A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TurfGrass TRENDS

Volume 6, Issue 9

September 1997

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Turfgrass Seedling Establishment

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Establishing turfgrass from seed as part of a new installation or renovation represents the most important stage in the life of the stand. Mistakes made during establishment evolve into chronic problems that often require additional inputs of water, fertilizer or pesticides to maintain an adequate stand. Many times, the mistakes made at establishment are a result of less than ideal conditions.

A clear understanding of the logistical considerations involved in establishing a healthy stand of turf is vital, such as; assessing site conditions, timing, soil preparation, selecting an adapted species or cultivar, seed rate, mulching, interval to traffic, etc. Optimizing each consideration to maximize establishment success, however, is often constrained as a result of construction, economic, scheduling issues, or environmental concerns associated with erodable soils. Each constraint then moves the manager further from the ideal. Without additional resources, will result in a less healthy stand more reliant on energy intensive inputs.

The establishment of a turfgrass stand from seed involves a myriad of decisions rooted in the basic principles of soil science, seed physiology, ecology, and pathology. Utilizing information based on these disciplines will lead to a healthier stand.

Soil Testing and Preparation

Improper soil preparation is a common reason for establishment failure. Soil preparation includes physical and chemical characteristics. Traditionally, soil nutrient testing has been recommended to ensure success, with particular emphasis on pH and phosphorus (P) levels. The soil reaction or pH is vital for determining nutrient availability and adequate P levels necessary for the energetic processes required during germination (see Hull, Turfgrass Trends Vol. 6 No. 5).

Recently, with the increasing use of modified rootzones, soil physical testing is becoming a standard practice. The increasing costs of modified root zones and the well publicized failures have lead to the establishment of an accredi-

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Reprint: *440-891-2744*
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tation program organized by the United States Golf Association (USGA) and implemented by the American Association for Laboratory Accreditation (A2LA). Soil physical testing provides valuable insights on the particle size distribution and functional performance. This information should be used to ensure an adequate balance between water holding and drainage. Obviously, water holding is essential for successful seedling establishment. However, excessive moisture can limit oxygen as well as increase the potential for seed rot.

Amending Problem Soils

The process of amending a soil to enhance its physical or chemical attributes has been an important aspect of successful establishment for many years. For example, organic amendments have been the cornerstone of the modified root zone mixtures for putting greens over the last 30 years. Still, inorganic amendments such as calcined clay, diatomaceous earth, fly ash, and natural zeolites are gaining in popularity. In each case, amendments are incorporated to enhance the nutrient and hydrologic properties of the growing medium.

In the last few years, investigations have been conducted on the use of organic composts for amending heavy clay soils. These studies, as well as ones conducted at Penn State University have identified key characteristics of composts such as C/N ratio, particle size, pH, metals, and soluble salt content that could determine their benefit. Results indicated that seedling establishment was significantly enhanced on compost amended soils compared to topsoil and no amendment. In addition, infiltration on the heavy clay soils was increased ten fold in some plots. Not only does this serve a valuable purpose in soil preparation, it contributes to the sustainability of the turf system.

