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TURFGRASS TRENDS

WINTER SURVIVAL

Effects of Fall-Applied N and K on Cold Hardiness of Perennial Ryegrass

By J. Scott Ebdon and David E. Webster

Winter kill is a non-specific term that can include several abiotic (non-living) stresses as well as biotic stresses such as low-temperature fungi. Low-temperature kill (freezing stress), ice cover and low-temperature disease are the principal agents associated with winter injuries in the Northeast. Perennial ryegrass (*Lolium perenne L.*) is planted throughout the region. Research shows that perennial ryegrass is one of the most susceptible cool-season grasses to low temperature (4, 5).

Direct low-temperature kill in perennial ryegrass, South Deerfield, Mass. Perennial ryegrass exhibits poor low-temperature hardiness. Freeze-stress injury in this photo was most severe in low-lying areas where free water accumulated to promote crown hydration. Photograph was taken in late March after snow had melted.

Freeze-stress injury is a function of several factors such as the species, physiological state of the plant, environmental conditions and the mechanism of injury (2).

Balanced nutrition is essential to quality turf. Nitrogen (N) is a critical nutrient in cold hardiness, and heavy applications of N in the fall period may increase freeze-stress injury. Low-temperature kill as well as low-temperature disease increase with crown hydration and tissue N.

An inverse relationship between cold hardiness and crown moisture content is often observed. The period of maximum cold hardiness in cool temperate regions occurs following acclimation (hardening) to low temperature in late December and early January (1). Winter kill from low temperature most often occurs during de-hardening in late winter and early spring as plants lose their cold hardiness (see photograph).

There are numerous reports that provide different results as to the relationship between N and potassium (K) and winter hardiness. Researchers (3) reported that a N-to-K ratio of 2-to-1 provided maximum low temperature survival in

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Kentucky bluegrass (*Poa pratensis L.*) and creeping bentgrass (*Agrostis stolonifera L.*) at all levels of N applied from 0 pounds to 16 pounds per 1,000 square feet per year. Their results suggest that a balance of potassium that is one-half that of nitrogen is important for maximum cold hardiness rather than low N or high K.

In recent years there has been a practitioner trend towards applying relatively high rates of K equal to or exceeding N. Although the effects of N or K applied alone and in combination have been studied, there is no agreement among turfgrass managers as to the optimum K fertilization program. Limited information is available as to the optimum N and K rates during the fall period to achieve maximum hardiness in late winter and early spring when grasses are most susceptible to freeze stress.

The objective of this study was to evaluate perennial ryegrass low-temperature hardiness in response to fall-applied N and K during de-hardening in late winter and its effects on crown hydration, lethal-freezing temperature, shoot-growth rate, tissue K concentration and low-temperature disease.

Materials and methods

Fertilizer studies were initiated in April 2000 at the Joseph Troll Turf Research Center (South Deerfield, Mass.), University of Massachusetts Amherst.

Fifteen N-K combinations were applied to established Palmer II perennial ryegrass. Soil extractable phosphorous (P) and K prior to treatment were high, so no supplemental P or K was recommended. Treatments included five rate levels of N (1, 3, 5, 7 and 9 pounds per 1,000 square feet per year) in all combinations with three rate levels of K (1, 5 and 9 pounds per 1,000 square feet per year). The 15 N-K treatment combinations were arranged as a randomized complete block with four replicates. Plots were mown twice per week at 1.25 inch, using reel mowers. Clippings were returned except when collections were made for growth determination and tissue nutrient analysis.

Urea (45-0-0) was used as the sole N source while potassium sulfate (0-0-50) was used as the sole source of K. Monthly N and K fertilizer applications were generally applied during the last week of each month and irrigated after fertilization. Approximately 60 percent to 70 percent of the total annual N was applied during the fall period from late August through late November. Late fall N in November was applied following the last mowing after shoot growth ceased.

Clippings were collected monthly following mowing events for a total of five collections per growing season from April through August in 2002 and 2003. Clippings were oven dried, weighed and expressed as grams (g) dry matter per square meter per day. Total tissue K was determined in 2002 and 2003 from chemical analysis of dried clippings collected in April prior to fertilizer treatments.

