and essential nutrients to grow and reproduce. While plants derive their energy from carbon acquired from the atmosphere through photosynthesis, the carbon in decomposing organic matter provides soil microbes with their energy supply. However, both plants and soil microbes use the same pool of essential soil nutrients. Since nitrogen is the nutrient that most often limits plant growth, the effects of mulch on soil fertility generally will be determined by how mulch affects the outcome of competition between plants and microbes for this key nutrient.

Nitrogen and other nutrients are decomposed by soil microbes (Fig. 1). The rate of

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decomposition of organic matter is affected by many factors including soil moisture, temperature and oxygen levels, but is highly dependent on the total biomass of microbes in the soil (Wardle 1992). Since microbes are generally limited by the supply of available carbon, microbial biomass can increase quickly when a biodegradable source of organic matter is applied to the soil surface.

As microbes decompose mulch on the soil surface, they acquire nutrients from the soil below in several ways. Fungal hyphae forage for nutrients in the soil much like plant roots (Frey et al. 2000). Nutrients can also be carried toward the surface in soil water by diffusion as well as evapotranspiration. Furthermore, the soil is worked continuously by earthworms, insects and natural weathering processes, which stir the nutrient pool and incorporate decomposing organic matter.

In a process known as nitrogen mineralization, inorganic forms of nitrogen (ammonium, nitrite and nitrate) are released from organic matter as it is decomposed. Once in mineral form, nitrogen can be taken up and used by plants.

Recent studies indicate that plants can also use dissolved organic nitrogen released from decaying organic matter (Nasholm et al. 1998, 2000). Plants and microbes compete for available nitrogen, and the process of nitrogen uptake by microbes is referred to as nitrogen immobilization, since any nitrogen acquired by microbes is not available to plants. Microbial turnover occurs as microbes die and decompose, releasing nutrients that can be acquired by living microbes or by plants.

C:N ratio of mulch as key determinant

The amount of nitrogen available for plants is determined by the net balance between the rate of nitrogen mineralized from decomposing organic matter and the rate of nitrogen that is immobilized by growth of soil microbes.

Microbes are considered to be stronger competitors than plants for nitrogen (Kaye and Hart 1997). In soils where nitrogen is limited, microbes generally outcompete plants for nitrogen, resulting in plant nutrient deficiencies and decreased plant growth. In fertile soils, there may be enough nitrogen to adequately support both microbial and plant growth.

The balance between nitrogen mineralization and immobilization is strongly influenced by the C:N ratio of the decaying organic matter (Facelli and Pickett 1991; Kaye and Hart 1997; Mary et al. 1996). Since soil microbes are generally carbon-limited, the addition of organic matter to the soil stimulates microbial growth. Organic matter with a high C:N ratio (greater than 30:1) does not contain enough nitrogen to support microbial growth fully. Therefore, microbes must scavenge additional nitrogen from the soil as they decompose high C:N organic matter, which decreases the amount of nitrogen available to plants.

The addition of nitrogen fertilizer to high C:N mulch (1 to 2 pounds/1,000 square feet is often recommended) can relax nitrogen competition between plants and microbes and stimulate plant growth. Conversely, decomposition of organic matter with a C:N ratio less than 30:1, which contains more nitrogen than required to support microbial growth, increases the availability of nitrogen for plants.

Our research has focused on whether this model of nutrient cycling, developed primarily through studies of forested and agricultural ecosystems, can explain effects of organic mulch on soil fertility and plant growth in ornamental landscapes. We compared two organic mulches that differ dramatically in their C:N ratios: recycled ground wood pallets with a C:N ratio greater than 100:1; and composted yard waste (a blend of wood chips, leaves and grass clippings) with a C:N ratio less than 20:1. The availability and use of both products as mulch is increasing dramatically because of recycling efforts designed to divert organic wastes from landfills (Glenn 1999; McKeever 1999).

Because these products vary widely in their C:N ratios, we predicted that they would have dramatically different effects on nitrogen availability and plant growth. Composted yard waste, with its low C:N ratio, should release nutrients at optimal rates in slow-release form, thereby increasing soil fertility and plant growth. Conversely, we predicted that the high C:N ratio of ground pal-

Spring Turfgrass Nutrition

Late winter and early spring is an ideal time to evaluate turfgrass fertility programs and make necessary adjustments for the new year. The cultural practices that we applied in the fall have a direct affect on turf response in the spring. Inadequate spring growth is often related to a lack of sunlight, cold soils, mowing too low, or other soil properties such as compaction. Late fall fertilization, when properly timed, is a critical cultural practice that enables the plant to increase production of carbohydrates and proteins for storage in the crown and root system of the plant. This nutritional build up leads to improved color going into the winter and an earlier spring green-up.

Of the three major elements, nitrogen is required in the largest quantity by turfgrasses. Soil types will greatly influence the quantity of nitrogen required. Springtime recommendations call for nitrogen amounts vary from .30 pounds up to 1 pounds per 1000 square feet. The Andersons offers a variety of NPK ratios, particle sizes, and products to provide the superintendent with the appropriate amount of nitrogen in the spring.

Phosphorus is important for new plant establishment and greatly contributes to root development. When applied to turf, phosphorus is tightly held by the soil making it the least required of the major elements.

Potassium, is associated with disease resistance, winter hardiness and turfgrass turgidity. Potassium's benefits to a fertility program are greatest however when applied throughout the growing season, not just during or prior to stress periods as was once the case. Over the years, the importance of potassium in turf programs continues to grow as major universities and turf managers enjoy the positive benefits of additional potassium in their programs in ratios closer to 1:1 for nitrogen and potassium.

Applying slow release nitrogen sources in the spring allows for increased rates of N while reducing the "peak and valley" effect associated with quick release fertilizers. Excessive amounts of nitrogen in the spring can contribute to root mass decline. In this situation, the shoots are favored over the roots when growing conditions are ideal and the roots will lose out and root mass will decrease. Using slow release fertilizers and lower rates allows the turf to better utilize the nutrition that is present, yielding more consistent growth and turf density.

The Andersons' controlled release homogenous methylene urea products such as Contec, and Nutralene blended formulations, are available in a variety of particle sizes and release curves, designed for the lowest cut bentgrass greens to the latest hybrid bermudagrass fairways .These materials are designed to limit surge growth while promoting turf density and extended greening. The Andersons Contec 18-9-18 with 63% methylene urea, minors, potassium sulfate and a 85 SGN is extremely popular on bentgrass and Poa annua greens, designed for spring summer and fall applications. The Andersons 13-2-26 Contec and 17-3-17 Contec, with their small particle sizes lending to rate flexibility, are ideal for bermuda greens and for overseeded grasses.

Low cut fairways requiring a small particle size to avoid speckling or mower pickup make the Andersons 31-3-10 homogenous methylene urea with minors an outstanding choice for spring applications. More short chain methylene ureas and a low percentage of water insoluble nitrogen ensure a rapid greenup, even under cool spring soil conditions. For a more gradual greenup, consider 25-5-15 with 50% Nutralene with Iron and Micros or 20-5-20 w/50% Nutralene with Iron and Micros. Both are an SGN 125 particle size are ideal formulations for bentgrass fairways cut below one half inch.

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lets would induce nutrient deficiencies and decrease plant growth by stimulating the growth of carbon-limited microbes resulting in high rates of nutrient immobilization.

A field study was conducted in replicated plots at The Ohio State University's Ohio Agricultural Research and Development Center in Wooster, Ohio, from 1998 to 2000. Plots were mulched with composted yard waste, ground wood pallets or were left untreated as bare soil controls. Mulch was applied to the soil surface in a layer two-inches thick. Each spring, any residual mulch was removed and replaced with fresh mulch.

