The Elements of Disease

Dr Kate Entwistle researches the role nutrient deficiency plays in turfgrass disease

Through experience and from our years of study, we know that disease development is dependent upon three things, firstly the presence of a pathogen (invariably a fungus), secondly suitable environmental conditions, and thirdly a susceptible host. If any one of these is lacking, disease cannot develop.

However, there apparently remains a misconception that it is the presence of the pathogen that is the most important factor of the three. Since the pathogen is almost invariably present on the sward or in the rootzone, I don't believe that this is the case. It is much more important to ensure that the turfgrass plant has low susceptibility to any potential infection than it is to worry about the likely presence of the pathogen.

Susceptibility comes down to stress and in turfgrass management stressing the sward is a daily necessity if the desired quality of the surface is to be achieved. Stress is difficult to define but involves a number of factors that can reduce the overall quality of the plant, its vigour and its ability to maintain optimal growth conditions.

This is where our ability to manage close-mown fine turfgrasses is tested to the extreme because whatever we do to try and keep the plant healthy, the boundaries are constantly being changed by the environmental conditions.

The best way to maintain plant health is to manage its nutrient availability. The elements taken up by the plant are used in countless physiological processes that ensure optimal growth and development through the year. If nutrient availability is compromised, these processes will be directly affected and the result will be a reduction in the overall quality of the plant.

Fusarium patch.

The purpose of this article is to pull together a relatively small amount of information from research, completed over the past decades by some of the leading turfgrass researchers around the world, to show how certain nutrients affect plant stress and disease development.

There is a vast amount of information on this subject that is freely available on the World Wide Web and much of the text below is taken from a relatively small number of articles found from recent searches. All of the text used from these articles is referenced so that you can obtain and read the entire article, should you wish to.

Although nutritional problems in turf are well known, especially on high sand content rootzones, extreme deficiencies are much less common. However, what is more common are non-acute symptoms of decreased growth and turfgrass quality that render the plant more susceptible to stress, disease and pest problems.

Red Leaf Spot on bentgrass.

Much of the general text relating to nutrient requirement that I have included in this article, is taken from Chapter 20: Turfgrass, written by T R Turner, in Nutrient Deficiencies and Toxicities in crop plants, edited by W F Bennett, 1993. Where information has been taken from this reference, it will be written in *italic* text. Other text, taken verbatim from various articles, is acknowledged with the author(s) name(s) and a complete reference provided at the end of this article.

Nutrients and nitrogen

How do we know when the turf requires nutrient input and what type of nutrient and what amount are required? Experience and analysis. Nutrient input is specific for each individual course since it is heavily affected by the rootzone composition and quality and by the grass species and cultivars present in the sward, not to mention mowing height.

In assessing nutritional deficiencies of turfgrass, a variety of aesthetic and functional characteristics are much more important than top growth rates. For example, low levels of a nutrient may result in the increased incidence of disease, which in turn reduces turfgrass quality. Many factors complicate the degree of nutrient deficiencies and they may occur in turfgrasses.

These factors include turfgrass species and cultivar; length of growing season; inherent soil nutrient levels, soil texture, and soil organic matter levels; degree of environmental, pest, and wear stresses; amount of rainfall and irrigation; management practices such as clipping removal versus recycling; and quality expectations at a specific site.

"Turfgrasses need certain nutrients in the right amounts to grow properly and maintain good health. When these nutrients are deficient or present in excess amounts, diseases can gain an advantage and seriously injure plants. Although well-designed fertility programs by themselves rarely provide complete control of turfgrass diseases, they can reduce or delay the need for fungicides and lessen the severity of disease outbreaks.

Turfgrasses need at least 16 nutrients for normal growth and development. They require some nutrients in large amounts and others only in minute quantities. Of all the mineral nutrients, nitrogen (N) has the greatest influence on turfgrass disease. Perhaps the main reason for this is that N affects nearly all aspects of plant resistance to fungal diseases. Plants use N to help manufacture anti-fungal compounds that protect them against invasion by pathogens. Too much N, conversely, can increase the severity of some diseases (Landschoot, 1999i)."