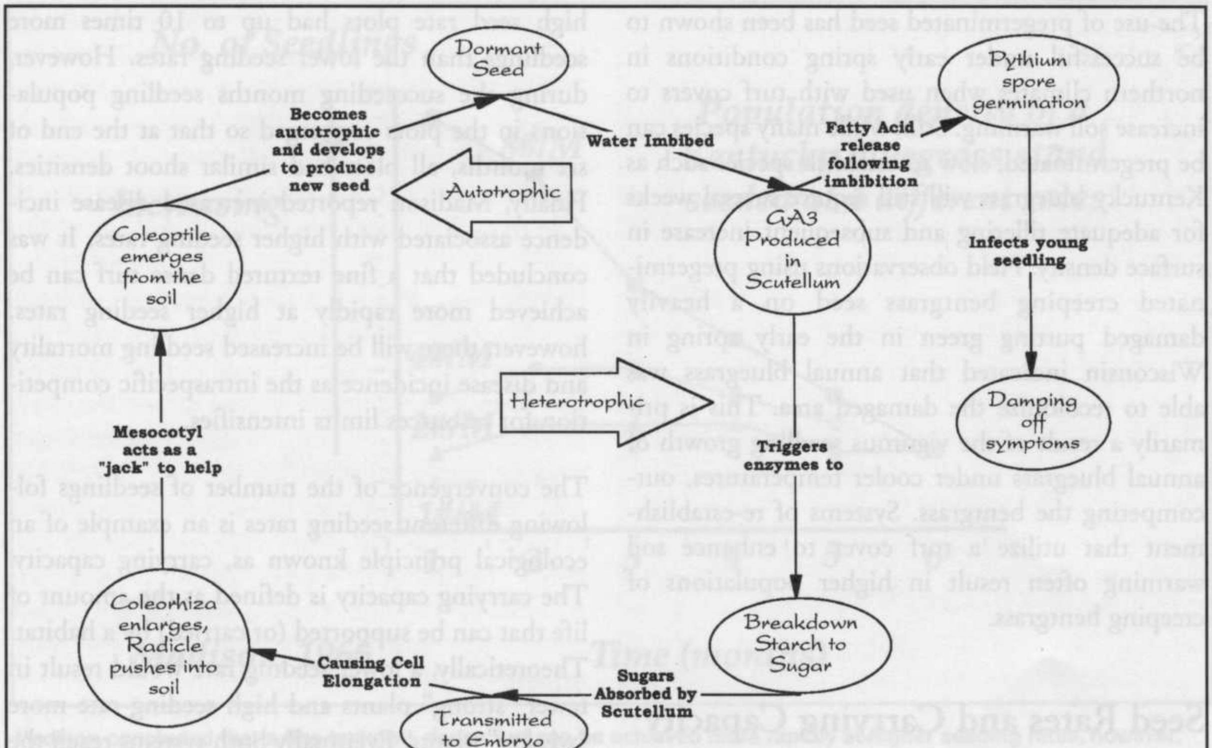
Seed Germination

Understanding the process of seed germination is basic to the development of a successful establishment program. A seed contains the genetic material, inherited from parents within a miniature plant (embryo), and an adjacent food supply (endosperm). The process of germination is triggered by the imbibition of water that sets in motion a chain of events that enables the plant to transition from heterotrophic (requiring complex organic compounds for energy) to autotrophic (produces its own energy) as it emerges from the soil to begin photosynthesis. If a seed is planted too deep in the soil, it may deplete its endosperm (food supply) and die before it can become autotrophic.

Interestingly, the transition from heterotrophic to autotrophic is the stage at which some preemergence herbicides limit competition from weed seedlings. As a weed seedling germinates and the radicle emerges, it encounters the soluble herbicide in the soil. The herbicide will inhibit cell division, but allow for cell enlargement. As the radicle continues to swell in a club shape it depletes the energy in the seed before the radicle can emerge from the soil similar to planting the seed too deep.

Seed Priming

Germination time varies depending on turfgrass species. Cool season grasses such as perennial ryegrass, tall fescue and creeping bentgrass can germinate and establish within a few weeks, while Kentucky bluegrass and some fine leaf fescues may require up to six to eight weeks to establish. To reduce the establishment time in the field, techniques



Water triggers germination, which is a chain of events that enables the plant to convert from an energy-dependent organism to one that produces its own energy.

that enhance emergence under less than ideal conditions have been developed. One of the more popular is seed priming. Seed priming is the process by which the hydration status of the seed is manipulated so that the seed imbibes water at a regulated rate, initiates germination, but does not allow for radicle emergence. Seed priming can be accomplished using an osmoticum such as salt or polyethylene glycol (PEG) or through solid matrix priming (SMP) with compounds that have a high water holding capacity such as soft coal, leonardite, or sphagnum moss. Experiments were conducted at Penn State University to investigate the viability of SMP as a means of enhancing cool season turfgrass (bluegrass, ryegrass and tall fescue) establishment.

