TURFGRASS TRENDS

SAND GREENS

How to Retain Nutrients on Calcerous Sand Greens

By Paul G. Johnson, Rich Koenig and Kelly Kopp

Nitrogen usually gets the most attention when it comes to fertilization, and there are good reasons for that. It's the nutrient with the most visual effect and results in the greatest effects to the plant. However potassium (K) is also essential, as is phosphorous (P).

We all know how to apply nitrogen using the range of fertilizer sources available today to superintendents and field managers. But what about P and K? Can we put on large amounts once or twice a year and have good results, or is the management more complicated than that?

In most soils, few applications are just fine, but in the modified root zones that we often deal with fertilization practices may not be that straightforward. This may be the particular case with calcareous sands that are found throughout North America, but are common in the intermountain West. Sands in general leach quickly, but to compound the low nutrient-holding capacity, the high pH of these sands often limits the availability of many important nutrients.

P levels can be maintained at very low levels and possibly discourage the germination of *Poa annua* without reducing the quality of the bentgrass turf.

In most cases, new sand root zones quickly gain cation exchange capacity because of the large amounts of organic matter deposited from the growing turfgrasses. However, sometimes in calcareous sands, this organic matter deposition is delayed because of slow turfgrass growth. Also, turf grown on these sands sometimes has substantial thatch layers because of low microbial activity.

To gain more information on proper management of these sands, we studied nitrogen (N), P, and K and their interactions on a creeping bentgrass (*Agrostis stolonifera* Huds.) green built with the calcareous sands common to the intermountain West region of North America.

Materials and methods

We conducted our experiments from 1998 to 2001 on a putting green established in 1995 to modified USGA recommendations (11) in North Logan, Utah. The sand differed from USGA specs by having an increased percentage of fine particles (23.1 percent in the .15 mm to .25-mm particle size and 12.1 percent in the .05 mm to .15-mm particle size).

When built, the root zone mix was prepared as 95 percent sand and 5 percent peat, but at the beginning of the experiment the percentage of organic matter was still very low. Soil particle breakdown was 95 percent sand, 5 percent silt and clay, and .5 per-

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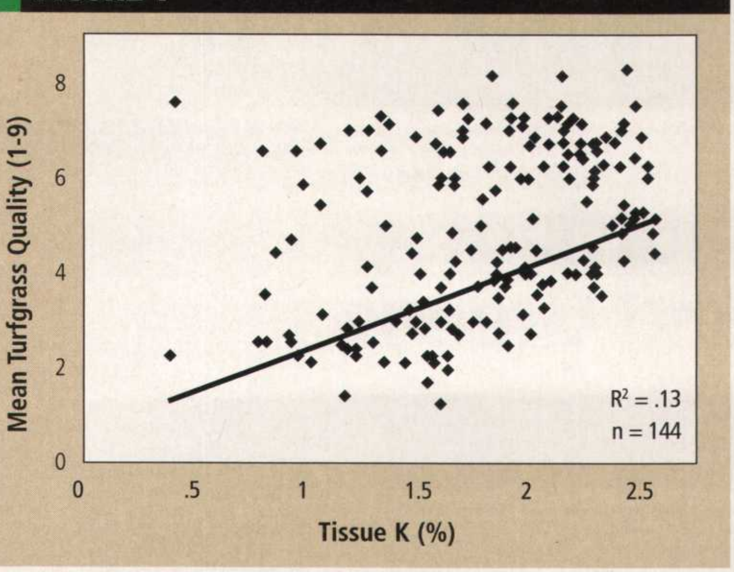
FIGURE 1



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cent organic matter. The bentgrass variety was Providence.

Nutrient levels at the start of the experiment were low in P and K. Zinc and sulfur levels were also low, but were amended at the start of the experiment with elemental sulfur at 87.5 pounds per acre and a micronutrient fertilizer. In general, the turfgrass quality of the putting green at the start of the experiments would not have been acceptable for a typical golf course because of poor density and lack of growth.