Both mulches increased microbial biomass as indicated by increased microbial nitrogen and a doubling of soil respiration.

To determine how fertility might interact with mulch to affect nutrient availability, half of the replicate plots from each of the three treatments were fertilized and the other half were left unfertilized. The fertilizer used was 18:5:4 NPK, with 56 percent of the nitrogen in slow-release form (methylene urea), and 44 percent of the nitrogen in fast-release form (17 percent ammonium nitrate and 27 percent water-soluble urea). Fertilizer was applied moderately of 3 pounds/1,000 square feet/year (2 pounds to 6 pounds/1,000 square feet/year is the recommended rate for trees and shrubs), with half of the annual amount applied at budbreak in spring and half in early October.

To determine how the experimental treatments affected soil parameters, soil was periodically sampled through the growing season to a depth of 6 inches (the zone in which most fine root activity and nutrient uptake by woody plants occurs). Soil samples were then analyzed for organic matter content, microbial biomass, total extractable nitrogen, immobilized nitrogen, nitrogen mineralization rate (the rate at which inorganic nitrogen is released from decomposing organic matter), and nitrogen in forms available for plant uptake (dissolved organic nitrogen and mineral nitrogen, including ammonium, nitrate and nitrite).

The data reported represent the average of five sampling dates over the course of the 1999 growing season. A river birch (*Betula nigra* "Cully" Heritage) and rhododendron (*Rhododendron* "Pioneer Silvery Pink") were planted in each plot to determine how these soil treatments affected the growth of ornamental trees and shrubs. We also quantified flower production of rhododendron.

Mulch and nutrient cycling: research results

Mulching with composted yard waste and ground wood pallets had dramatic effects on soil organic matter, microbial activity and nitrogen cycling that were apparent after only one season. Both mulches increased the organic matter in the soil relative to the bare soil control, with the yard waste mulch having the most substantial effect.

Both mulches also increased microbial biomass, as indicated by increased microbial nitrogen and a doubling of soil respiration. These results are consistent with the hypothesis that soil microbes are carbon-limited, and that the addition of organic carbon can increase microbial biomass in the soil.

The effects that the increased organic matter and microbial activity had on nitrogen availability and plant growth, however, were highly dependent on the C:N ratio of the mulch.

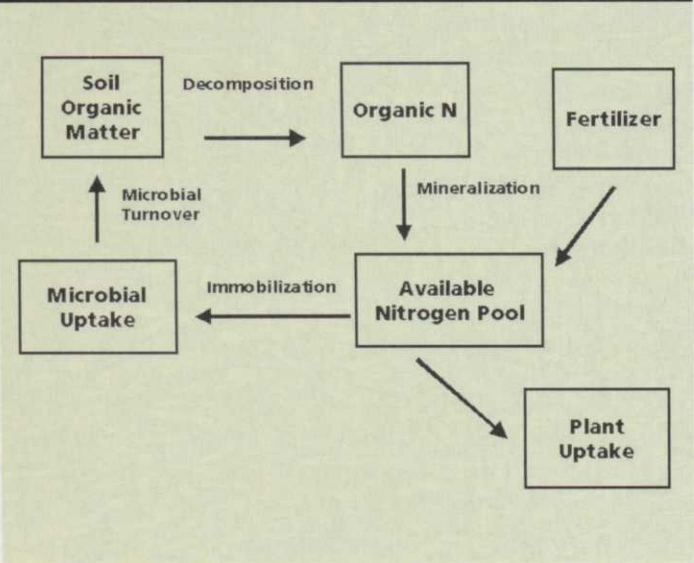
The low C:N composted yard waste mulch dramatically increased total extractable soil nitrogen, while mulching with ground wood had little effect. This is not surprising, given the high concentration of nitrogen in the yard waste mulch (about 2 percent) relative to that of the wood pallet mulch (less than .5 percent).

Most of the total soil nitrogen pool was tied up by soil microbes in all treatments, but the proportion immobilized by microbes was higher in plots mulched with wood pallets (83 percent) than in the bare soil (76 percent) or composted yard waste (72 percent) treatments. Microbial immobilization of such a high proportion of the already small pool of total nitrogen in the wood pallet plots would leave little left for plants.

In the yard-waste treatment, on the other hand, immobilization of a smaller proportion of a much larger nitrogen pool should result in much higher levels of nitrogen available for plants.

Indeed, the rate at which nitrogen was

FIGURE 1



released from decomposing organic matter (nitrogen mineralization rate) was much higher in plots mulched with composted yard waste than in the wood-pallet treatment. This greatly increased nitrogen in forms available to plants (dissolved organic nitrogen, ammonium and nitrate). Ultimately, the nutrient uptake (foliar nitrogen concentrations) were 20 percent to 25 percent higher in the composted yard waste than in the bare soil or wood pallet treatments, as well as growth of river birch and rhododendron.

Furthermore, mulching with composted yard waste increased flower production of rhododendron by more than 300 percent relative to the wood-pallet and bare-soil treatments.

Mulching with yard waste also had other substantial beneficial effects. Available phosphorus and potassium were increased, as was soil-cation exchange capacity. Furthermore, bulk density was decreased by 10 percent, which improves soil tilth and reduces compaction. Fertilization had no additional effect on the growth of plants mulched with composted yard waste, indicating that nutrients released by decomposition of the compost were able to meet fully the requirements of both microbes and plants, making additional fertilization unnecessary.

Fertilization of plants growing in bare soil increased their growth to the same level as those mulched with composted yard waste, further indicating that mulching with this compost can serve as high-quality organic fertilizer.

On the other hand, the high degree of microbial immobilization of nitrogen in the wood-pallet treatment greatly reduced the rate of nitrogen mineralization, which resulted in a much smaller pool of nitrogen in forms available for plant uptake (Fig. 4d). A similar pattern was observed for soil phosphorus levels. Not surprisingly, nutrient uptake was reduced and plants grew much slower when mulched with recycled wood pallets.

These results are consistent with the hypothesis that soil microbes are better competitors for nutrient than are plants, and that the addition of organic matter with high C:N ratios can induce nutrient deficiencies in plants by stimulating microbial growth.

Fertilization relaxed the competition between plants and microbes for nitrogen and phosphorus in the ground-wood treatment, thereby increasing plant growth. However, fertilization increased growth of rhododendron only to the level of plants growing in the untreated bare soil, indicating that fertilization compensated only partially for the nitrogen immobilizing effects of the wood pallet mulch. Fertilization of rhododendrons in the bare soil treatment resulted in plants that were 100 percent larger than fertilized plants that were mulched with ground wood pallets. However, fertilization increased the growth of river birch mulched with wood pallets to levels nearly equal to that of fertilized plants in the bare soil treatment. This indicates that river birch was better able to compete with microbes for nitrogen than was Pioneer Silvery Pink rhododendron.

Surprisingly, fertilization had little effect on soil organic matter, microbial biomass or total extractable nitrogen. Fertilization did increase soil nitrate levels, but the effect was small and short-lived relative to the dramatic effects of mulching with composed yard waste.

Increased plant growth in response to mulching has been attributed primarily to conservation of soil moisture and weed suppression. In our study, neither of the mulches had any effect on soil moisture or average soil temperature, and plots were fastidiously weeded so these variables were not a factor. Rather, the primary effects of mulches were conclusively linked to the impacts of their C:N ratio on microbial biomass and nutrient cycling as they decomposed.

Clearly, understanding the dominating influence of soil microbes on nitrogen availability is key to understanding the dynamics of soil fertility.

Horticultural implications

Mulching is one of the most used cultural practices in ornamental landscapes. Our research has shown that organic mulches can have major effects on soil fertility and plant growth. Mulching with low C:N composted yard waste increased plant growth by increasing soil organic matter, microbial biomass and nutrient availability, which demonstrates that composted yard waste serves as high-quality organic fertilizer as it decomposes.

