TURFGRASS TRENDS

ADDING AMMI TO NTEP

Better Reporting Now for NTEP Data

AMMI Model: A Radical Change in NTEP Process

By J. Scott Ebdon and Kevin Morris

The National Turfgrass Evaluation Program (NTEP) began in 1980. It strives to: Provide a mechanism for uniform turfgrass evaluations; advance the science of evaluations; collect and disseminate turfgrass performance data; and enhance the transfer and use of information and technology related to turfgrass improvement and evaluation.

To that end, significant progress and changes have been made in the reporting, collection, analysis and scientific merit of NTEP data. The NTEP Policy Committee, an amalgamation of university representatives, turfgrass breeders, seed trade associations and industry representatives, is the governing body that guides NTEP activities and operations. In 2007, the NTEP Policy Committee unanimously voted to analyze NTEP performance data using the additive main effect and multiplicative interaction (AMMI) model.

The use of AMMI is the most radical change the NTEP Policy Committee has approved since the adoption of Least Significant Difference (LSD). The LSD was a significant change in the reporting of NTEP data. The scientific community accepts it because it allows NTEP customers to identify top-rated turfgrass with some statistical certainty. NTEP replicates all entries (cultivars) and uses other accepted statistical techniques such as randomization to estimate an experimental error so that LSD values can be computed. Accuracy of the data increases with the number of replications. However, increasing the number of replications (i.e., the number of field plots) to gain accuracy is costly to NTEP and its cooperators in terms of the extra labor and maintenance required.

Despite the scientific merit of using LSD, NTEP customers were slow to accept LSD values. Like the LSD, AMMI has been shown to provide greater scientific merit than standard statistical methods. Specifically, AMMI has been shown to be more accurate in the analysis of NTEP turf performance data (Ebdon and Gauch, 2002a). As such, the reliability of the data used by seed companies and turf professionals in making planting decisions and cultivar selections has improved significantly. AMMI analysis of turf quality (a visual rating of uniformity, density, and color) is more reliable than previous methods used by NTEP in analyzing and reporting turf performance data (Ebdon, 2002).

NTEP has changed how its turf performance data is organized. In past years,

Continued on page 42

IN THIS ISSUE

OUR SPONSORS

TABLE 1: AMMI TURF QUALITY ANALYSIS

NTEP LOCATION	MANAGEMENT SCHEDULE *	AMMI GROUP
Kentucky	A	1
Louisiana	A	1
Mississippi	A	1
North Carolina	A	1
Oklahoma	A	1
Tennessee	A	1
Texas 2	B	1
Virginia	B	1
Florida 1	A	2
Texas 1	B	2
Arizona	A	3
California	A	3
Florida 2	B	3

** Schedule A: 0.5- to 1-inch height of cut, 0.5- to 1-lb. N per growing month, irrigation to prevent stress.*

Schedule B: 1.5- to 2.5-inch height of cut, 0.5- to 0.75-lb. N per growing month, irrigation to prevent dormancy.

2008 bermudagrass test data grouped according to management schedule and AMMI analysis. Thirty-one bermudagrass cultivars were evaluated for turf quality across 13 NTEP test locations in 2008.

Continued from page 41

NTEP organized turf quality data according to the cooperators test location and region of the country or by the cooperators turf maintenance schedule (low or high maintenance). Turf quality data submitted by NTEP cooperators is now being organized according to AMMI suggested groupings.

There are several advantages of using AMMI to group NTEP test locations in the reporting of turf quality. Unlike previous NTEP reporting of data by region or maintenance schedule, NTEP test locations reported according to the AMMI grouping share the same planting recommendation. That is to say top performing cultivars are the same for all NTEP locations within the same AMMI grouping. As such, AMMI grouping of NTEP locations simplifies the planting recommendations for both the turf practitioner and turf seed company. As described below, grouping locations according to AMMI allows seed companies to market their turf seed varieties into specific locations where their varieties are best adapted. The AMMI grouping of specific locations does not necessarily follow any maintenance schedule or climatic region.

Table 1 summarizes the results of AMMI analysis of turf quality data for 31 cultivars of bermudagrass collected by 13 cooperators in 2008.