We conducted two separate but related experiments. In Experiment 1, P and K rates were varied, and N was held constant. In Experiment 2, we varied rates of N and K with constant levels of added P. In 1999, the fertilizer treatments were divided among six applications between April and November. This schedule caused some burning of the turf. To prevent these effects in 2000 and 2001, we divided the same yearly nutrient amounts among 12 applications to more closely simulate fertilization intervals on putting greens. The fertilizer treatments are summarized in Table 1.

The plots were irrigated with .1 inch of water immediately after the treatments were applied. Irrigation during the growing season was scheduled to replace approximately 80 percent of evapotranspiration every two days. Weather data was determined by an on-site Campbell Scientific weather station. The turf was mowed at .16 inches four times each week and clippings were removed at each mowing. The summer growing seasons of 1999, 2000 and 2001 were nearly rain-free, so the water applied to the experiment was highly controlled.

We rated turfgrass quality of the plots at least once each month using a 1 to 9 scale, where 1 is brown, dormant turf and 9 represents the best quality. Shoot density and color were also rated at least once each year. Soil samples from each plot were collected five times each year and analyzed for P and K levels. Tissue samples were also collected and analyzed yearly in early August. To determine the relationships between turfgrass quality and soil test P and tissue P, we used models to estimate critical levels of soil and tissue test P above which turfgrass quality was not improved.

TABLE 1

Nitrogen, phosphorus and potassium fertilizer rates used in Experiment 1 and 2.

Nutrient	Exp. 1: PxK Study	Exp. 2: NxK Study	Nutrient Source (1999)	Nutrient Source (2000-1)
-----pounds of nutrient per 1,000 square feet per year -----				
N	5	2, 3, 5, 7	urea	urea
P_2O_5	.25, 1.25, 2.5, 5	5	phosphoric acid	monoammonium phosphate
K2O	0, 2.5, 5, 7.5	0, 2.5, 5, 7.5, 10	potassium chloride	potassium chloride

Results and discussion

We began this research particularly interested in the interactions of the applied nutrients, particularly N and K. In other words, we were looking for different responses of K at different rates of N fertilization. However, we observed no such interactions. As a result, all the results will be on the simple effects of N, P and K fertilization.

Phosphorous: Very little phosphorous was required by the bentgrass turf in this experiment. Prior to the experiments, the bentgrass turf showed classic P deficiency symptoms of purple coloration together with very stunted growth. The quality dramatically increased as soon as the P fertilization began. Only the lowest P level (.25 pounds of phosphorus pentoxide per 1,000 square feet per year) did not provide adequate quality turf. These results indicate that P levels can be maintained at very low levels and possibly discourage the germination of *Poa annua*, without reducing the qual-

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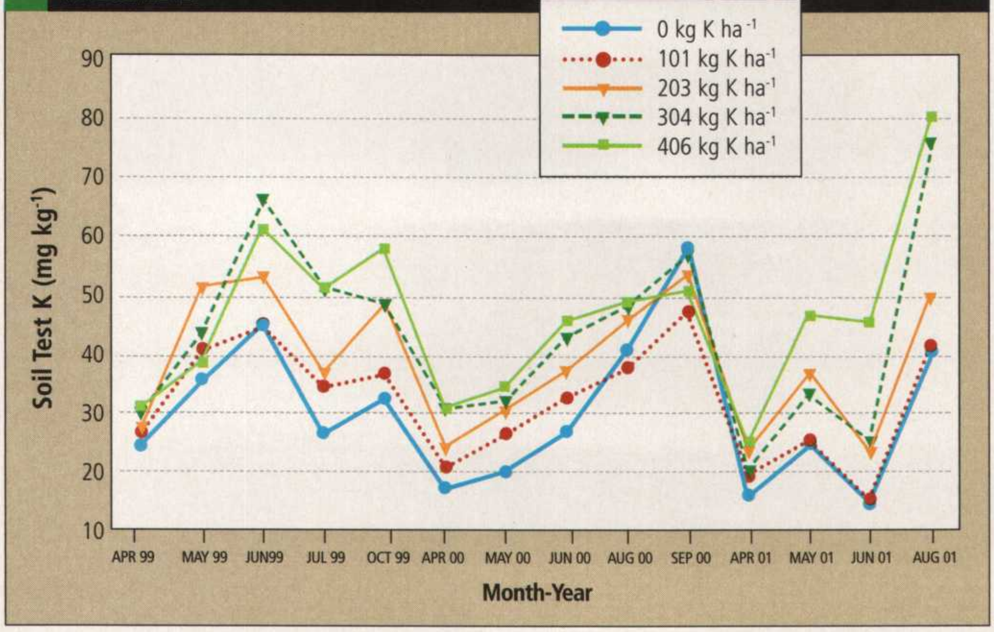
FIGURE 2