On the other hand, high C:N mulch derived from recycled wood pallets induced nutrient deficiencies and decreased plant growth. The high carbon content of the ground wood stimulated the growth of soil microbes, which competed more successfully than plants for the limited supply of nutrients.

The nitrogen-depleting effect of mulch diminishes over time as it decomposes. As microbes die and decompose, the nitrogen they contain is released for use by plants unless the carbon source is replenished by adding fresh mulch. Nitrogen immobilization by microbes will probably have a greater impact on herbaceous plants and newly transplanted woody plants than on well-established trees and shrubs with extensive root systems.

Nevertheless, it may be best to reserve mulches with a high C:N ratio for use away from plants, such as on paths. Alternately, these products can be blended with composted materials with a low C:N ratio, such as yard waste, animal manure or sewage sludge.

Soils in landscapes surrounding new homes and other buildings are often nutrient deficient, with little organic matter because topsoil is removed and soil profiles are inverted during construction. We've shown that mulching with composted yard waste decreases compaction while increasing organic matter, microbial biomass, nutrient availability and plant growth. Yet, ironically, yard trimmings are often collected and removed from ornamental landscapes. Composting them instead for use as mulch offers great potential for rehabilitating degraded soils, while diverting a valuable natural resource from landfills.

John Lloyd recently completed his Ph.D. in the department of entomology at The Ohio State University/Ohio Agricultural Research and Development Center in Wooster, where Dan Herms is an assistant professor of entomology, Ben Stinner is Kellogg Professor of Agricultural Ecosystem Management, and Harry Hoitink is professor of plant pathology. Lloyd is currently an assistant professor in the department of plant, soil, and entomological sciences at the University of Idaho in Moscow, Idaho.

REFERENCES

Attiwell, P.M., and M.A. Adams. 1993. "Nutrient cycling in forests." *New Phytologist* 124: 561-582.

Facelli, J.M., and S.T.A. Pickett. 1991. "Plant litter: its dynamics and effects on plant community structure." *Botanical Review* 57:1-32.

Frey, S.D., E.T. Elliott, K. Paustian, G.A. Peterson. 2000. "Fungal translocation as a mechanism for soil nitrogen inputs to surface residue decomposition in a no-tillage agroecosystem." *Soil Biology and Biochemistry* 32:689-698.

Glenn, J. 1999. "Producers expand line of mulch products." *BioCycle* 40:45-47.

Kaye, J.P., and S.C. Hart. 1997. "Competition for nitrogen between plants and soil microorganisms." *Trends in Ecology and Evolution* 12: 139-142.

Mary, B., S. Recous, D. Darwis, and D. Robin. 1996. "Interactions between decomposition of plant residues and nitrogen cycling in soil." *Plant and Soil* 181: 71-82.

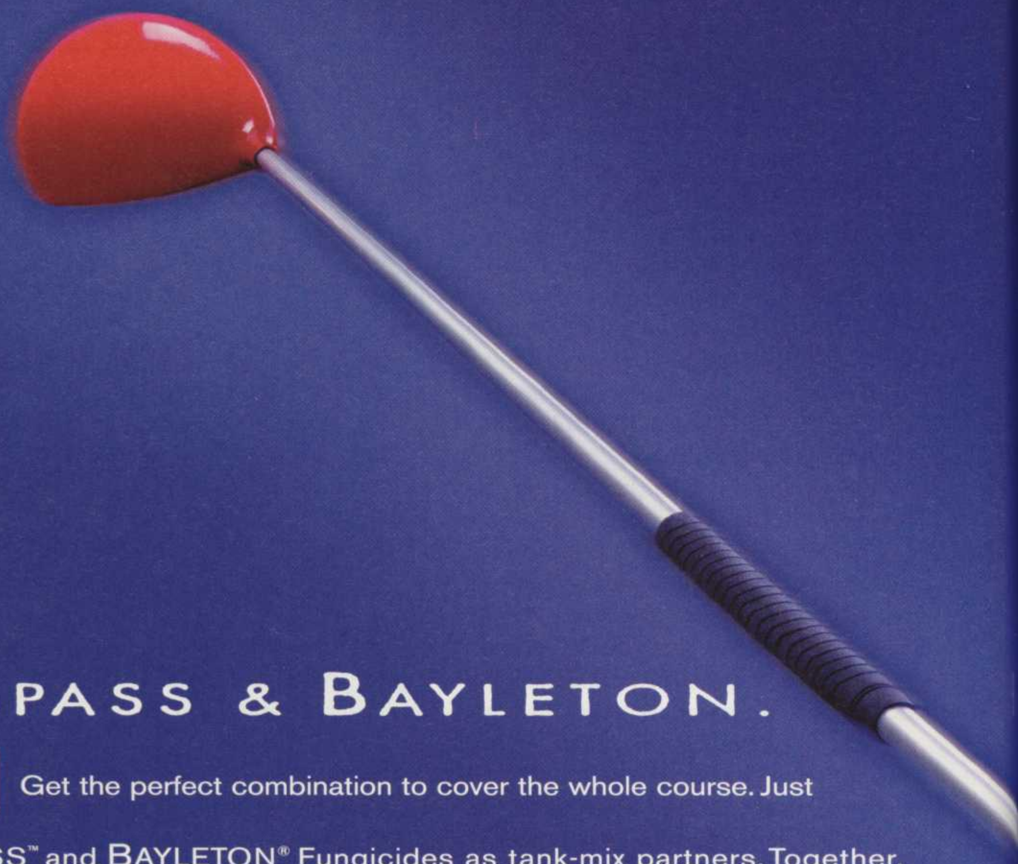
McKeever, D.B. 1999. "How woody residuals are recycled in the United States." *BioCycle* 40: 33-44.

Nasholm, T., A. Ekblad, A. Nordin, R. Giesler, M. Högberg, and P. Högberg. 1998. "Boreal forest plants take up organic nitrogen." *Nature* 392:914-916.

Nasholm, T., K. Huss-Danell, and P. Högberg. 2000. "Uptake of organic nitrogen in the field by four agriculturally important plant species." *Ecology* 81:1155-1161.

Robinson, D.W. 1988. "Mulches and herbicides in ornamental plantings." *HortScience* 23:547-552.

Wardle, D.A. 1992. "A comparative assessment of factors which influence microbial biomass carbon and nitrogen levels in soil." *Biological Review* 67:321-358.