AMMI identified three distinct groupings of NTEP locations. Eight locations were grouped into AMMI Group 1; two and three locations were grouped into AMMI Group 2 and AMMI Group 3, respectively. These AMMI groupings do not follow any regional grouping or maintenance schedule (low, NTEP Schedule B versus high, NTEP Schedule A). Some locations with the same maintenance schedule are from the same state (Texas) but fall into different AMMI groups. Also, some locations from the same AMMI grouping (AMMI Group 1) represent different maintenance schedules and different regions of the country ranging from the Mid-Atlantic transition zone (Virginia) to the desert Southwest (Texas).

The turf quality as reported by different cooperators analyzed using AMMI is highly correlated from location to location within the same AMMI grouping. For example, for AMMI Group 1, the correlation ranged from 0.71 to 1.00 (1.00 equates to a perfect fit or prediction for all cultivars from location to location), indicating top performers from the roster of 31 bermudagrass cultivars are the same for all eight locations. Similarly, for AMMI Group 2 and AMMI Group 3, the correlation was 0.86 between the two locations in AMMI Group 2 and ranged from 0.66 to 0.99 for the three locations in AMMI Group 3. Accordingly, these locations within the same AMMI group can use the same planting recommendation.

Years ago, the NTEP Policy Committee abolished the use of "Grand Means" in the reporting of cultivar data. Grand means, which are averages across all NTEP locations,

have been shown not to be very reliable for developing an accurate planting recommendation to a specific location (Brede, 2001). Grouping of locations according to climatic region or maintenance schedule causes inconsistent results or different "top-rated entries" from location to location because of significant interaction between the cultivar and its growing environment. Cultivar selections based on the grand mean are inaccurate under such arbitrary groupings of location.

AMMI groupings (also known as mega-environments) are based on AMMI analysis and the partitioning of NTEP locations into uniform cultivar-environment interaction patterns (Ebdon and Gauch, 2002b). As such, AMMI group grand means (the cultivar mean averaged across all locations within the same AMMI grouping) and the cultivar mean at individual locations within the same AMMI grouping are highly correlated. For example, in AMMI Group 1, the correlation between the AMMI Group 1 grand mean and individual locations (eight locations in all) ranged from 0.92 to 1.00. Similarly, for AMMI Group 2 and AMMI Group 3, the correlation between the AMMI group grand means and all other locations within the same AMMI grouping ranged from 0.94 to 0.99. However, the AMMI group grand means from different AMMI groupings are uncorrelated. For example, the correlation between AMMI Group 1 and AMMI Group 3 grand means was 0.35, indicating poor predictive value when comparing top rated cultivars from locations from different AMMI groupings.

These AMMI groupings allow for all 31 cultivars in all locations within the same AMMI grouping to be ordered (from top performers to bottom performers) according to the AMMI group grand mean. AMMI groupings allow turf seed companies to simplify the marketing of their seed by targeting top-rated (adapted) cultivars to specific mega-environments (several locations) while redistributing their efforts to target other markets (mega-environments) using other highly rated cultivars. Top performers from one AMMI grouping are not necessarily top performers in another AMMI grouping or mega-environment.

The most significant advantage of AMMI analysis is the gain in accuracy over standard methods for computing means. Ordinary means rely on averaging over replicates (NTEP uses three replicates). AMMI analysis computes an adjusted mean (Ebdon and Gauch, 2002a) that is different from ordinary means averaged over replicates. The AMMI adjusted means are more accurate. Recent research has shown that data statistically analyzed by AMMI is 5 times more accurate than previous methods (Ebdon and Gauch, 2011). In the example in Table 1, AMMI adjusted means were 1.5 times more accurate than ordinary means. This increased accuracy amounts to the same level of accuracy as increasing the number of NTEP replications from 3 to 4.5 (without actually increasing the number of field plots at each location), at a savings of over $18,000 to NTEP (a single replication costs approximately $10 per year). Over a 5-year evaluation cycle and numerous test locations the savings to NTEP are significant, especially for larger tests such as Kentucky bluegrass, perennial ryegrass and tall fescue.

Significant changes have been made using AMMI analysis to improve the scientific merit and simplify the reporting of NTEP data to its customers. In the future, NTEP will continue to improve various aspects of the NTEP mission and thereby provide the most reliable and accurate data possible.

This increased accuracy amounts to the same level of accuracy as increasing the number of NTEP replications from 3 to 4.5.