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ity of the bentgrass turf. Levels of P can also be maintained at low levels to reduce any water-quality concerns.

Nitrogen: Our results with nitrogen treatments were nothing new and similar to other research and observations by many superintendents. The optimal fertilization rate per year was between 3 pounds and 5 pounds per 1,000 square feet per year. Seven pounds per 1,000 square feet per year was excessive. The plots fertilized at the highest N rate were very dense and dark green, but quickly developed substantial thatch layers increasing the tendency for scalping by the mowers. They also experienced more localized dry spot problems.

Potassium: Potassium responses of the creeping bentgrass turf were essentially not present. Even though K is commonly referred to as the second most important nutrient for healthy golf turf, we observed little or no positive influence of high K fertilization rates. Levels of K in the soil increased with higher application rates, but not in the proportion one might expect. When higher amounts of K were found in the plants, there was a slight increase in quality, but the relationship was very weak (Fig. 1). One likely reason for this lack of response is simply the inability of the sands to hold even moderate amounts of potassium. Even low application rates may have exceeded the nutrient holding capacity. Most likely, the K is leaching through the root zone.

We often worry about leaching of nitrogen, especially because of environmental concerns of nitrate in the groundwater. But leaching of K may also be an issue, more for the plants than the environment, however. The most effective management of turf on these sand root zones might be through the use of slow-release K fertilizers, foliar applications or frequent treatments. With these methods, nutrients will be available to the plant and not as much lost through leaching.

The lack of response to K is not only characteristic of calcareous sands, but turf on all soils. Potassium is known to have its greatest influence when the plants are under stress, especially moisture and traffic stress. Neither of these stresses were present in our study. As a result, any future work on this topic will involve drought stress and heavy simulated traffic treatments.

This leaching of K in the root zone was most pronounced in spring when soil test K was very low after leaching throughout the winter (Fig. 2). This low level of K may slow the development of a healthy and stress tolerant turf in the spring in preparation for the heat stress of summer. Special efforts to raise the levels of K in the soil and in the plant tissue may be an especially important spring fertilization management goal on sites with low nutrient-holding capacity.

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REFERENCES

Johnson, P.G., R. Koenig and K. Kopp. 2003. "Nitrogen, phosphorous and potassium responses and requirements in calcareous sand greens." *Agron. J.* 95:697-702.

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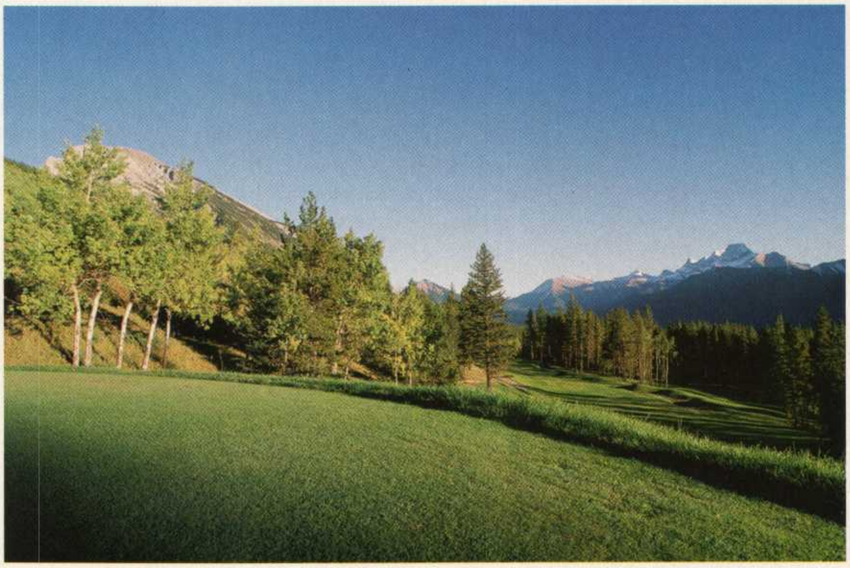
Since 1986 when The Andersons Turf Growth Regulator (TGR) products were first introduced to the market, the company has gained much knowledge of the effectiveness of these products under a range of use areas, rates and turf types. Currently The Andersons offers its Turf Growth Regulator products in four different product formulations:

- 31-3-7 Fertilizer with TGR *Poa annua* Control;
- 14-0-29 High K Fertilizer with TGR *Poa annua* Control;
- 14-0-28 with Turf Enhancer; and
- Turf Enhancer 2SC.



The active ingredient in all these products is paclobutrazol, a systemic mode of action growth inhibiter. It inhibits gibberellic acid biosynthesis in the plant that results in a reduction in cellular elongation. The key benefits from the TGR products are clipping reduction, increased density, enhanced turf quality, decreased water usage and *Poa annua* reduction.

The Andersons TGR products are the best available growth regulator products for a *Poa annua*-reduction program. The company's years of experience along with university testing illustrates the strength of TGR products for *Poa annua*-reduction. Spring and fall applications of either the 31-3-7 Fertilizer with TGR and the 14-0-29 High K Fertilizer along with the spray applications of Turf Enhancer 2SC or granular 14-0-28 with Turf Enhancer through the summer months provide the best programs for accelerated *Poa annua* reduction programs. The key to success with a *Poa annua* reduction program is to continue with the program until the *Poa* population is reduced to the desired level. To determine the best timing recommendation for your area, we advise consulting with your Andersons distributor or Andersons territory manager.

For a clipping-reduction program, applications of either the granular 14-0-28 with Turf Enhancer or the Turf Enhancer 2SC sprayable programs work best. Both can be applied at the 21-day to 30-day intervals throughout the growing season to reduce clipping yield. The other benefits to this program are enhanced greening and a tighter, denser turf stand that requires less water that will handle environmental stress better than turf that is nonregulated. The turf manager can use a combination of the granular product and sprayable products that suits his program the best.

The Andersons TGR products can be used to enhance grow in and establishment of new turf. Usage on turf should begin after the third or fourth mowing and continued on a 14- to 21-day interval. This will force the young turf to grow horizontally — in lieu of vertical growth.

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Article contributed by Dave Louttit, Andersons Territory Manager

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New Benefits of Endophyte-Infected Grasses Emerge

By Parwinder Grewal and Doug Richmond

Endophytes can provide enhanced drought tolerance, summer survival, and insect and disease resistance to grasses.

Endophytes are fungi belonging to the genus *Neotyphodium* that live in the leaves and stems of grasses and are carried from plant to plant only through seed. These fungi do not cause any disease in the grasses, but under most circumstances they are beneficial to the growth and survival of infected plants. This association naturally occurs in perennial ryegrass and several species of fescues, but not in Kentucky bluegrass or bentgrass.

The fungus obtains all food resources from the grass host, but in return provides several benefits to the plant. Research provides evidence of greater persistence and growth of endophyte-containing grasses, relative to plants that lack endophytes.

Endophytes modify how plants acquire and use their available resources and make them more widely adapted to environmental conditions. Endophyte-containing grass cultivars have greater seed survival, germination and establishment than cultivars lacking endophytes. The presence of endophytes confers drought resistance and enhances summer survival of grasses.

Endophyte-containing cultivars also perform better in poor-quality acidic soils and soils with low phosphorus content.

Enhanced insect, nematode resistance

The endophytes provide a built-in systemic pesticide for the plant. Defensive chemicals are produced by the endophyte that are disruptive to numerous animal species capable of using endophyte-free grasses for food.