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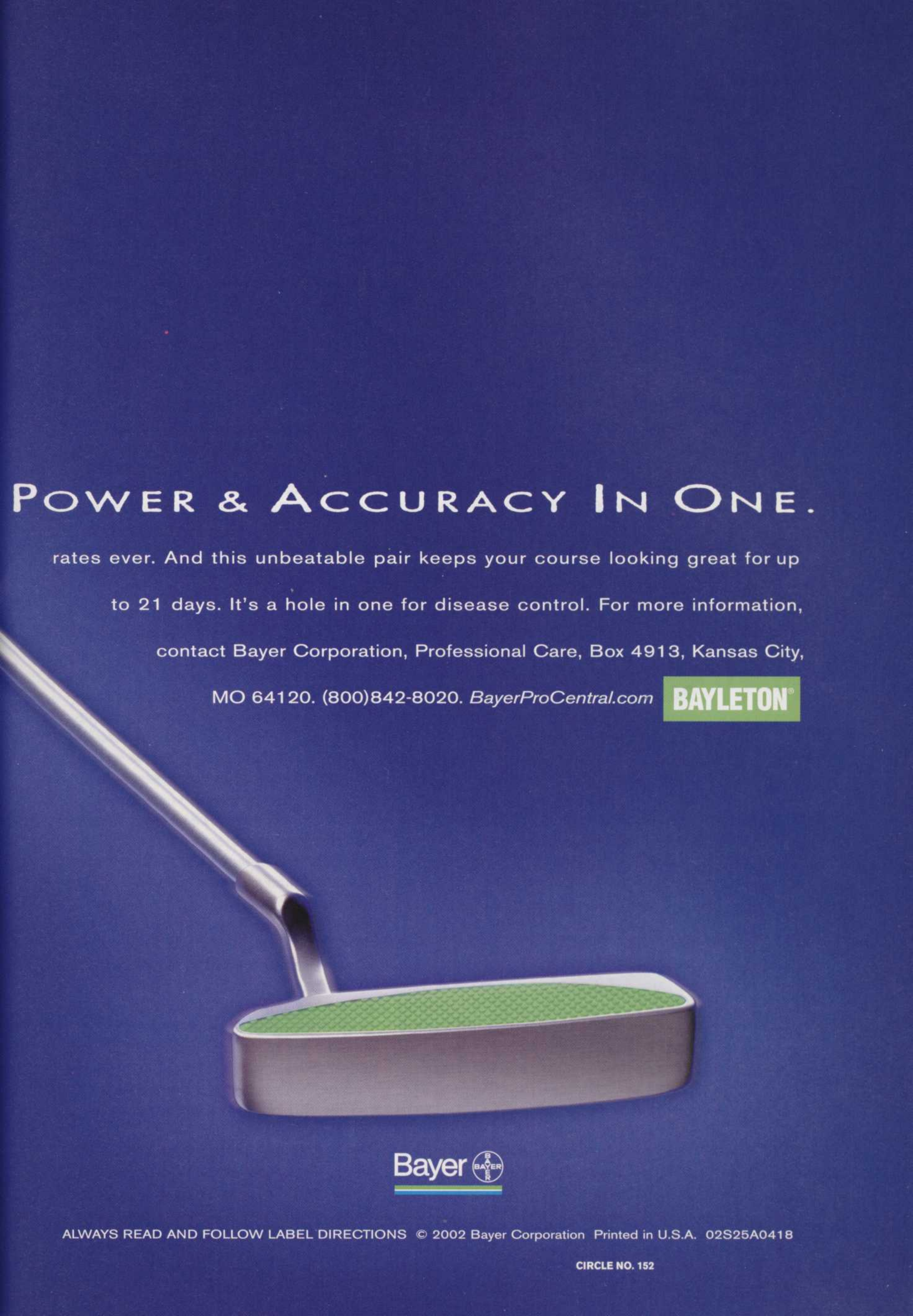

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Users Drive Research Into New Growth Regulator Applications

By Dennis Shepard

Plant growth regulators (PGRs) were initially developed to slow turf growth and suppress seedheads. Their use on high-quality turf was limited because of potential phytotoxicity, unpredictable turf response and differences in activity on cool- and warm-season turf.

Trinexapac-ethyl (Primo MAXX) was the first PGR to provide growth suppression and improved turf quality in all the major turfgrasses. Research projects, combined with suggestions from Primo MAXX users, helped develop uses that had not been successful with other PGRs. These include use during overseeding, tank mixing with fungicides to enhance activity, pre-stress turf conditioning, use on greens, sod production and others.

PGR mode of action

PGR products work in different ways to affect turf growth and development. They either slow cell division in meristematic areas, inhibit cell elongation by slowing the production of gibberellic acid, or act by enhancing ethylene gas release, which affects flowering.

Mefluidide (Embark, Embark Lite), developed in the 1970s, is absorbed through the leaves, slows cell division. Paclobutrazol (Trimmit 2SC, Turf Enhancer 2SC) and flurprimidol (Cutless), developed in the 1980s, are root-absorbed and slow cell elongation by stopping formation of the more than 120 forms of gibberellic acid early in the biosynthetic pathway.

Never apply a product to an entire golf course, lawn or athletic field without first trying it on a practice green, sideline or small side yard.

Trinexapac-ethyl (TE) has foliar uptake and slows cell elongation by stopping the conversion of one gibberellic acid (GA_{20}) to another [GA_1], which is the final step in gibberellic acid production. This leads to slower plant growth.

Ethephon (Proxy) was registered for use on turf in 1998. It affects turfgrass growth and development by enhancing the release of ethylene gas.

PGR development and use

In high-quality, cool-season turf areas, mefluidide is primarily used to reduce *Poa annua* seedheads. When applied at the correct time, it does an excellent job. Superintendents should be aware that turf plants use much of their stored energy during seed production and flowering, and there is potential for phytotoxicity from any PGR during this period because of the weakened state of the turfgrass plant.

Paclobutrazol is primarily used on cool-season turfgrasses to slow growth and reduce *Poa annua* in bentgrass golf courses. Application rates range from 6.4 ounces to 24 ounces of product per acre (greens vs. fairway use). It will suppress turfgrass growth for a six- to eight-week period.

Poa annua appears to be more sensitive to paclobutrazol than creeping bentgrass. Superintendents should evaluate the amount of *Poa annua* they have before using paclobutrazol, and determine if they want to keep it or reduce it. The turf response depends on the regulator rate. Higher rates can be used for two to three applications in the spring and fall when the risk of phytotoxicity to the creeping bentgrass is lower. As temperatures grow warmer, superintendents should reduce the rate of paclobutrazol, not use a PGR or switch to TE.

Ethephon was labeled for use on turfgrass in 1998, and research has been conducted to determine rates and turf response. It is primarily used on cool-season species. A key area of research has been on suppressing *Poa annua* seedheads. Research in California has shown a single application of Proxy (21.7 percent ethephon) at rates of 5 or 10 ounces/1,000 square feet, reduced *Poa annua* seedheads 80 percent to 90 percent.

Proxy has little effect on seedheads that are present at the time of application (Gelernter). Research is continuing in other areas of the country.

Trinexapac-ethyl (TE) has been the most widely researched PGR to date, with hundreds of research projects at land-grant universities in the United States. Growth reduction and improved quality of warm- and cool-season turf, successful use on greens and fairways, a predictable response and lack of phytotoxicity aided acceptance by turf managers and inspired new research.

Growth management with trinexapac-ethyl

Initial research into TE in the late 1980s and early 1990s investigated rates and response on highway roadside turf, home and commercial lawns, and golf course fairways. It was a new class of chemistry (cyclohexadione) that exhibited different growth responses from other PGRs.

It was challenging to determine where it could be the most benefit to turf management. Rates were determined for 50 percent growth suppression for species maintained at fairway heights. Research has also been conducted on the effect of multiple TE applications to turfgrass growth and quality (Fagerness, Lickfeldt).

Along with suppressing turf vertical growth, TE affects a number of other turf morphological characteristics. Turf density normally increases with repeat applications due to enhanced lateral growth of stolons and rhizomes, and increased tillering.

Turf treated with TE normally turns darker green. Research has determined that chlorophyll content increases, and there is a higher concentration in the smaller, more compact leaves (Ervin, Heckman). Scalping is reduced when mowings are missed due to rainfall or other problems.

Superintendents with kikuyugrass fairways have found TE dramatically reduces scalping throughout the growing season (Gelernter).

Mowing equipment performance and lifespan may be enhanced because of less mowing and less force required to mow the turf. Catching and dragging of clippings can often be eliminated, which saves time and labor. In addition, tasks such as trimming and edging are reduced.

TE effects on cultural practices

Turf managers should apply their normal fertilizer program to TE-treated turf. Nitrogen is a key component of amino acids, proteins, enzymes and chlorophyll. The turf plant can better use the nitrogen and other nutrients for other purposes instead of using them to stimulate foliar growth.