Field experiments indicated that success of SMP treatment was dependent on species and cultivars with some cultivars of Kentucky bluegrass such as Glade, Gnome, and Marquis showing substantial benefits. Perennial ryegrass cultivars were not substantially different, while tall fescue cultivars Guardian and TF300 were only slightly enhanced. Still, the researchers concluded that SMP seed could be desirable under cool periods when seedling emergence would be reduced or for quick establishment. In a separate experiment conducted on Kentucky bluegrass, SMP seed did not directly increase seedling growth rate, however, seedlings were larger. Again, this could be desirable for enhanced establishment under suboptimal conditions.

Pregerminated Seed

Golf turf and sports turf managers who manage intensively disrupted sites or experience a catastrophic loss of turf have been using a system that applies germinated seedlings to the turf area. Pregermination is generally accomplished over several days through a meticulous series of hydration regimes with various temperatures. Once the radicle has emerged, the seedling is applied to the turf area. This is a very sensitive time in the life of the seedling where it is most susceptible to desiccation as a result of the leaf surface area and the lack of adequate rooting.

The use of pregerminated seed has been shown to be successful under early spring conditions in northern climates when used with turf covers to increase soil warming. Still, while many species can be pregerminated, slow to establish species such as Kentucky bluegrass will still require several weeks for adequate tillering and subsequent increase in surface density. Field observations using pregerminated creeping bentgrass seed on a heavily damaged putting green in the early spring in Wisconsin indicated that annual bluegrass was able to recolonize the damaged area. This is primarily a result of the vigorous seedling growth of annual bluegrass under cooler temperatures, outcompeting the bentgrass. Systems of re-establishment that utilize a turf cover to enhance soil warming often result in higher populations of creeping bentgrass.

Seed Rates and Carrying Capacity

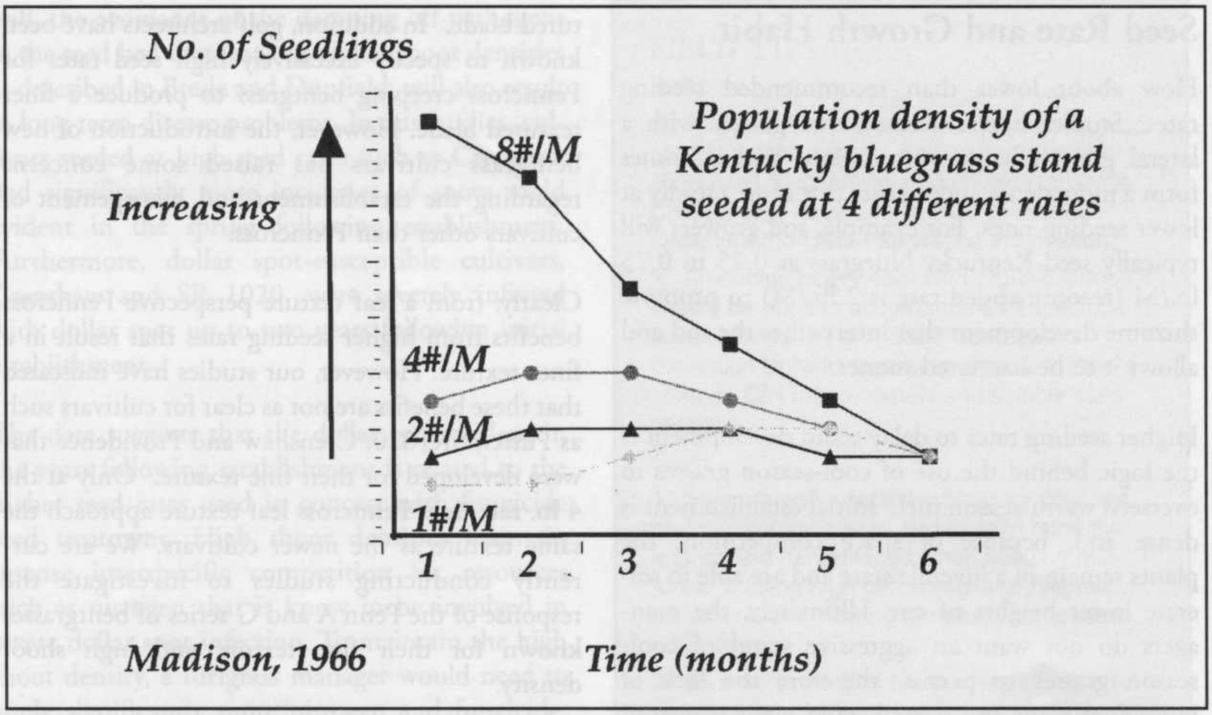
Seed rate is a primarily a function of seed size. However, it also depends on the turfgrass species, pure live seed (purity & germination) in a seed lot, environmental conditions at establishment, seed cost, growth habit (upright vs. prostrate) and establishment rate desired. Most cool-season turfgrasses are seeded at a rate that results in approximately 10 to 25 seeds per square inch, except for the bentgrasses. There are between 6 and 8 million seeds in one pound of creeping bentgrass, while a pound of Kentucky bluegrass has between 1 and 2 million seeds and a pound of perennial ryegrass only 200,000 to 300,000 seeds. Subsequently, bentgrass seed rates were designed to deliver 30 to 60 seeds per square inch, typically achieved by sowing 0.5 to 1.0 lb. per 1000 square feet (M).