Endophyte-infected grasses are resistant to sod webworms, chinchbugs, billbugs and numerous other surface-feeding insects. Previous research at The Ohio State University showed that excellent control of bluegrass billbug can be obtained in Kentucky bluegrass lawns overseeded with endophyte-infected perennial ryegrass. This research also established that only about 40 percent of the plants in a turf sward have to contain endophytes to obtain effective control of bluegrass billbug and sod webworm.

Turfgrass insects, nematodes and mite pests that can be managed with the use of endophyte-containing grasses are listed in Table 1 (page 90).

Although endophytes are more effective against above-ground insect pests, below-ground insects and plant-parasitic nematodes are also affected. The fungus and its alkaloids are concentrated in above-ground plant tissues, but as much as 15 percent of the lolines and smaller amounts of ergot alkaloids may occur in tall fescue roots. Ergot alkaloids strongly deterred feeding by the Japanese beetle grubs in laboratory bioassays and reduced their survival and weight gain in stands of endophyte-containing grasses in some field trials. Plant-parasitic nematode populations in the soil have been found to be smaller under endophyte-containing grasses than the endophyte-free grass stands.

Aside from the direct toxic affect that endophyte-infected plants have on many surface feeding insects, endophytes provide the additional benefit of altering insect foraging behavior. Insects such as chinch bugs and sod webworms spend more time moving and less time feeding in stands of turfgrass containing even moderate proportions of endophyte-infected plants.

This increase in movement makes the insects much more vulnerable to predators and pathogens and may be a death knell for newly hatched larvae or nymphs. These neonate insects are equipped with very little in the way of energy reserves, so they must find a suitable food source quickly or perish in the process of searching.

Effects of cultural practices

Levels of endophyte-produced alkaloids depend on several environmental factors. Seasonal variation typically shows maximal levels at the end of the growing season, but peramine in tall fescue shows no seasonal effects.

Temperature, sunlight and rainfall all have an impact on alkaloid production. Our own

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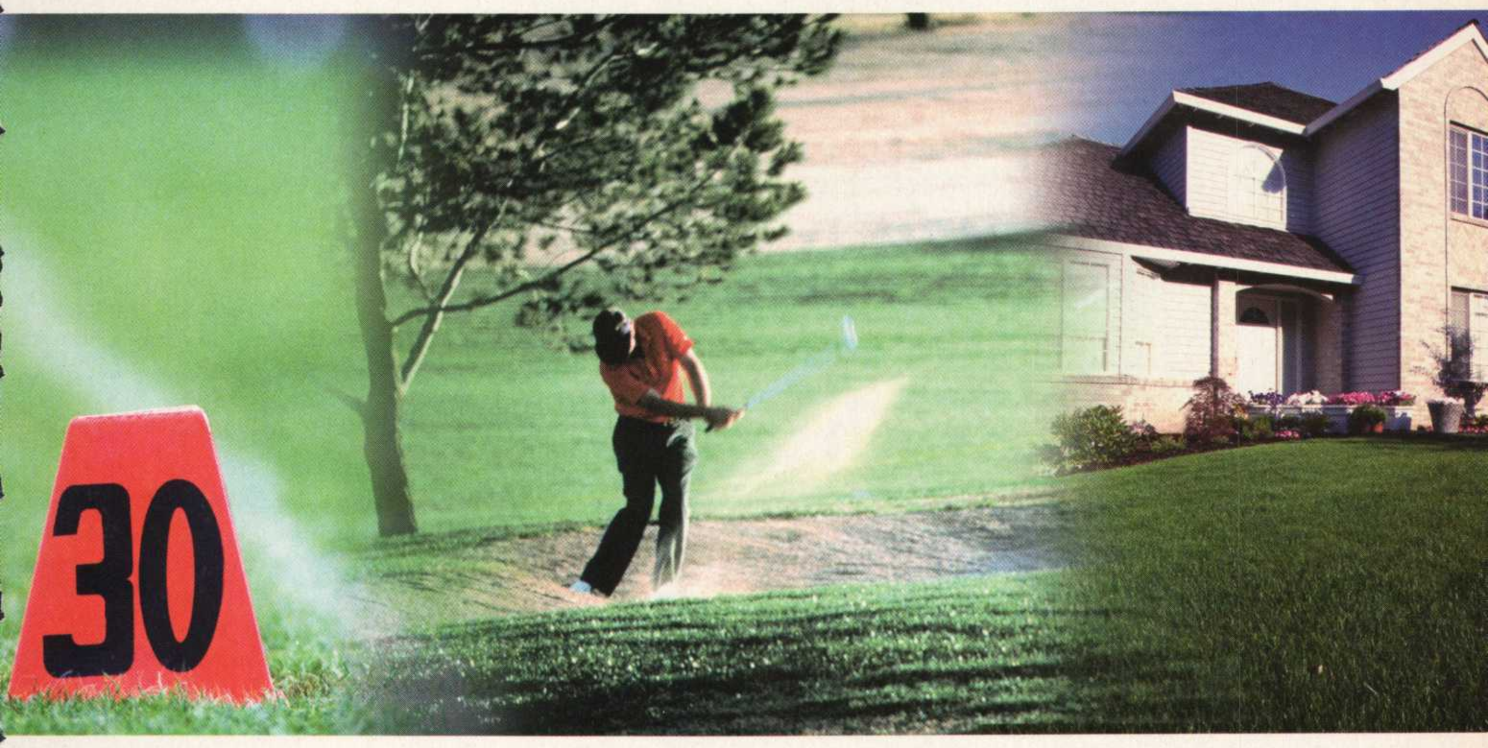