> The only turfgrass systems that will likely benefit from the addition of diazotrophs in terms of supplying nitrogen are those grown without nitrogen fertilizer inputs.

TE application to warm-season turf prior to overseeding enhances establishment. Superintendents often apply TE one to five days prior to overseeding to slow growth and competition of the warm-season turf (usually bermudagrass) with the developing overseeded species.

TE can be applied at twice the normal application rates prior to overseeding for extended growth suppression. A post-overseeding application is normally made after the first mowing of the overseeded species. Superintendents have also reported that TE application to creeping bentgrass aids transition when interseeding and/or converting from one cultivar to another. This is commonly done when converting from an older cultivar like Penncross to a newer cultivar like the A or G series of bentgrass.

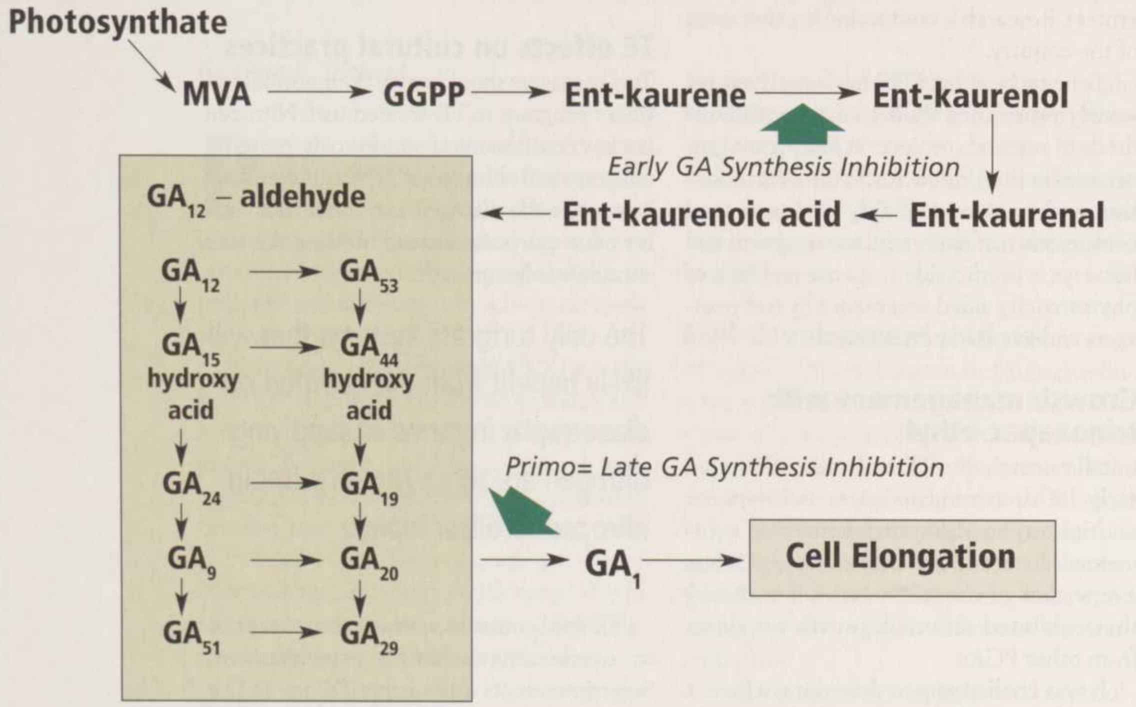
The foliage absorbs TE within one hour of application and there is no soil residual to affect seed germination negatively.

Prestress conditioning of golf turf

TE can be applied to turf at reduced rates more frequently. Many superintendents, primarily those with creeping bentgrass, have incorporated this practice into their spray program. They are typically spraying some-

FIGURE 1

Gibberellic Acid Biosynthesis



thing every seven to 10 days during parts of the year, and they often add TE at one-half to one-third the label rate, with activity expected to last 10 to 14 days.

Tank mixes with TE and fungicides are especially beneficial. The turf is growing slower, and less fungicide is removed with each mowing. There is no evidence that any PGR causes or enhances turf diseases.

Fertility and PGRs can influence disease development (Golembiewski). However, if a disease is present at the time of PGR application, it will take longer for new growth to mask the symptoms. PGRs should not be applied to diseased turf.

Once TE was labeled for use on fairways, research began for its potential use on greens. This use was added to the 1996 label revision.

Superintendents were primarily interested in TE use on greens to increase speed, and hopefully provide another tool to fight *Poa annua*. When used with other cultural practices, TE can help increase putting speed 6 to 12 inches as determined by a Stimpmeter. Mowing height is a key factor that influences putting speed.

With any turfgrass, if too much leaf tissue is continually removed, photosynthesis is reduced and turf vigor will gradually decline and make it susceptible to diseases and cultural stresses. Superintendents have reported they can apply TE and slightly raise mowing heights and maintain acceptable speed. This will help with the overall health of the turf.

TE is also used extensively on Tifdwarf, Tifgreen and ultradwarf bermudagrass greens. In areas like Florida and the Gulf Coast states, extended cloud cover and low mowing heights typically cause bermudagrass greens to become thin, and algae can develop. TE helps maintain turf density and quality. Rates as low as 1 to 2 ounces per acre can provide considerable improvement (Foy).

Turfgrasses prefer to grow in sunlight, and quality will decrease when turf is maintained in shade. The turf stand eventually thins and the shoots are spindly. Gibberellic acid (GA) levels can increase under low

light, and this contributes to enhanced vertical growth. Research has determined that TE application to newly established turf in shade environments will maintain turf quality for longer periods than untreated turf (Goss, Qian). TE suppresses GA levels and growth is slowed.

Water-use research projects with TE have found it may reduce irrigation requirements (Fry). Possible explanations of how TE can influence water-use rates include:

- TE-treated turf has smaller, more compact leaves, which may reduce water loss through transpiration.
- The turf is more dense and water loss from soil evaporation may be reduced.
- As turf vertical growth is reduced, plant energy is redirected to enhance development of lateral stems and roots for access to soil moisture.
- As GA levels decrease, abscisic acid (ABA) levels increase, which play a role in stomatal closure and water conversation.

PGRs either slow cell division in meristematic areas, slow cell elongation by slowing the production of gibberellic acid or enhance ethylene gas release, which affects flowering.

The future

The development of TE has been a cooperative effort of industry, university researchers and suggestions from turf managers.

As use of TE increased, new uses and ideas were developed, and research projects were established to investigate. This has helped develop new areas of research that should continue.

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REFERENCES

Bingaman, B.R. and N.E. Christians. 1998. "Effects of Trinexapac-ethyl on Kentucky Bluegrass Sod Establishment." *Agronomy Abs.* p.126.

Ervin, Eric H. and A.J. Koski. 1998. "Growth Responses of *Lolum perenne* L. to Trinexapac-ethyl." *HortScience*: 33(7):1200-1202.

Ervin, Eric H. and A.J. Koski. 2001. "Trinexapac-ethyl Increases Kentucky Bluegrass Leaf Cell Density and Chlorophyll." *HortScience.* 36(4):787-789.

Fagerness, Matt J. and D. Penner. 1998. "Evaluation of V-10029 and Trinexapac-ethyl for Annual Bluegrass Seedhead Suppression and Growth Inhibition in Five Cool-season Species." *Weed Technology* 12:436-440.

Fagerness, Matt J. and F.H. Yelverton. 2000. "Tissue Production and Quality of Tifway Bermudagrass as affected by Seasonal Application Patterns of Trinexapac-ethyl." *Crop Sci.* 40:493-497.

Foy, John H. 2000. "Going for the Gold with Bermudagrass Greens: Part II." *USGA Green Section Record.* 38(6):1-5.

