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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,

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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.

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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.

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