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research shows that extreme temperatures repress alkaloid levels relative to the levels between 14 degrees and 21 degrees Celsius in tall fescue and perennial ryegrass.

In a greenhouse trial, we found that the contents of different ergot alkaloids were variable at different temperatures, but there were no clear trends on the effect of temperature on any particular alkaloid between 14 degrees and 25 degrees Celsius, thus supporting the usefulness of planting endophyte-containing grasses in the Midwest. In this trial, we also found that both the survival and weight gain by fall armyworms were significantly lower when feeding on endophyte-containing perennial ryegrass than the nonendophytic perennial ryegrass at all temperatures.

Both nitrogen (N) and phosphorus (P) fertilizers can alter the levels of alkaloids in tall fescue. The application of nitrogen increases the concentration of major ergopeptide alkaloids in tall fescue cultivar Kentucky 31. At the University of Georgia, it was demonstrated that the source of nitrogen is also important, as all concentrations of NO_3 –N increased ergopeptide alkaloid content as opposed to NH_4^+ -N that was effective only at high concentrations.

Ergopeptide concentrations were highest in drought-stressed plants that were fertilized at the moderate or high N rate. Ergot alkaloid accumulation in roots of tall fescue increased linearly with phosphorus availability in the soil, but in the shoots the alkaloid concentration increased with increasing phosphorus availability in the soil from 17 milligrams to 50 milligrams P per kilogram of soil, but declined at 96 milligram P per kilogram of soil.

We found that the levels of ergot alkaloids in endophyte-containing perennial ryegrass and tall fescue are affected by the common cultural practices such as mowing height and mowing frequency. We found that the major ergot alkaloids including ergonovine, ergocristine and ergocriptine significantly increased in tall fescue with increased mowing height from 1 inch to 3 inches (Fig. 1). Increased mowing height reduced masked chafer grub populations at the University of Kentucky.

In another greenhouse experiment, we tested the effect of two mowing frequencies, once a week (weekly) or once every two weeks (biweekly) on ergot alkaloids. The mowing height was 2 inches in this experiment. We found that decreased mowing frequency caused a five-fold increase in the amount of ergovaline and a 2.6-fold increase in ergonovine (Fig. 2).

In both the above experiments we used the fall armyworm as a bioassay insect to detect the impact of our treatments on the resistance of grass plants to insects. We found that as the concentrations of ergonovine in the shoots increased due to less frequent mowing, the dry weight of the fall armyworm decreased.

FIGURE 1

Effect of mowing height on concentrations of major ergot alkaloids in tall fescue shoots after one or two months in the greenhouse at 25 degrees Celsius. Grass was mowed weekly at either 1-, 2- or 3-inch height. Same lowercase letters on the bars indicate no significant differences between mowing height treatments within each month.

