the last two months of the study was associated with the perennial ryegrass blend, 'Marvelgreen,' 'Marvelgreen'-'Laser' mixture, 'Colt' rough bluegrass, 'Jamestown' chewings fescue, and the 'Jamestown'-'Laser' mixture. 'Penncross' creeping bentgrass never established to the point where it provided acceptable ground cover in this study.

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DRIS EVALUATION OF THE NUTRIENT STATUS OF BAHIA AND ST. AUGUSTINE TURFGRASSES

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Abstract. **The DRIS (Diagnosis and Recommendation Integrated System) approach to interpreting the mineral analysis of turf clippings from home lawns was investigated. Turf clippings were collected from 100 bahiagrass (*Paspalum notatum* (L.) Flugge) and 182 St. Augustine (*Stenotaphrum secundatum* (Walt.) Kuntze) home lawns. Visual ratings of turf color and density were made at the time of sample collection. Tissue samples were analyzed for N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu. Conventionally calculated DRIS nutrient ratio norms were reasonably similar in value for the two grasses. Some norms appeared particularly important for turf quality, and many of these involved micronutrients. A computer program based on IBM-PC BASIC was developed to use the DRIS nutrient ratio means and SD's to calculate DRIS indices for identifying nutrient imbalances and to identify the most limiting nutrients. It appears that DRIS can be a useful tool for evaluating the nutrient status of the turfgrasses studied, and the accumulation of a larger data base for these grasses is warranted to further refine the DRIS analysis. The DRIS program herein has been written in such a way as to facilitate modification when additional data are available.**

The DRIS (Diagnosis and Recommmendation Integrated System) method of interpreting nutrient content of plant tissue was first detailed by Beaufils (1). DRIS is concerned with the balance of various nutrients within the plant (7), as opposed to the more common assessment of the concentration of individual nutrients. To develop a DRIS analysis, it is necessary to determine optimum ratios for all nutrient combinations. For a given species, there appear to be specific nutrient ratios for maximum crop performance that transcend local conditions such as soil and climate. Cultivar effects appear to be minimal. The system provides a means for comparing the degree to which various nutrients limit yield, either as a result of deficiencies or excesses.

Bahiagrass (*Paspalum notatum* (L.) Flugge) and St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Kuntze) are the two species of turfgrass most often grown in Florida. St. Augustinegrass is used for home lawns, and in commercial landscapes in which an attractive appearance is desired. Bahiagrass also is used in home lawns and commercial landscapes, but generally is considered less attractive than St. Augustinegrass. However bahiagrass has a lower maintenance requirement (irrigation, fertilization, mowing), and also is widely used along highways. Fertilizer recommendations have been developed for both of these grasses (5), but little information is available for using tissue analyses to aid in the diagnosis of nutritional problems of these grasses.

Turfgrasses in Florida generally are grown in very coarse textured soils that may have been drastically altered during the construction of adjacent structures. For this reason, it often is difficult to interpret soil analyses. Additonally, soil tests generally provide little information useful for detecting micronutrient problems. Plant tissue analyses may provide a better means of detecting nutrient deficiencies and/or excesses. The present study was designed to determine the potential for using DRIS to evaluate the nutrient status of turfgrasses.

Methods and Materials

In Sept. 1984, ChemLawn (Columbus, OH) personnel used grass shears to collect leaf blades from 100 bahiagrass and 182 St. Augustinegrass home lawns in four widely separated locations in Florida: Jacksonville, Tampa Bay, Sarasota, and Ft. Lauderdale/Miami. At the time of sampling, visual ratings of turf color were made using a 1 to 4 scale (4 = "best possible"), and density was rated on a 1 to 3 scale (3 = "best possible"). A "quality" score was calculated as the multiple of the color and density ratings. Samples with a quality score exceeding 5 arbitrarily were designated as "Superior", and the others were designated as "Inferior". The tissue samples were dried at 70 C and ground in a stainless-steel Wiley mill prior to H_2SO_4:H_2O_2 digestion (4). Nitrogen and P were determined in the digestates using a Technicon Autoanalyzer. Metal ions were determined by atomic absorption spectrophotometry.

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DRIS methodology, as described by Elwali and Gascho (2), was used to determine nutrient ratio norms. For both the "Superior" and "Inferior" groups, nutrient ratios were created such that each nutrient occurred as a numerator and again as a denominator in conjunction with each of the other nutrients for which the plant tissue was analyzed. The mean, standard deviation (SD), and variance of each nutrient ratio was calculated for each group using the Proc Means procedure of SAS (6). The ratio created by dividing the variance of the "Inferior" group by the variance of the "Superior" group was calculated for each nutrient ratio. For each pair of nutrients, the form of the nutrient ratio (for example N/K vs. K/N) which provided the greater variance ratio was selected as the DRIS reference parameter for that pair of nutrients. The mean and SD for each of these reference parameters were selected from the "Superior" performing group. These parameters were used to compute DRIS indices by means of a computer program for the IBM-PC. Any two nutrients were considered to be in optimum balance if the ratio of their concentrations in a sample was within the range given by the general mean value plus or minus one standard deviation of that ratio in the reference population.