Many turfgrass diseases are more prevalent under low N (nitrogen) fertility. These include dollar spot (Cook, et al. 1964ii; Endo, 1966iii), red thread (Cahill et al, 1983iv), Rusts (Couch, 1973v), take-all patch (Dernoeden, 1987vi) and yellow tuft (Dernoeden & Jackson, 1980vii). High N levels versus moderate N levels, however, may increase turfgrass susceptibility to several other diseases, such as Rhizoctonia brown patch (Bloom & Couch, 1960viii), anthracnose (Danneberger et al, 1983ix) and Drechslera leaf spot (Madsen & Hodges, 1980x).

Phosphorus

Although leaf symptoms associated with extreme P (phosphorus) deficiency may not be exhibited, turfgrass quality and performance can be seriously affected by inadequate soil P. Phosphorus deficiency on established turfgrass stands is less common than during the establishment phase.

Probably the most frequent occurrences of moderate to sever P deficiency on established turf are on very high sandy soils, such as putting greens that have been highly modified and have a high sand content (80% or more).

Some diseases that can have major impacts on turfgrass quality have been shown to be influenced by P applications, although these effects generally appear minor compared with those of some other nutrients, particularly N and K (potassium). Phosphorus applications may interact with other nutrients in reducing the incidence of fusarium patch (Goss & Gould, 1968axi), take-all patch (Davidson & Goss, 1972xii) and red thread (Goss, 1969xiii).

Potassium

"Fertilizer naturally plays a most important role in the maintenance of good turf. Well-balanced nutritional programmes can aid materially in helping to suppress weeds and diseases.

Potassium, one of the three major plant food elements, plays an important role in turfgrass vigor, which in turn influences disease development. Potassium

serves many roles in the grass plant and, if it becomes deficient can cause:

- Accumulation of carbohydrates that cannot be synthesized in to proteins.
- An excess of non-protein nitrogen.
- Failure to produce new cells for lack of amino acids essential for protoplasm formation.
- Slower growth of meristematic tissue that permits replacement of diseased tissues.
- Thinner cell walls and epidermal tissues.

W.E. Pritchett and Granville C. Horn of Florida have reported less dollar spot disease caused by Sclerotinia homoeocarpa where potassium was applied. J. Drew Smith in his book Fungi and Turf Diseases in 1955 stated that application of potash assisted slightly in recovery from infection of Sclerotinia dollar spot disease. Here are two indications, arrived at independently, that potassium does have some effect on dollar spot (Goss & Gould, 1968bxiv)."

Whereas severe K deficiency symptoms have (also) rarely been reported for established turfgrasses, many beneficial responses have been observed as a result of K applications. These responses indicate that mild deficiencies are rather common. Potassium appears to play an important role in tolerance to heat, drought and cold of turfgrasses.

Stripe smut on bentgrass.

Whereas no leaf symptoms of K deficiency may be apparent, beneficial responses in stress tolerance and thus turfgrass quality may result from K applications. It was suggested (Beard & Rieke, 1966xv) that winter survival of turfgrass was at a maximum when applied K rates were approximately half that of applied N (nitrogen) rates.

"Potassium (K) seems to be an important component in the prevention of diseases, perhaps because it prevents plant stress (Elliott & Simone, 2001xvi)".

"In our investigations in western Washington we have found this disease (fusarium patch) to decrease with increasing levels of potassium. The greatest fusarium patch infection occurs from early fall to early winter when the potassium level of tissue is approaching its lowest level. Take-all patch, caused by the fungus Ophiobolus graminis var. avenae has responded with practical significance to both phosphorus and potassium nutrition.

We have reported in a previous paper, that potassium had a suppressing effect on the amount of disease in two years of investigations at Washington State University. Potassium was found to reduce the amount of disease, regardless of nitrogen and phosphorus levels (Goss & Gould, 1968b)."