J. Scott Ebdon is associate professor of turfgrass science and management at the University of Massachusetts Amherst. Kevin Morris is the Executive Director of the National Turfgrass Evaluation Program (NTEP) and the National Turfgrass Federation.

REFERENCES

Brede, D. 2001. How predictable is your NTEP site? *Turfgrass Trends.* 10(9): 1-5.

Ebdon, J. S. 2002. Scientists look for ways to improve turf evaluations. *Turfgrass Trends.* 11(8): 7-14.

Ebdon, J. S., and H. G. Gauch. 2002a. Additive main effect and multiplicative interaction analysis of national turfgrass performance trials: I. Interpretation of genotype x environment interaction. Crop Sci. 42: 489-496.

Ebdon, J. S., and H. G. Gauch. 2002b. Additive main effect and multiplicative interaction analysis of national turfgrass performance trials. II. Cultivar recommendations. Crop Sci. 42: 489-496.

Ebdon, J. S., and H. G. Gauch. 2011. Direct validation of AMMI predictions in turfgrass trials. Crop Sci. In Press.

Legume Inclusion

Rethink Weed Definitions for Greener Turf

By James McCurdy, Scott McElroy and Beth Guertal

Organic, whole, local, eco-friendly, pesticide-free and sustainable. Superintendents can't escape this growing list of adjectives surrounding the green movement. But with a few tweaks, fairways and roughs can become cheaper to maintain and, yes, "greener."

It is impossible to summarize the environmental effects of turfgrass as simply good or bad. Benefits of turfgrass are well documented and include erosion control, increased water infiltration, reduced nutrient leaching, aesthetics and carbon sequestration. Yet the negative impact of turf is rightfully questioned, due in part to the large nutrient and water requirements.

Management of turf is the act of maintaining its value. As turf managers, we have at least a small impact and sometimes a major impact on the environments we are maintaining. Industry outsiders often lead the common public to believe that where there is turf there is environmental decay. However, there is a wide range of turfgrass scenarios, from highway rights-of-way to high-end private golf clubs. When we properly manage individual scenarios, we can make turf more sustainable and we can bolster our industry's public image.

Legume inclusion within turfgrass is a proposed means of increasing the sustainability of certain turf scenarios. Legumes host soil-born bacteria within their roots, most commonly *Rhizobia* spp., which are capable of biologically fixing atmospheric

Hop clover and ball clover.

nitrogen (N_2 and N_2O). Subsequently, fixed nitrogen is shared with the host legume and is incorporated into the plant as important compounds, such as protein. In fact some of our most noxious leguminous weeds, like clover (*Trifolium* spp.) and lespedeza (*Kummerowia* spp.), have long been cultivated as food for grazing animals due to their palatability and protein content. Legumes also transfer nitrogen to associated grasses and improve soil fertility. This occurs indirectly through excreted nitrogen and decomposition of nodules, foliage and roots.

Turf nitrogen requirements vary with species and environmental conditions. Common nitrogen rates range from 0.1 pounds per 1,000 square feet annually for bahia- and centipede- grass to greater than 6 pounds per 1,000 square feet annually for hybrid bermudagrass. That gets expensive. Just as concerning is the environmental cost associated with nitrogen application. With most fast-release fertilizers like urea, a large portion of the applied nitrogen will either volatilize into the atmosphere where it becomes a potent greenhouse gas, or it will be carried away into surface waters.

Including and managing for legume biodiversity within turf offers an alternative means of maintaining adequate soil nitrogen levels for healthy turf, without application of supplemental fertility. It's an approach that works well in low-fertility areas such as roughs and the driving range. In addition, legumes are often more tolerant of temporary drought than turfgrass. Of the legumes capable of turf inclusion, white clover (*Trifolium repens*) is the best reviewed. Estimates of nitrogen fixation for grass-clover systems range from 2 to 5 pounds per 1,000 square feet per year.

Strategies that lead to legume establishment within turf include:

1) Managing an existing stand until it is more vigorous and healthy
2) Seeded establishment

Choosing legumes to sow into turf should be scenario dependent. Surveying your local weed population is the most effective way to identify which legumes to include in your turf. By matching the local flora, it may improve the persistence of your seeded legume stand. Mowing height and legume growth habit are also especially important considerations. Fairways necessitate legumes that are tolerant of low mowing heights like white clover, strawberry clover (*Trifolium fragiferum*) and Japanese lespedeza (*Kummerowia striata*).