Micrograms per gram of tissue dry weight

MOWING HEIGHT	ERGOCRISTINE 1 mo	ERGOCRISTINE 2 mo	ERGONOVINE 1 mo	ERGONOVINE 2 mo	ERGOCRYPTINE 1 mo	ERGOCRYPTINE 2 mo
1 Inch	3.5	4.3	1.5	2.3	1.1	8.5
2 Inch	3.2	3.9	1.6	2.8	2	9
3 Inch	3.8	4.6	1.8	3	3.6	15.3

FIGURE 2

Effect of mowing frequency on concentrations of major ergot alkaloids in tall fescue shoots after two months in the greenhouse at 25 degrees Celsius. Grass was mowed at 2-inch height either weekly or biweekly. Same lowercase letters on the bars indicate no significant differences between mowing height treatments within each month.

Nanograms per gram of tissue dry weight

MOWING FREQUENCY	ERGONOVINE	ERGOVALINE	ERGOCRYPTINE
Weekly	200	3.1	228
Every two weeks	490	14.5	245

Enhanced ability to compete

Endophyte-containing plants are generally more competitive and tend to dominate plant communities over time.

Research in Indiana showed that in mixed perennial ryegrass and white clover swards, the presence of the endophyte in ryegrass resulted in a significant decrease in white clover. Endophyte-containing ryegrass maintained greater cover under severe insect stress, whereas stands lacking the endophyte persisted poorly and were more heavily invaded by weeds.

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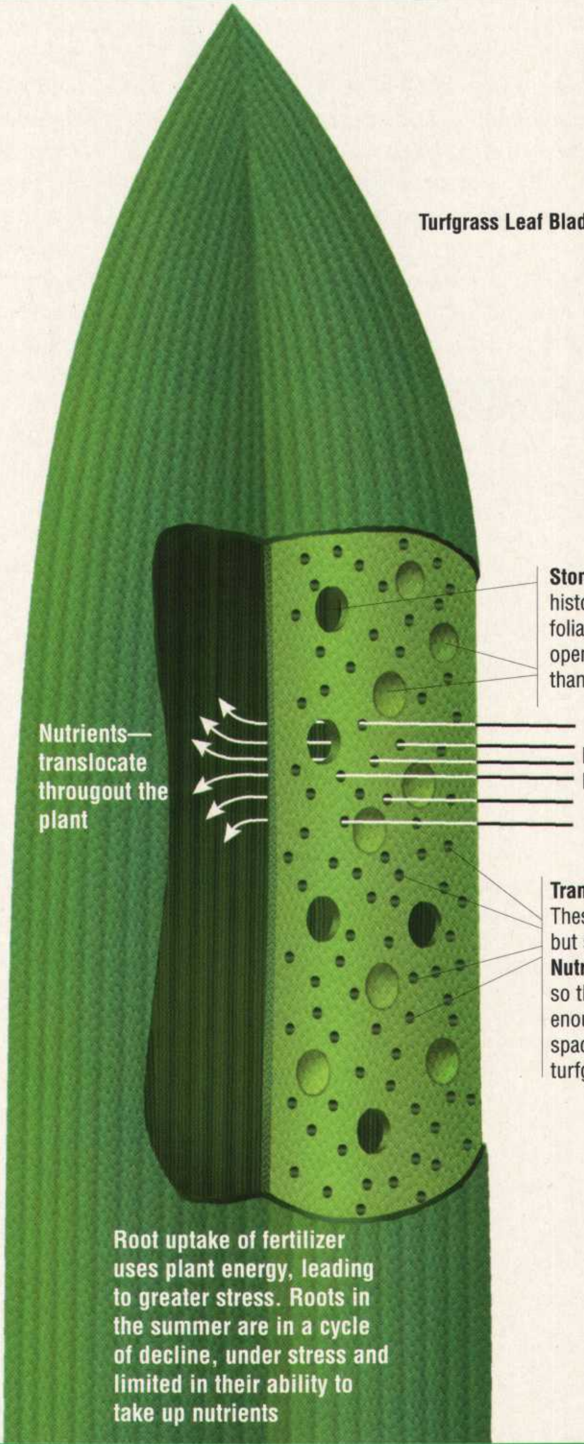

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Following drought, survival and cover of endophyte-containing tall fescue was significantly enhanced. Reduced cover of stands lacking the endophyte allowed other grasses and dicots to increase. These results indicate that the abundance and diversity of other plant species may be reduced by competition with endophyte-containing grasses.