Maintain WSN rates to no more than 1 pound N per 1,000 square feet per growing month during periods of active shoot growth in the fall.

Plots were rated for gray snow mold (*Typhula incarnata*) as percent of plot in early spring of 2002 and 2003. Shoot growth rate, tissue K and snow mold severity are reported here averaged over 2002 and 2003 growing year.

To determine cold hardiness, plant samples were taken from field plots during late winter and early spring of 2004. Plant material was evaluated for low-temperature hardiness by exposing individual plants to a range of 11 decreasing treatment temperatures. After temperature exposure, plant material was removed and planted in the greenhouse to evaluate re-growth and survival. Plants with any new growth were counted as survivors.

The temperature at which 50 percent of the plant (crown) tissue that survived was expressed as the LT50 (lethal temperature at which 50 percent of the plant material survive). At the time of field sampling, crowns were also removed from each N-K treatment

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plot and used to determine percent crown moisture content.

Effects of fall-applied N

Nitrogen was an important factor affecting low-temperature hardiness. Excessive N applied during periods of active shoot growth during the fall (September and October) increased the potential for low-temperature kill.

Water-soluble N (WSN) applied in September at 2 pounds N per 1,000 square feet followed by 1 pound per 1,000 square feet in October was associated with significantly higher killing temperatures (less cold hardy) (Figure 1).

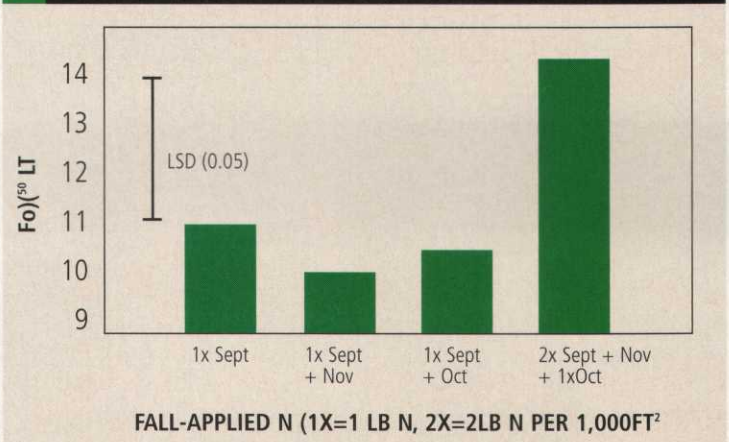
Late fall-applied N in November did not appear to increase the potential for low-temperature kill. A single application at 1 pound N per 1,000 square feet applied in September was no different in cold hardiness from other fall-applied N treatments, all of which incorporate late fall N.

When compared to 1 pound of N in September, higher crown moisture content was observed in response to N applied in September at 2 pounds per 1,000 square feet followed by 1 pound per 1,000 square feet in October (Figure 2). This increase in tissue moisture also promoted low-temperature disease (Typhula incarnata) (Figure 3).

Winter disease increased by as much as 25 percent over other fall-applied N treatments. Timing and rate of N are critical to the success of fall-applied N. It is better to err on the side of applying N too late than too early during the late fall period.

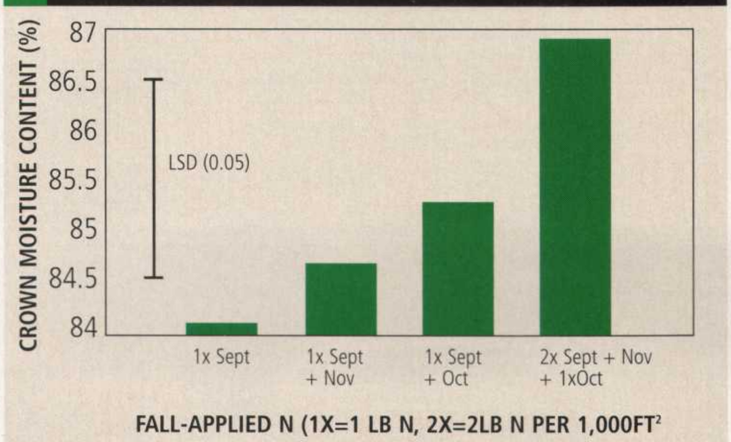
Secondly, it is recommended to maintain WSN rates to no more than 1 pound N per 1,000 square feet per growing month during periods of active shoot growth in the fall.