Species selection

When selecting a legume, focus on tried and true selections. Do not expect common forage type legumes to produce an aesthetically pleasing turf. For example, white clovers are commonly classified in one of three morphological groups: small, intermediate and large. Large types, which were bred for forage production, would rarely be acceptable in any turf scenario other than tall roughs. Intermediate varieties may be acceptable for roughs, while small varieties lend themselves to fairways. Within the last decade, smaller clover varieties have been developed for the sole purpose of turf inclusion. These clovers are collectively called micro-clovers and are included in several cool-season turf blends available in the United Kingdom and Europe.

Seeding time and rate is important for proper establishment of any clover species. Most published research revolves around the inclusion of white clover in maintained turfgrass. White clover plots in Auburn, Ala., have been successfully established when seeded in late summer to early fall (August through October) and late winter (March). Although fall seeding works well, hard winters and spring frosts decrease seedling survival. Seeding rates vary with species, climate and geography. But common rates range from one-quarter to one-half pound per 1,000 square feet. As with any overseeding, good seed to soil contact is important. Most winters in the Southeast are mild enough and provide adequate soil moisture for establishment of white clover. However, fall seeding may require light supplemental irrigation to ensure seed germination and survival.

Whenever you choose to establish clover, don't be surprised if clover emergence is spotty at first. For this reason, split seeding applications (in fall and spring) may provide the best

Continued on page 46

PHOTO COURTESY: JAMES MCCURDY

White clover and bermudagrass.

Continued from page 45

clover establishment. In addition, monitoring soil nutrient levels is important for all turf management scenarios, even those with legumes included. Adequate soil P and K aid in successful establishment, but ideal soil pH varies with species. So soil tests are recommended.

Seed inoculation prior to planting is common, although it may not be necessary. Natural soil populations are typically able to sustain productive stands, and inoculation has no reported effect upon seed germination. It is important to pick the proper species and strain of bacteria for the legume being seeded. For example, the *Rhizobium* spp. used to inoculate soybeans cannot be used to inoculate clover. Even different clover species are inoculated by different strains, so check several sources and with your seed provider.

Once established, the next challenge is to manage in favor of the desired legumes. Most superintendents associate legumes with clumpy, non-uniform patches. It's true. Legume populations are highly self-regulating. They come and go as soil nitrogen levels fluctuate. However, they become more evenly distributed when mowing and fertilization are reduced. Several steps can help ensure legume health and persistence, such as:

- **Decreasing supplemental nitrogen.** When paired with well-fertilized grass, clover density quickly decreases due to its inability to compete for light. White clover leaves have a higher photosynthetic capacity at low nitrogen levels than do competing perennial ryegrass. Another reason to reduce nitrogen application is its negative effect on biological nitrogen fixation. Fixation is highly dependent on the level of nodulation occurring in root tissues and activity of the bacteria within. High concentrations of soil nitrogen inhibit nodule growth and development.
- **Reducing mowing frequency.** Legumes are much less tolerant of frequent mowing than grasses are. The growing point of grass is well hidden below canopy level. However, most legumes must regenerate foliage lost to mowing by sending up new leaves from the base of the plant, which is energetically unfavorable.
- **Adjusting mowing height and timing.** White clover is especially tolerant of low mowing heights. However, that is not the case for the majority of clover species. Most annuals are less tolerant of close mowing heights, especially during heavy flowering periods. However, if plants can fully mature, seed dispersal may occur naturally or with mowing. Using mowing as a tool to disperse next year's crop is especially important with annuals, while perennials like white clover reestablish mostly through stoloniferous growth.

Deciding to include legumes in your turf is a step toward sustainability. Turf-legume scenarios challenge contemporary turfgrass weed management. However, given the benefits, legume inclusion is a coming-of-age method of going green.

James McCurdy, M.S., is a graduate research assistant at Auburn University in Alabama. Scott McElroy, Ph.D. and Beth Guertal, Ph.D., are associate professors of agronomy and soils at Auburn.