Gelernter, Wendy and L.J. Stowell. 2001. "Learning To Love Kikuyugrass." *Golf Course Management.* 69(8): 55-59.

Gelernter, Wendy, and L. J. Stowell. 2001. Advances in *Poa* seedhead management. *Golf Course Management* 69(10):49-53.

Golembiewski, Robert C. and T.K. Danneberger. 1998. "Dollar Spot Severity as Influenced by Trinexapac-ethyl, Creeping Bentgrass Cultivar, and Nitrogen Fertility." *Agron. J.* 90:466-470.

Goss, Ryan.M. 2000. "Trinexapac-ethyl and Nitrogen Effects on Creeping Bentgrass Under Reduced Light Conditions." M.S. Thesis. Michigan State University.

Heckman, Neil L., G.L. Horst, and R.E. Gaussoin. 2001. "Influence of Trinexapac-ethyl on Specific Leaf Weight and Chlorophyll Content of *Poa pratensis.*" *International Turfgrass Research Journal* Volume 9, 2001. pp. 287-290.

Heckman Neil L., G.L Horst, R.E. Gaussoin and K.W. Frank. 2001. "Storage and Handling Characteristics of Trinexapac-ethyl Treated Kentucky Bluegrass Sod." *HortScience* 36(6) 1-4.

Jiang, Hongfei and Jack Fry. 1998. "Drought Responses of Perennial Ryegrass Treated with Plant Growth Regulators." *HortScience* 33(2):270-273.

Lickfeldt, Darin, W., D. S. Gardner, B.E. Branham, and T.B. Voigt. 2001. "Implications of Repeated Trinexapac-ethyl Applications on Kentucky Bluegrass." *Agron. J.* 93:1164-1168.

Qian, Yaling.L. and M.C. Engelke. 1999. "Influence of Trinexapac-ethyl on Diamond Zoysiagrass in a Shade Environment." *Crop Sci.* 39:202-208.

Watschke, T.L., M.G. Prinster, and J.M. Brueninger. 1992. "Plant Growth Regulators and Turfgrass Management." *Turfgrass-Agronomy Monograph* No. 32 of the ASA-CSSA-SSSA, Madison, WI.

Linear Aerification Encourages Good Soil Respiration

By Martyn Jones

Adequate soil respiration is essential for healthy turfgrass and is influenced by the physical and biological characteristics of the soil.

Turfgrass roots and soil microbes require oxygen for respiration, and its availability can only be assured where there is a rapid and constant exchange of gases between the soil and external atmosphere. Gaseous exchange occurs through diffusion and its efficiency depends on a continuous network of macropores from the surface and down throughout the rooting depth of the grasses.

Macropores are defined as soil pores larger than 75 micrometers in diameter and will readily release water through the forces of gravity. Pores of a smaller diameter are termed micropores, and will retain water against the pull of gravity and can be expected to remain full of water after natural drainage has ceased.

Traffic, be it pedestrian or vehicular, will compress the surface, reducing the majority of macropores to micropores and, consequently, diminishing oxygen diffusion rates. The accumulation of organic residues within the soil pores creates a root zone dominated by water-filled micropores. Oxygen diffusion through water is 10,000 times slower than it is through air. Therefore, it's little wonder that soil respiration is generally poor in sports soils. It is essential that soils have an adequate distribution of macropores and that there is an uninterrupted network from the surface and down to the full rooting depth.

In many instances, a compacted surface layer rich in organic matter is the limiting factor to adequate soil respiration.

Understandably, it is necessary that the macropore system be preserved at the surface, where gaseous exchange between the soil and the outside atmosphere is to occur. Even a thin layer of compacted soil, devoid of macropores, is going to reduce the oxygen diffusion rate dramatically.

Deep dethatching and linear aerification help preserve infiltration rates and efficient gaseous exchange, as well as remove a large proportion of organic residues.

In many instances, a compacted surface layer rich in organic matter is the limiting factor to adequate soil respiration. Maintaining an open surface with high water infiltration and oxygen diffusion rates is a prerequisite to good soil respiration but, all too often, the influence of this zone is overlooked and only deep cultivation is considered.

The surface organic-rich layer, varying in depth depending on the sport and maintenance regime, is the zone in which there is the greatest demand for oxygen. The highest population of soil organisms occupies this zone, and it's the main rooting layer for mown turfgrasses. Consequently, it's the area in which most respiration occurs and the need for gaseous exchange is greatest.

As temperatures rise, and as long as drought does not become a limiting factor, the demand for oxygen by turfgrass roots and soil microbes increases. It is important, there-

Close-up shows the ability to make clean slits left with a Rotorake aerator.

fore that the surface is maintained in an open state throughout the growing season, when the demand for oxygen is at its highest. It's far less important during the dormant season when respiration rates are minimal.

Numerous methods can be adopted to preserve the diffusion rate at the surface, but linear aerification has been designed specifically to treat the upper level of the soil. When executed under the right conditions, the technique offers multiple benefits. Not only does it preserve infiltration rates and efficient gaseous exchange, but it can also remove a large proportion of the organic residues that contribute to the development of micropores in the first place.

The equipment also severs stolons and shallow rhizomes to stimulate greater turf density. Additionally, when a more open surface is established, there is an interruption to the capillary movement of water, and evaporation losses are reduced. The technique is also of major benefit when overseeding to ensure greater seed-to-soil contact and enhanced germination.

Martyn Jones is head of the turf academy at Myerscough College in Preston, England, where he leads the only turfgrass Science degree program currently available in Europe. As a consultant agronomist, he has advised major golf courses and sports stadiums throughout the continent.

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CIRCLE NO. 139

BY FRANK H. ANDORKA JR., MANAGING EDITOR

The Price of Progress

Now that plant growth regulators have evolved into an integral turf-maintenance tool, the next step for manufacturers is to lower their cost

It's amazing how times have changed for plant growth regulators since their introduction to the turf market in the 1950s. Superintendents avoided them because of their reputation for doing damage to, rather than helping, their turf. Now they find it hard to live without them.

As successful as PGRs have become, manufacturers complain that the market has flattened. Superintendents want to use the chemicals to produce the highest quality turf, but some superintendents find themselves deciding between a PGR or an extra fertilizer application. More often than not, the PGR loses the battle because superintendents view fertilization as a more vital use of their limited financial resources.

Manufacturers find themselves in a bind. They've spent millions of dollars to develop the PGRs, so they have to charge prices designed to recoup their investments. At the same time, high prices inevitably shrink their market.

So despite PGRs benefits, the market won't grow beyond today's numbers until chemical companies develop cheaper versions of today's chemicals, says Russ Mitchell, technical director and agronomist for United Horticultural Supply. When the patents on the current chemistries expire, superintendents will see their prices plunge. For the end-user, however, the development won't occur for many years, he adds.

"It's a difficult decision for some superintendents," Mitchell says. "They know they need PGRs to grow the best turf, but when there's a budget crunch, it's always the first chemical to get cut. The market needs a lower-priced brand."

Given the long road PGRs have taken to achieve the status they have today, it's hard to bet against innovations in the market that could bring down prices and improve the products' efficacy. After all, chemical companies never intended plant growth regulators for use on high-quality turf.

They've come a long way

When the first PGRs entered the market, companies expected suburban homeowners to apply PGRs to their home lawns, according to Bruce Branham, associate professor of turfgrass at the University of Illinois.

Turning those expectations upside down, PGR use by homeowners is practically non-existent while use by superintendents has exploded.

At first, superintendents refused to use the products because their mode of action — inhibiting cell division — often caused unsightly yellowing. The slowing of cell production also weakened the turf, leaving it more susceptible to disease pathogens.