FIGURE 1



Effects of fall-applied N on median lethal temperatures (LT 50) in perennial ryegrass during late winter.

FIGURE 2



Effects of fall-applied N on crown moisture in perennial ryegrass during late winter.

Effects of fall-applied K

The role of K in plants is complex because of its many physiological functions. Potassium's ability to bind water during the formation of ice crystals has been suggested as a possible mechanism in cold tolerance.

In our study, K had an influence on crown moisture, cold tolerance and low-temperature fungi; however, K effects were dependent on the rate of N applied during the fall period.

At N rates of 2 and 1 pound per 1,000 square feet applied in September and October (5 pounds of total N per 1,000 square feet during the early-to-late fall period), cold hardiness decreased and crown hydration increased with K fertilization.

At these N rates, a significant increase in the uptake of K was observed, which was commensurate with increases in the rate of shoot growth and loss in cold hardiness.

The higher tissue (and crown) moisture content promoted by K also increased gray

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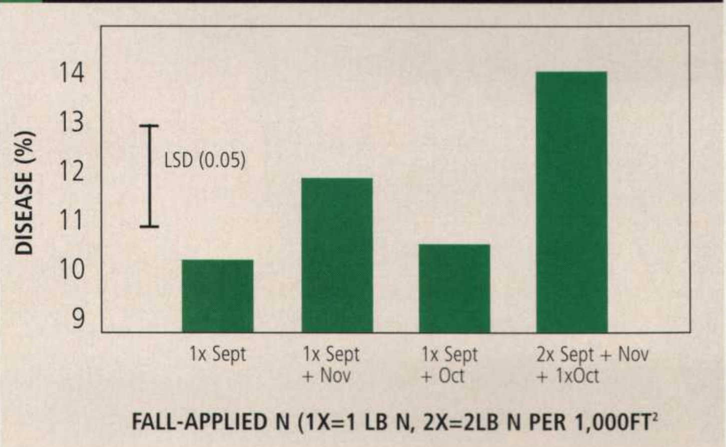
FIGURE 3



Effects of fall-applied N on gray snow mold severity (Typhula incarnata) in perennial ryegrass.

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snow mold severity by as much as 40 percent as K rates increased from one to 9 pounds per 1,000 square feet per year. Although soil exchangeable K indicated optimum levels, K was growth limiting at this moderately high N rate.

In contrast, with a single application at 1 pound N per 1,000 square feet applied in September, cold hardiness increased with K fertilization (Figure 4), possibly due to luxury consumption of K. Luxury consumption of K is an accumulation of K in tissues beyond those levels needed to sustain normal growth.

At the rate of 1 pound N per 1,000 square feet, no increase in the rate of shoot growth (and crown hydration) was observed with K, although significant uptake (and accumulation) of K was detected. Potassium acting to either increase solute concentrations and to bind water and/or to increase energy reserves are possible physiological explanations to the role of K in enhancing cold hardiness.

Conclusions

Late fall-applied N had no effect on winter kill. Nitrogen applied after shoot growth had ceased had no significant effect on either cold hardiness or winter disease.

Applications of 3 pounds WSN during periods of active shoot growth (in September and October) caused significant increases in crown hydration and winter kill from low temperature stress and disease.

Winter kill from fall-applied K was dependent on the rate of N. Applications of 1 pound of WSN with high levels of K approaching 5 pounds per 1,000 square feet per year and higher decreased the potential for low-temperature kill, possibly due to luxury consumption of K. These K rates are above those levels typically recommended. No detrimental effects on winter survival were ever observed with relatively high levels of K so long as WSN rates in the fall did not exceed 1 pound per 1,000 square feet per growing month.

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ACKNOWLEDGMENT

This research was funded by the Massachusetts Turf and Lawn Grass Association and the New England Regional Turfgrass Foundation.

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