PHOTO COURTESY: JAMES MCCURDY

Ad Index

Clark Talks Turf

TIMELY TURF ADVICE

Goosegrass Management on Putting Greens in the South

Scott McElroy, Ph.D. is an associate professor of turfgrass science at Auburn University, specializing in weed management in turfgrass. He conducts many weed management and control experiments annually. Here he shares with *Golfdom* his experiences controlling goosegrass on putting greens.

My discussion with McElroy focused on goosegrass control in bermudagrass and creeping bentgrass in the transition zone and the warm season grass zone.

Q What is the first step to managing goosegrass on greens? The most important thing to controlling goosegrass on any putting green is to get rid of goosegrass everywhere around the green. Control goosegrass in the fairways, approaches, surrounds and collars. Eliminate the seed source. Until you eliminate the goosegrass seed source, you are wasting your time trying to control goosegrass on the greens.

Q How about cultural practices for goosegrass control? I notice most goosegrass on greens in the clean-up pass. Mow the clean-up pass only two or three times a week. Substitute rolling for mowing to reduce traffic stress when possible on the outer edges of the green.

Implement a vigorous thatch control program. Goosegrass will often grow in thatchy areas because the thatch provides protection for the crown from low mowing heights. Improve drainage. Particularly on bermudagrass greens, I observe goosegrass growing in low, wet areas. I've actually seen goosegrass growing in a patch of moss on greens. Hand removal of goosegrass using a knife or tool is still effective. Since goosegrass grows in a rosette, it is pretty easy to pop the rosette out of the ground.

Q Do you recommend preemergence herbicides for goosegrass control on creeping bentgrass greens? It's a trade-off. A preemergence herbicide containing bensulide will help control goosegrass. No doubt about it. The trade-off is that bensulide could damage the root system of the creeping bentgrass. During hot summers in the South, roots are critical for creeping bentgrass survival. There is no single right answer for everyone. Golfer expectations, the goosegrass population, creeping bentgrass health, your experiences with bensulide and your best guess on summer weather should all factor into your decision whether to apply bensulider.

Q Are there any postemergence herbicide options for goosegrass control on creeping bentgrass greens? None that I am aware of that are labeled for goosegrass control on creeping bentgrass greens. In some of my research I have observed that Acclaim Extra (fenoxaprop-p-ethyl) applied at very low rates every three weeks will control goosegrass without harming the creeping bentgrass. Unfortunately, Acclaim Extra is not labeled for that use.

Q Let's switch gears to preemergence goosegrass control on bermudagrass greens. What are the options? Ronstar (oxadiazon), Barricade (prodiamine) and Pendulum (pendimethalin) plus Tower (dimethenamid-P) are all effective for goosegrass control on bermudagrass putting greens. The problem is reading the label and trying to understand if the label supports their use on bermudagrass putting greens. Some of these herbicides directly prohibit their use, while others are vague. In many cases, the labels are open to interpretation. Read the labels carefully and consult with the manufacturer before applying a preemergence herbicide to a bermudagrass green.

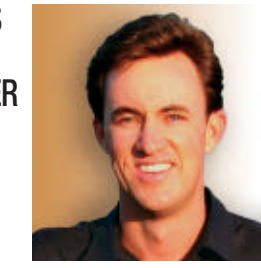
Q How about postemergence herbicide control options for bermudagrass greens? Revolver (foramsulfuron) is safe on bermudagrass putting greens. The challenge is getting consistent goosegrass control. Due to low mowing heights used on a green, there isn't much turfgrass canopy to intercept the herbicide. To improve goosegrass control with Revolver, apply the herbicide in 20 to 40 gallons per acre using a nozzle that produces a medium-sized or smaller droplet.

Q What is the outlook for the live oak trees at Toomer's Corner vandalized using an herbicide? Neither tree looks good right now. The long-term prognosis isn't good.

Clark Throssell, Ph.D., loves to talk turf. He can be reached at clarkthrossell@bresnan.net.

Changing Lifestyles Hurting Country Clubs

THE AMERICAN MIDDLE CLASS IS DYING, AND AS MANY COUNTRY CLUBS WILL TELL YOU, THE UPPER MIDDLE CLASS IS FAST BECOMING A RELIC TOO.