"Back then, it was a niche market, designed for out-of-play areas on the golf course and roadside turf control," says Joe DiPaola, golf market manager for Syngenta Professional Products, the current producer of Primo.

In the 1980s and 1990s, however, more research produced different modes of action. Instead of slowing cell growth, the new products targeted a plant hormone called gibberellic acid (GA), DiPaola says. If you slow production of GA in turf, you inhibit its growth without the damage caused by previous products. Now, DiPaola says most superintendents count PGRs as part of their regular maintenance programs.

PGRs Through the Ages

Decade	Mode of Action	Point of Entry	Examples
1950s - 1980s	mitotic inhibitors	foliar or root	maleic hydrazide, mefluidide
1980s	early gibberellic acid synthesis	root	paclobutrazol, flurprimidol
	phytotoxic responses	foliar and/or root	sulfometuron-methyl, chlorsulfuron, ethofumesate
1990s	late gibberellic acid synthesis	foliar and crown	trinexapac-ethyl
	plant hormone generator	foliar	ethephon

SOURCE: SYNGENTA PROFESSIONAL PRODUCTS

Ancillary benefits

Once superintendents started using PGRs on an array of turf, ancillary benefits emerged. Superintendents slowly recognized that PGRs didn't just slow growth. They also reported that overall turf quality improved significantly with repeated use of PGRs

Slower growth allows turf to put down deeper root systems, which produces denser turf, Mitchell says. Deeper roots allow plants to resist disease more effectively, show more consistent color and weather stressful conditions better.

In 1999, superintendents started using PGRs on greens for the first time. It gave them a new weapon in the ongoing battle with *Poa annua*. In fact, Branham says companies pushed *Poa annua* seedhead suppression as one of the primary add-on benefits of PGR use.

"There are certain products on the market that do keep *Poa annua* seedheads in check," Branham says. "Superintendents still have to do their research before putting a specific PGR on their turf, however, because not all PGRs handle suppression equally well."

In addition to suppressing the seedheads, Raymond says PGRs can also help "smooth out" putting greens. If a green has a rye/*Poa* mixture, for example, judicious use of PGRs can help them grow at the same rate.

"I've had superintendents tell me that the use of PGRs has promoted uniform greens to the point where you can't tell the difference between different varieties of grass," Raymond says. "If the superintendents can't see the difference, you can bet the golfers can't either."

Prospects for the future

Insiders agree that if manufacturers want to expand the market significantly, they should focus on producing inexpensive products. The expense of research and development, however, discourages companies from making the investment, Mitchell says.

"Since current PGRs work well, most companies are moving on to areas like fungicides, where there's greater potential for revenue growth," Mitchell says. "I wouldn't spend a lot of time waiting for the next great growth regulator."

Even competitors acknowledge that Syngenta's Primo leads the market. That's because Syngenta has marketed the additional benefits of PGRs most effectively, says Mike Bandy, marketing manager for professional control products for The Andersons, which manufactures Primo competitor TGR. That doesn't mean the other producers should close up shop, however.

"The effectiveness of products, including Primo, depends largely on where you are in the country and what grasses you have," Bandy says. "As long as there are regional differences, there will be a demand for various products in the market."

In addition, the quest for new applications for the older technology won't stop just because the market is flat. Raymond says superintendents will drive the research with their observations, as they did with the discovery of enhanced turf quality after PGR use.

"Superintendents are clever in the way they notice subtle changes on the course," Raymond says. "PGRs never would have grown in popularity if superintendents hadn't noticed a significant increase in quality and passed along that news to their neighbors."

The University of Illinois' Branham believes that, eventually, nearly all golf courses will use either new chemistries (or revisions of older ones) with lower rates and longer efficacies to manage turf.

"Even if we only fine-tune the existing chemistries, they will give superintendents an unprecedented level of control over how and where their turf grows," Branham says. "We may eventually be able to grow grass where we want it and when we want it. That will largely be because of PGRs." ■

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Lighten Up

While expected to deliver carpet-like fairways, superintendents aren't over-relying on insecticide use to get the job done

BY LARRY AYLWARD, EDITOR

It's been a given for years that golfers demand greens to be at a premium and in consistent condition throughout the playing months. Today, however, many golfers expect fairways to be in as good a state as the greens. In short, the bar has been raised on fairway maintenance.

But superintendents aren't pulling out the stops when it comes to insect control on fairways because of the added pressure they face to keep fairways in top shape. While they're expected to deliver carpet-like fairways, superintendents are *not* relying on increased use of insecticides to get the job done.

Rob Kloska, superintendent of Jupiter Island Club in Hobe Sound, Fla., realizes the increased importance placed on fairway maintenance, but he still adheres to an integrated pest management program.

"I don't believe in broad-spectrum spraying of insecticides," says Kloska, whose course's main insect enemies are mole crickets and grubs. "I'd rather find the problems, see the problems and treat the problems."

Mike Melichar, customer agronomist for Dow AgroSciences turf and ornamental business, says there's been a movement to get away from broadcast applications of insecticides on fairways, especially for surface-feeding insects. "Superintendents are looking for softer, safer and less mobile chemistries," he adds.

Mark the spot

At Hidden River Golf & Casting Club, located in woodsy upper Michigan, the first-rate bentgrass fairways are finely manicured. But since the course features the trout-laden Maple River, certified superintendent Steve Sump is careful in his approach when treating for insects.

PHOTO COURTESY OF CHIPCO PROFESSIONAL PRODUCTS

Mole crickets can wipe out fairways in the South. Florida superintendent Rob Kloska maps the mole cricket hot spots on his course before blasting them with fipronil.

"Preventative" is not a word muttered from Sump's lips when he talks about fairway insect control. Neither is "blanket application," which makes him cringe. "Spot treatment" and "curative approach" are the words Sump prefers regarding fairway insecticide control.

"When your course experiences insect outbreaks, you map where they are so that in the coming years you have an idea where they'll occur," says Sump, who treats ants, black turfgrass ataenius and cutworms with a granular insecticide. "When I see a problem, I spot treat it. I also try to use the lowest active ingredient insecticide available."

Don Dodson, superintendent of Lakeview Resort in Morgantown, W.Va., says he's cut back on the use of fairway insecticides because of environmental concerns, his course's low maintenance budget and golfer courtesy.

Dodson's approach is also curative. He measures the severity of an outbreak before determining whether to act on it. While he may see insect-inflicted damage, he won't react to the problem unless golfers notice the damage and comment on it.

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Dodson, Kloska and Sump believe more superintendents are spraying less insecticides on fairways. Even superintendents at high-end clubs aren't spraying wall-to-wall insecticides, they say. If they're practicing preventative programs, they're doing so only on areas with a history of insect outbreaks.

"We're trying to be more responsible because, No. 1, it's the right thing to do," Kloska says. "And No. 2, if we continue to be careless with the insecticides we use, they're going to keep taking them away from us. We can't afford that."

The "they" Kloska refers to are EPA officials and other environmentally minded lawmakers. Kloska is not saying those people are wrong; he's stressing that superintendents use the tools available to them more wisely. If they don't — and if their tools are revoked — superintendents will pay the price, literally.

"It will end up costing us more," Kloska says of a potential scenario where new and safer insecticides will be more expensive because they will have to go through more testing to be registered. "The cost will be passed on to us, which is justified," Kloska notes.

Economically speaking

Kloska's philosophy is "spot treatment with everything." While his is an environmental stance, it's also economic.

"We owe it to the people we work for to spend money properly and to follow labels," Kloska says. "Why do I want to treat an area that doesn't need to be treated? That's just costing me money."

Kloska says fipronil is his best weapon against mole crickets. It's also economical, he notes, citing the products long-lasting effect. "It's $315 per acre, but for the control you get the price is phenomenal," he adds.