Madison conducted a study to determine the optimum seed rate of turfgrasses. This work, like many other studies conducted by Madison, provided the baseline information that to this day is still relied upon. There were several interesting results including the observation that Penncross creeping bentgrass seeded at 0.5 lb. rate had the same visual cover rating at 1 month after establishment as the 5 lb. rate.

Madison monitored Kentucky bluegrass seedling density over a six month period. At establishment, high seed rate plots had up to 10 times more seedlings than the lower seeding rates. However, during the succeeding months seedling populations in the plots converged so that at the end of six months, all plots had similar shoot densities. Finally, Madison reported increased disease incidence associated with higher seeding rates. It was concluded that a fine textured dense turf can be achieved more rapidly at higher seeding rates, however, there will be increased seedling mortality and disease incidence as the intraspecific competition for resources limits intensifies.

The convergence of the number of seedlings following different seeding rates is an example of an ecological principle known as, carrying capacity. The carrying capacity is defined as the amount of life that can be supported (or carried) by a habitat. Theoretically, a lower seeding rate would result in fewer "strong" plants and high seeding rate more "weaker" plants. Eventually both systems reach the carrying capacity of the habitat and further population growth is subject to severe competition resulting in plant death. Ecologically, the loss of an individual plant is more than compensated for by the extended growth of the surviving plants. As stands mature, a balance is achieved between number of individuals and the size (tillering) of the individuals. This balance is explained by the self-thinning principle described in Danneberger.

Studies conducted using high seed rates for creeping bentgrass indicated that seedling survival is increased when the seed is pretreated with a fungicide. In fact, the number of shoots per unit area continues to be significantly greater in these plots one year after establishment. The period of self thinning appears to be extended through the reduction of seed bed diseases. It has been noted that certain organisms can, for periods of time, overshoot the carrying capacity, however, plants are not known to be one of these organisms. Plants have the ability to "sense" each other by picking up radiation reflected by nearby leaves and changing their growth characteristics well before their resources are reduced. Still, the data reveal as the stand matures and intraspecific competition for resources continues, the long term consequences of thinning and plant death can be severe.



Madison concluded that a fine textured, dense turf can be achieved more rapidly at higher seeding rates, however, there will be increased seedling mortality and disease incidence as the stand nears carrying capacity.