"On occasion, applications of potassium fertilizers suppress dollar spot, leaf spot, take-all patch and stripe smut*. Although our understanding of the conditions under which this occurs is sketchy, the susceptible plants presumably are in need of this nutrient. Because potassium regulates many plant functions – including cell wall thickness and the plants' water content – it is easy to see why a deficiency can lead to weaker and more disease-prone plants (Landschoot, 1999)."

Manganese

"Take-all patch is a root disease that has plagued creeping-bentgrass fairways and greens for decades. Golf course superintendents often rely on cultural methods for take-all patch management.

One cultural practice that has been effective in suppressing take-all patch is the application of ammonium-containing fertilizers, especially ammonium sulphate. The main reason for the success of ammonium sulphate appears to be that it makes soils more acidic – a condition that inhibits the disease.

After years of researching the influence of nutrients on take-all of wheat (essentially the same disease that affects creeping bentgrass), scientists at Purdue University proposed that acidifying the soil surrounding roots promotes the build up of microbes that convert manganese to a form that the plant can take-up and use while, at the same time, suppressing microbes that prevent manganese uptake by plants. Manganese is involved in the synthesis of compounds that protect grasses from take-all disease and also affects root development (Landschoot, 1999)."

"Researchers recently conducted experiments over a three year period on a golf course in central New Jersey in an effort to determine fertilizer management practices that could suppress this devastating disease (take-all patch). Research clearly showed that manganese fertilization can effectively suppress take-all patch. Research found that manganese fertilization reduced disease severity by about 70% (Heckman, et al, 2003xvii)."

"Applications of manganese and copper are thought to increase the plants resistance to disease through the utilisation of these elements in the increased synthesis of phenolic and ligneous compounds (Hill, et al, 1999xviii)". In their research, Hill et al completed an experiment on a creeping bentgrass fairway that was naturally infected with Gaeumannomyces graminis var. avenae to determine if foliar applications of Mn^{2+} (1.02 and 2.04 kg/ha per application) and Cu^{2+} (0.68 kg/ha per application) would reduce take-all severity.

Treatments were initiated in July 1995 and applied every four weeks through 1997 (with the exception of December, January and February).

"Disease incidence was decreased from 20% on untreated turf to 5% with the high rate of manganese sulphate. For both years, turf treated with the high rate of Mn^{2+} had less disease than turf receiving the low rate of Mn^{2+}. The application of copper sulphate did not influence disease development (Hill et al, 1999)."

Minor nutrient stresses can go unnoticed

Nutrient balance and availability in turfgrasses has received much attention over the past decades and there are countless articles and scientific papers that show how certain elements can help in reducing the outbreak of disease or lessening the severity of infections.

It is possible to tell from the general appearance of the sward when the plants are under heavy nutrient stress, but minor nutrient stresses can have profound effects on the plants susceptibility to infections and can easily go unnoticed. Not just my words but also those of countless researches around the world.

"Managing micronutrients is not an exact science. Those managing sandy or high-pH soils, salt-affected sites, or who are growing-in a golf course should be familiar with the interactions among micronutrients, the factors that can cause imbalances, and what fertilizer strategies can be used successfully. So take the time to learn more about the role of micronutrients in turfgrass systems and how site conditions, management practices and weather conditions can impact their availability. This is one time when micro-managing is not just acceptable, but is downright necessary (Skorluski, 2003xix)."

In this article, I have deliberately focused on the elements N, P, K and Mn, since there is so much research evidence to support their role in turfgrass stress management and disease development. It should be borne in mind that I have taken only small parts of the referenced articles to provide an overview of the role of micronutrients in turfgrass disease management.

If disease problems are plaguing your turf, a full nutrient analysis may help you to determine which nutrients, if any, are deficient. Small applications of the right nutrient (in the right form) can have significant effects on the severity of disease problems and nutrient availability in 'disease-prone swards' may be worth a second thought – now that you have a few more facts.

*** Author comment: Stripe smut was identified (by independent pathologists) as causing damage to bentgrass plants in a turfgrass sample received in May 2004.**

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