Dave Shetlar, professor of entomology at The Ohio State University, agrees that most superintendents have made a conscious effort to reduce insecticide use on fairways. "On the other hand, we have the tools that allow superintendents to do that," he notes.

"There are products that are extremely effective on a range of organisms," Shetlar says, noting insecticides such as imidacloprid and halofenozide feature multiple activities. "Superintendents have the luxury of reducing the number of applications while achieving the same level of control."

Tips for control

Fairway insect outbreaks will keep Dodson on his toes. The past few years, he's noticed an onslaught of May and June green beetles. Also, he recently noticed the fairways were crawling with earthworms. "It's always something different," Dodson says.

Over the years, Dodson has learned the tricks of the trade to keep up with the bugs. To attract problem insects to the fairway surface, he recommends superintendents mix "imol" – a mixture of iron and molasses — into their spraying tanks. Insects are attracted to the sugary substance, says Dodson, who learned the tip from Gary Grandstaff, superintendent of the Pete Dye GC in Bridgeport, W. Va.

There are other cultural practices superintendents can follow to control fairway insects. Sump advises superintendents to control thatch content on fairways. Too much thatch provides a haven for insects, Sump notes. Grubs can live just below the thatch layer and chew on turf roots.

Also, irrigation often parallels insect control, Sump points out. If fairway turf is kept dry, the chance of an insect outbreak decreases.

Shetlar says turf with increased root depth is an obvious detriment to insect damage. He recommends deep-core aerification and reduced compaction to assist root growth. "Fertility at the right times of the year — late in the season and early in the season — will also stimulate root growth and assist in reducing grub damage," he adds. ■

You can reach Larry Aylward, the author of this story, at laylward@advanstar.com

Tips → Fungicide Use

How to Prevent Resistance

BY RICH HANRAHAN

I've known some superintendents to work and play in excess, learning the hard way that everything is best in moderation. This can also be said for turf management.

When a product works well — a pest-control product, for example — it's tempting to use it a lot or even exclusively. That can be a mistake. In the case of pest-control products, the result can be that in time the product won't work as well. In the worst-case scenario, it won't work at all. The pest will have become resistant to it.

Fungicides can be vulnerable to light, irrigation, rainfall and mowing, which may reduce their effectiveness, so we reapply. Fungicides must also be reapplied to protect against new disease growth. But every time certain fungicides are applied, the odds increase that the organism may develop resistance.

To preserve the usefulness of your fungicides, you should develop a strategy to prevent resistance. Resistance begins to develop when a fungus makes a genetic adjustment or undergoes a mutation that reduces its sensitivity to a particular fungicide. This adjustment or mutation allows the affected fungus to survive the fungicide. Naturally, the surviving organism is likely to become the dominant strain when the same fungicide is used frequently and exclusively with it. Over time, the resistant strain replaces all other strains, and the disease becomes more difficult to control. This process is often well under way before you realize it has begun.

When resistance develops, it is typically not limited to individual chemical compounds. Usually, strains of fungi that have become resistant to a fungicide will be resistant to all fungicides in the same chemical class. In other words, overexposure to just one fungicide might destroy the usefulness of several.

About resistance

A strategy must be designed for proper application timing. Sometimes a preventative application is best applied prior to a fast-moving disease's appearance. In other situations, a curative application at the first sign of disease is adequate.

Reducing the risk of disease resistance should always be top of mind to preserve a fungicide's future use. Generally, rotating chemistries will reduce the risk of developing fungicide-resistant fungal pathogens, ensuring a product's longevity. Rotating and tank-mixing chemistries in different chemical classes and with different modes of action are important when planning for fungicide resistance management.

You must also remember:

- Not all fungi and fungicides are the same, especially when it comes to resistance. The chemistries of some fungicides are much more inclined to provoke resistance than others, and some fungi are more apt to develop resistance than others.
- Fungi with higher reproductive rates are more likely to develop resistance because they pass on the mutated gene more quickly and broadly. Diseases that infect many stages of a plant under a range of environmental conditions are also more likely to develop resistance because the disease can attack in so many ways. Some fungi that have shown a propensity for developing resistance are botrytis, brown rot and phytophthora. Brown patch, fusarium and red thread, in contrast, are significantly less likely to develop resistance.

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- Site-specific fungicides run a higher risk of resistance because they work by inhibiting just one function in the fungal cell. Once resistance develops to this site, the fungicide is ineffective. Multi-site fungicides, on the other hand, interfere with several vital functions of the fungal cell. They are less likely to foster resistant fungi because even if resistance develops to one site, the fungicide can still attack the fungus through another site.

The benzimidazole class is an example of a site-specific or single-point class of fungicides. So are phenylamides and strobilurins.

The benzamide class represents a class of chemicals that is less likely to foster resistance because it provides a multi-site attack. Examples of other multi-site fungicides include fosetyl-aluminum, propamocarb, and chlorothalonil. If fungi develop a mutation that protects them from one form of attack, they are still going to be susceptible to these fungicides' other attacks and therefore controlled.

When rotated and used in tank-mix combinations, certain fungicides can effectively control a broad spectrum of diseases without the concern for resistance development. The variety of fungicides available provide you with many good tools to use in developing and running a successful disease-resistance management program.

Mix it up

Using multiple fungicides from different chemical classes with varying modes of action is a key technique in managing resistance. The two basic approaches are rotation and tank mixing.

The basic strategy behind both rotation and tank mixing is that if a fungus has developed resistance to one of your fungicides, multiple fungicides will vastly increase your odds of ridding turf of the fungus before it has a chance to spread and mutate further.

Rotation involves using two or more fungicides in sequence, each alone; tank mixing involves mixing two or more fungicides together so they can be applied simultaneously. Typically, your strategy would include both high-risk and low-risk fungicides, but tank mixing even multiple at-risk compounds can also reduce resistance, as long as those tank-mixed fungicides have different modes of action. (Always be sure to tank mix in accordance with label recommendations.)

Reduce the frequency

Overusing any fungicide promotes resistance, so never make more applications than you need to achieve control. The fewer applications you make, the less the fungus is exposed to the chemical class and the fewer opportunities the fungus has to develop resistance to it. Adding one more application "for good measure" is not a good idea.

Apply at the right rate

On the other hand, when you do apply a fungicide, be sure to apply enough. Cutting the rate used in a single application will increase the likelihood of resistance developing. This is because you expose the organism to the fungicide without providing enough product to control it. Always observe the recommended rates and strive to achieve complete coverage of the plants.

Reduce your dependence

Of course, the only way to prevent fungicide resistance completely is by avoiding at-risk fungicides altogether. While this may be impossible, you can reduce your dependence on fungicides by developing an integrated pest management approach. For example, wherever possible, use plant species and/or varieties that are disease resistant.

Fungicide selection

There are many fungicides on the market that claim to prevent or cure various common diseases. However, be aware that although a product may be labeled for a particular disease, it does not guarantee it will solve your problem. Efficacy can vary from geographic region to region, and different strains of certain diseases may require different fungicides to cure the disease. So how do you know which to choose?

Trial and error can be expensive, inefficient and may further damage the turf. You should talk with colleagues in your area to see what has worked best for them. Consult with an expert such as a turf pathologist or university researcher to get recommendations. Many universities have conducted extensive trials to test fungicide efficacy on a number of turfgrass species and varieties. After gathering shared knowledge, you will be ready to make an informed fungicide selection. Your best choice will be a fungicide with little or no cases of documented resistance and one that provides additional turf-enhancing qualities. ■

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The Company Line

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- control ornamental diseases such as leaf spots and blights, scab, rust, Diploidia tip blight and stem, crown and root rots; and
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