Results and Discussion

For most nutrients, there was little difference in mean nutrient content between the Superior and Inferior performance groups of either grass species, and there was little difference in nutrient content between species (Table 1). The mean values of Fe, and especially Mn, were greater in the Inferior performing group in bahiagrass. Nitrogen, and to a lesser extent, Mn, was somewhat lower in the Inferior performing group in St. Augustinegrass. However, in light of the standard deviations (SD) associated with these means, it would be difficult to attribute performance variations to differences in mean values of various nutrients. For bahiagrass, the SD associated with N, Fe, and Mn were substantially greater for the Inferior performance group, relative to the Superior group. However, this pattern was not evident for St. Augustinegrass. In summary, a simple analysis of the nutrient content of the grasses revealed little that could be used to identify superior and inferior performing turfgrass.

Table 1. Bahiagrass and St. Augustinegrass nutrient value means and standard deviations of the means (SD) for the "Superior" and "Inferior" performance groups.

	Bahiagrass				St. Augustinegrass			
	Superior		Inferior		Superior		Inferior	
Nutrient	Mean	SD	Mean	SD	Mean	SD	Mean	SD
N[z]	1.87	0.37	1.92	0.60	1.92	0.59	1.72	0.62
P	0.32	0.12	0.34	0.12	0.42	0.14	0.40	0.15
K	1.25	0.39	1.20	0.44	1.52	0.57	1.35	0.47
Ca	0.44	0.10	0.46	0.18	0.34	0.14	0.40	0.20
Mg	0.24	0.08	0.26	0.07	0.21	0.06	0.21	0.06
Fe	127	75	142	151	217	200	226	212
Mn	20	15	43	33	26	31	20	15
Zn	50	21	46	19	72	51	67	43
Cu	7	2	7	3	9	3	7	3

[z]N, P, K, Ca, and Mg are expressed as %. Fe, Mn, Zn, and Cu are expressed as mg kg^{-1}.

Table 2. Bahiagrass turf DRIS parameters, variance ratios, means, and standard deviations (SD).

Parameter	Variance ratio	Mean	SD	Parameter	Variance ratio	Mean	SD
N/K[z]	1.91	1.61	0.45	0.01 Fe/K	291	1.02	0.53
100 N/Zn	1.21	4.45	2.40	0.01 Fe/Ca	0.91	2.85	1.44
10 N/Cu	6.38	3.06	1.01	0.01 Fe/Mg	4.46	6.05	4.77
10 P/N	0.87	1.71	0.48	Fe/Zn	3.43	2.80	1.60
10 P/K	2.04	2.69	0.90	0.1 Mn/N	3.59	1.13	1.06
100 P/Cu	3.41	5.13	2.04	0.1 Mn/P	4.64	6.58	5.06
10 Ca/N	4.55	2.50	0.94	0.1 Mn/K	77.53	1.70	1.26
Ca/P	2.43	1.58	0.75	0.1 Mn/Ca	7.09	4.41	2.71
10 Ca/K	59.17	3.88	1.54	0.1 Mn/Mg	4.02	8.79	7.90
Ca/Mg	2.58	2.03	0.80	Mn/Cu	4.99	3.53	3.70
100 Ca/Cu	0.97	7.75	3.92	10 Mn/Zn	3.39	4.32	3.06
100 Ca/Zn	2.50	1.07	0.60	10 Mn/Fe	9.14	1.71	0.96
10 Mg/N	1.17	1.35	0.59	0.01 Zn/P	0.69	1.67	0.70
10 Mg/P	0.99	8.55	5.07	0.1 Zn/K	6.48	4.40	2.28
10 Mg/K	1.22	2.24	1.29	0.01 Zn/Mg	0.72	2.30	1.11
100 Mg/Cu	1.73	4.14	2.27	Cu/K	11.66	5.80	2.51
0.1 Fe/N	9.06	6.97	4.91	10 Cu/Zn	1.67	1.58	0.94
0.01 Fe/P	9.39	4.20	2.46	100 Cu/Fe	1.76	6.52	3.19

[z]N, P, K, Ca, and Mg are expressed as %. Fe, Mn, Zn, and Cu are expressed as mg kg^{-1}.

Based on the magnitude of the variance ratios, certain combinations of nutrients appeared to be particularly important for turfgrass growth. For example, the ratio 10 Ca/K has a variance ratio of 59.17, indicating that superior performing bahiagrass probably will have a 10 Ca/K ratio near 3.88 (Table 2). (The ratio Ca/K was calculated as 0.388. By convention, the ratio is reported as 10 Ca/K = 3.88.) When the variance ratio is near unity, such as for 100 Ca/Cu, it appears that a 100 Ca/Cu ratio of 7.75 may be found in either superior or inferior performing bahiagrass. For each bahiagrass nutrient, at least 25% of the nutrient ratios involving that nutrient had variance ratios $\geq$ 3.0, and all nutrient ratios involving Mn had variance ratios $\geq$ 3.0 (Table 3). High variance ratios were not as commonly observed for the St. Augustinegrass data (Table 4), and neither Mg, Mn, or Cu was involved in a nutrient ratio with a variance ratio $\geq$ 3.0.