Interspecific Competition

Rapid establishment of a dense cover is one of the desirable characteristics of turfgrass. As mentioned earlier, the grasses differ in the time required to germinate and establish a dense cover. The lack of parity among the grasses in this area can have a substantial effect on the resultant stand population, especially when planting a mixture of several species. The interspecific competition for resources will result in a stand population that does not reflect the actual number of individual seeds sown.

It is recommended that perennial ryegrass not exceed 20 percent by weight of a mixture with Kentucky bluegrass because of the rapid seedling growth of ryegrass. The ryegrass becomes established and utilizes resources such as light, water and nutrients before a bluegrass is germinated. This results in a stand made up of mostly perennial ryegrass.

A useful technique that could limit the competitive edge of the ryegrass is immediate close mowing. This has been shown to substantially reduce ryegrass populations in the resultant stand, while utilizing the benefits of a rapid cover.

Turfgrass species competition with annual bluegrass is of critical importance to turfgrass managers. Brede and Dunfield conducted studies on variable seed rates of Kentucky bluegrass a means of limiting annual bluegrass invasion where a seed bank was present.

They found that increasing seed rates of certain aggressive cultivars can reduce annual bluegrass invasion in the seed bed. However, these high seed rates tended to have greater seedling disease incidence. Using treated seed enhanced seedling survival and maintained a high shoot density that was more reliant on pesticides to remain healthy.

The competitive ability of creeping bentgrasses with annual bluegrass would be an important selection standard, however, very little information exists on the new bentgrass cultivars. Harivandi and Hagen conducted a study with new cultivars seeded at the 0.5 lb. rate and collected data in the second year on annual bluegrass populations. The results indicated that there were differences from 10 to 50 percent depending on cultivar. Additional research is currently underway at Rutgers University.

Seed Rate and Growth Habit.

How about lower than recommended seeding rates? Studies have indicated that grasses with a lateral growth habit from stolons and rhizomes form a more dense and mature turf more rapidly at lower seeding rates. For example, sod growers will typically seed Kentucky bluegrass at 0.25 to 0.75 lb./M (recommended rate is 2 lb./M) to promote rhizome development that intertwines the sod and allows it to be harvested sooner.

Higher seeding rates to delay stand development is the logic behind the use of cool-season grasses to overseed warm-season turf. Initial establishment is dense and, because of space competition, the plants remain in a juvenile state and are able to tolerate lower heights of cut. Ultimately, the managers do not want an aggressive stand of cool-season grasses to persist, therefore the lack of individual plant and overall stand vigor is viewed as an advantage. Why else would a sane person seed perennial ryegrass at 30 lb./M (5 times the recommended rate)?

Morphologically, many of the new bentgrass cultivars were developed for more upright growth that would provide a more superior putting surface. In fact, higher seeding rates for the cultivars tested in our trials that were developed for upright growth (Putter, Crenshaw and SR1020) provided a dense turf sooner at slightly above the recommended rates. Penncross ratings from our study were consistent with those reported by Madison (1966): Seeded at the 0.5 lb. rate the cultivar had the same visual cover rating as the 5lb. rate. The moderately upright Providence provides 95% cover at six weeks when seeded between 0.85 and 1.15 lb. rates, while the upright Crenshaw seemed to require about 2 lb. Any recommendations based on these results should be made with consideration for the cultivar regarding disease susceptibility as well as time to full cover.

Seed Rate and Leaf Texture

As seed rate increases the number of individuals per unit area increases and the tend to be more upright, and narrow blade (fine texture). This is a common technique for enhancing the fine texture of tall fescue stands that typically have a coarse textured blade. In addition, golf architects have been known to specify excessively high seed rates for Penncross creeping bentgrass to produce a finer textured blade. However, the introduction of new bentgrass cultivars has raised some concerns regarding the establishment and management of cultivars other than Penncross.