BY GEOFF SHACKELFORD

It's no state secret that golf is facing many dilemmas. Some of the problems are self-inflicted, and Lord knows you don't come to *Golfdom* to have me remind you of the obvious and depressing fact that our industry, like so many others, is struggling.

Yet what's always troubled me about the doom and gloom talk of golf's troubles is, you can drive by any public course on a nice day and see people waiting in line to tee off, both on the course and at the range. And despite our high unemployment rate and dire economy, you can stop into any golf superstore and find people of all shapes and sizes browsing the latest gear. Furthermore, considering the economic calamity brought on by Wall Street's crap-shooting ways, rounds of golf played should have actually plummeted more than they have. Shoot, even the PGA Tour's ratings are up this year, thanks to record-low TV ratings last year and a new crop of talented up-and-comers that engages fans.

Golf is not going anywhere. Yet I'm afraid there's a deeper, darker undercurrent that has not been addressed in the debate about our sport's future. It's what no one wants to say for fear of questioning the wisdom of our form of capitalism and because it's an issue we can't control: the American middle class is dying, and as many country clubs will tell you, the upper middle class is fast becoming a relic too.

It's important that the golf industry keeps this in mind when it analyzes how to reinvigorate both the game and memberships. Plus, it's been too long since I've seen an inbox full of hate mail for brushing up against what some consider a delicate and debatable social issue that dares to question whether "market forces" are the answer to every dilemma known to man.

The anecdotal evidence of the income divide grows stronger by the day, as the country club world continues to adapt to modern demands such as lower prices, lax dress codes, Pilates classes and more. And yet, we keep watching country clubs fold, convert to semi-private courses or offer virtual giveaways just to keep their doors open. Even many of the nation's elite clubs, with their top 100 courses and much-ballyhooed facilities, are finding that the next generation simply can't write the check no matter how much they'd love to join an exclusive club at the current bargain bin prices.

Country clubs' struggles are typically blamed on today's way of life, a way of life in which dad no longer whiles away the hours at the club. And there is the widespread belief that the recreational desires of young families differ now in an age where women, who have long been afterthoughts at many country clubs, are now the decision makers in a household and are finally getting to exact revenge for years of discriminatory practices. I used to subscribe to all of the reasons country clubs were dying, and I still do.

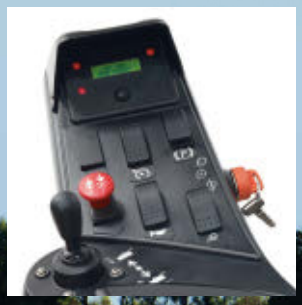
Yet we know that country-clubs-for-a-day never really caught on even as they catered to the modern mindset. Yes, many were overbuilt or constructed in remote locations that were difficult for people to get to. But ultimately, no matter how clubs try to reinvigorate play and increase their memberships, the "member inventory" shortage we are seeing is the result of too many people being unable to justify spending money on non-essentials such as recreation. Breaking down the current golf model to create a new one will not work until we see our middle classes have what used to be a no-brainer: the extra money to enjoy whapping a little white ball around every now and then.

You can reach Shack, Golfdom's contributing editor, at geoffshack@me.com. Check out his blog – now a part of the Golf Digest family – at www.geoffshackelford.com.

YOUR COURSE. YOUR CONTROL. YOUR RESULTS.

The new Jacobsen® LF-550™/570™ Fairway mower assures you tournament-quality results regardless of operator.

Achieve greater control and better results across your fairways. The new Jacobsen® LF-550™/570™ features programmable controls, added functionality and simplified maintenance. Combined with Jacobsen Classic XP™ Reels, on-board diagnostics and versatility-enhancing accessories, you're assured our legendary quality of cut regardless of who's driving. Learn more, and request a demo by contacting your local Jacobsen dealer.



The exclusive electric hydro control with programmable speed controls is pass code protected, giving superintendents control over mow and transport speeds to assure optimal FOC.

90 YEARS OF PERFORMANCE
90
JACOBSEN
A Textron Company
1921-2011

www.Jacobsen.com

GCSAA GOLD PARTNER

PGA

PROUD MEMBER SportsTurf MANAGERS ASSOCIATION

GCBAA

JACOBSEN
A Textron Company

The Official Turf Equipment Supplier to The PGA of America and The Exclusive Turf Equipment Supplier to PGA Golf Properties.