Our research demonstrates the competitive ability of endophyte-containing grasses could substantially contribute to reduction in weed invasion and establishment in lawns.

Allelopathic effects of tall fescue on red clover and birdsfoot trefoil were first demonstrated in the 1970s. Our own recent research shows that endophyte-containing tall fescue and perennial ryegrass are often better able to compete against common weed species. In a field study on newly established plots, we observed that the population of crabgrass was lower in endophyte-infected stands of perennial ryegrass compared to uninfected stands.

Likewise, the density of plantains (buckhorn and common) was consistently lower in stands of endophyte infected tall fescue compared with uninfected stands. These plots were under minimal management, received no fertilizer or pesticide inputs, and were mowed at 3.5-inch heights.

TABLE 1

Major insect, mite and nematode pests of cool-season turf that can be potentially managed with endophyte-infected grasses.

INSECTS

Annual bluegrass weevils, *Hyperodes spp*
Armyworm, *Pseudaletia unipuncta*
Bluegrass billbug, *Sphenophorus parvulus*
Chinch bug, *Blissus leucopterus leucopterus*
Hairy chinch bug, *Blissus leucopterus hirtus*
Black cutworm, *Agrotis ipsilon**
Bronzed cutworm, *Nephelodes minians*
Fall armyworm, *Spodoptera frugiperda**
Greenbug, *Schizaphis graminum (Rondani)*
Bluegrass webworm, *Parapediasia teterrellus*
Cranberry girdler, *Chrysoteuchia topiaria*
Larger sod webworm, *Pediasia trisectus*
Vagabond crambus, *Agriphila vulgivagellus*
Japanese beetle, *Popillia japonica**
Southern masked chafer, *Cyclocephala lurida**

MITES

Clover mite, *Bryobia praetiosa*
Winter grain mite, *Penthaleus major*

PLANT PARASITIC NEMATODES

Ring nematode *Crionemoides spp.*
Spiral nematode *Helicotylenchus spp.*
Lance nematode *Hoplolaimus spp.*
Lesion nematode *Pratylenchus spp.*
Stubby root nematode *Tylenchorhynchus spp.*
Pin nematode *Longidorus sp.*
Dagger nematode *Xiphinema sp.*

*Represents species that can feed and develop on endophytic grasses, but have slower development than those feeding on nonendophytic grasses

Weed management

Aside from providing protection from insect pests, endophytes can provide a measure of protection against other important turfgrass problems that are not so obviously related.

Although it's a fact that insect feeding can reduce the vigor and persistence of turfgrass plants, we rarely make the connection between this kind of damage and other ensuing problems such as weed invasions. In fact, we tend to think of weeds and insects as separate and independent concerns in turfgrass management and, to a large extent, our approach toward research and extension reflects this way of thinking.

When turfgrasses are attacked by insects, their ability to compete with the ever-present pressure from encroaching weeds is degraded. Even worse, when insects cause mortality of turfgrass plants, the new occupant of the formerly turfgrass covered site will likely be an undesirable plant.

In a simple study, we observed weed invasion into stands of Kentucky bluegrass suffering from different levels of damage caused by the bluegrass billbug. At the undamaged site, few weeds were ever present, and none of these weeds were able to become established. However, at the site where moderate billbug damage was apparent, weeds, such as dandelion, black medic and crabgrass, were a significant problem.

But what if the above-mentioned sites had been planted with endophyte-enhanced turfgrasses? For one thing, insects that feed on the above-ground portions of turfgrass plants (billbugs, armyworms, cutworms, sod webworms and chinch bugs) are much less likely to cause significant damage to endophyte-enhanced grasses.

In a series of greenhouse studies, we observed