Clearly, from a leaf texture perspective Penncross benefits from higher seeding rates that result in a finer texture. However, our studies have indicated that these benefits are not as clear for cultivars such as Putter, SR1020, Crenshaw and Providence that were developed for their fine texture. Only at the 4 lb. rate does Penncross leaf texture approach the same texture as the newer cultivars. We are currently conducting studies to investigate the response of the Penn A and G series of bentgrasses known for their fine texture and high shoot density.

Pathology

This discussion has primarily addressed plant to soil and plant to plant interactions. A critical aspect of the seed bed that exerts a strong influence on seedling establishment is the interaction between plants and microbes. To many turfgrass managers, this is most evident when the seedling becomes infected, symptoms are visible, and stand population is reduced as part of the self thinning rule. Researchers have determined that the interaction between plants and microbes begins as the seed imbibes water and commences germination.

Ruttledge and Nelson have identified how the process of seed germination actually can stimulate the germination of *Pythium* spp. in the soil known to cause damping off diseases. During germination, fatty acid compounds released from the seed stimulate germination of spores in the soil. These spores eventually lead to infection.The more seed present, the more fatty acid released and the greater the potential for damping off problems. This has been increasingly evident as more turfgrass managers use higher seed rates to accelerate establishment. The result is increased disease problems. We are currently collaborating with Dr. Nelson's lab to investigate the fatty acid release patterns of creeping bentgrass cultivars and their influence on subsequent *Pythium* infection.

Still, the avoidance of the damping off pathogens in the seed bed that leads to higher shoot densities as described in Brede and Dunfield, will also result in long term disease problems. In our studies, cultivars seeded at high seed rates such as Crenshaw had significantly more incidence of snow mold evident in the spring following establishment. Furthermore, dollar spot-susceptible cultivars, Crenshaw and SR 1020, were severely infested with dollar spot up to two years following initial establishment.

The data suggests that the dollar spot evident in the years following establishment is related to the higher seed rates used in concert with fungicide seed treatment. High shoot densities maintain intense interspecific competition for resources such as nitrogen that is know to be involved in severe dollar spot infection. To maintain the high shoot density, a turfgrass manager would need to apply significantly more nitrogen and fungicide, an approach not recognized as sustainable.

Summary

The pressure to reduce energy intensive inputs for turfgrass management and become more resource efficient is most easily addressed at establishment. For example, it is much easier to amend a soil when it is not vegetated than to attempt long term amending using core cultivation.

Ecological and pathological principles at work in the seed bed and throughout seedling growth must be observed to limit the amount of plant loss during establishment. Finally, the logistical aspects of seedling establishment are well documented and many have been researched for their effectiveness. It makes good sense to employ knowledge based decisions founded on sound scientific principles than to rely on magazine advertisements and sales pitches. Simply put, a well adapted species sown on a healthy adequately drained soil will be a more resource efficient stand over time.

Dr. Frank Rossi is assistant professor of Turfgrass Science and Extension Turfgrass Specialist at Cornell University in New York. His research interests include turfgrass ecology and stress physiology.

FIELD TIPS

Soil

1. Proper soil preparation is essential for successful establishment. Soil testing should be conducted for chemical and physical analysis. Contact your local Cooperative Extension office and the USGA for testing information.

2. Amending heavy soils with organic compost should be done in accordance with specifications outlined in Penn State Cooperative Extension Bulletin regarding organic matter content, C/N ration, metals and soluble slats present.

Seed

1. Select a well adapted cultivar for your use and maintenance level and keep in mind the appropriate percentages when seeding mixtures. If using high percentages of ryegrass, consider close mowing to reduce competitive advantage.

2. Be sure to seed at recommended rates to ensure minimum intraspecific competition. If high seed rates are used, be sure to compensate for additional plants by increasing inputs to maintain high density.

3. Primed and pregerminated seed are viable options for seeding under less than ideal conditions but are species and cultivar dependent.

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