The best test of the computer program developed for calculating DRIS indices is to try it on an independent data set based on field fertility trials in which known deficiencies were induced or identified. Given the extent and importance of bahiagrass and St. Augustinegrass turf in Florida, surprisingly little published data are available for testing the DRIS analysis. For bahiagrass, the only turfgrass data that could be found came from a greenhouse study of Pen-

Table 3. Frequency that a bahiagrass nutrient was involved in a nutrient ratio that had a variance ratio $\geq$ 3.

Nutrient	Frequency
	%
N	50
P	38
K	63
Ca	38
Mg	25
Fe	75
Mn	100
Zn	38
Cu	38

Table 4. St. Augustinegras turf DRIS parameters, variance ratios, means, and standard deviations (SD).

Parameter	Variance ratio	Mean	SD	Parameter	Variance ratio	Mean	SD
N/K[z]	1.06	1.35	0.42	0.01 Fe/N	1.97	1.28	1.63
10 N/Mn	1.19	1.17	0.80	0.01 Fe/P	3.78	5.88	5.65
10 P/N	1.00	2.30	1.01	0.01 Fe/K	1.18	1.63	1.67
10 P/K	1.38	3.01	1.41	0.01 Fe/Ca	1.10	7.19	7.00
100 P/Mn	1.25	2.64	1.91	0.001 Fe/Mg	0.48	1.12	1.36
100 P/Cu	1.29	5.48	2.66	Fe/Zn	1.70	3.49	3.05
K/Mg	1.03	7.72	3.42	Mn/Cu	0.75	3.50	3.36
100 K/Mn	1.62	9.21	6.22	10 Mn/Fe	1.18	1.48	1.21
10 Ca/N	3.41	2.00	1.21	0.1 Zn/N	1.94	4.07	2.68
10 Ca/P	1.61	9.66	6.30	0.01 Zn/P	0.44	2.03	1.85
10 Ca/K	1.85	2.63	1.99	0.1 Zn/K	3.08	5.19	3.43
Ca/Mg	2.77	1.75	0.85	0.01 Zn/Ca	0.26	2.39	2.03
100 Ca/Mn	1.75	2.34	2.00	0.01 Zn/Mg	0.65	3.72	3.01
100 Ca/Cu	2.30	4.82	3.17	Zn/Mn	1.18	4.59	4.26
10 Mg/N	2.91	1.18	0.47	Cu/N	1.02	4.77	2.08
10 Mg/P	1.65	5.71	2.65	Cu/K	0.68	6.57	3.96
100 Mg/Mn	1.00	1.27	0.78	10 Cu/Zn	1.05	1.42	0.66
100 Mg/Cu	1.00	2.86	1.45	100 Cu/Fe	1.10	5.59	3.22

[z]N, P, K, Ca, and Mg are expressed as %. Fe, Mn, Zn, and Cu are expressed as mg kg^{-1}.

sacola bahiagrass conducted by Knoop (3). The turf was maintained in a complete nutrient solution for approximately 2.5 months. Then N, P, and K were omitted individually and in all possible combinations. Two months later, leaf tissue was sampled and analyzed for N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu. Considering the nutrients varied in this experiment, i.e., N, P, and K, the calculated DRIS indices were lower for the missing nutrients in almost all cases (Table 5). For example, when P and K were omitted, the indicies for N, P, and K were +11, –62, –54, respectively. Nutrients with the smaller (or more negative) indices are considered to be the most deficient by DRIS methodology. Clearly, the analysis showed P and K to be more limiting than N. This, of course, is what would be expected for the –PK treatment. Only in the case of the –N treatment did the DRIS analysis identify a nutrient (P) other than that which was omitted to be the most deficient of the three treatment variables, and even in that case *the omitted* nutrient (N) had a strongly negative DRIS index. Considering all nutrients, the DRIS analysis *identified* Ca and Fe to be in short supply in all treatments. Knoop himself pointed out that Ca was low at the time that the "minus" treatments were imposed. He did not, however, make any mention of the possible insufficiency of Fe or considerable excess of Cu that is evident in the DRIS analysis (Table 5).

For testing the St. Augustinegrass DRIS program, the authors utilized unpublished tissue analyses from a P-K test conducted by the senior author on mineral soil at the Agricultural Research and Education Center in Ft. Lauderdale (Table 6). The DRIS program correctly identified P and K as the nutrients most limiting in plots not receiving P and K, respectively.

The St. Augustinegrass DRIS analysis also appeared to properly identify known deficiencies in an unpublished N-P-K study conducted by the senior author on organic soil in the Everglades Agricultural Area. In this study, K fertilization had no effect on visual appearance or clipping weight yield, and all DRIS indices for K were positive or small (Table 7). Visual quality and yield were severly reduced in the absence of P fertilization. The DRIS indices were strongly negative for tissue collected from the –P plots, and were progressively less negative as the rate of P fertilization increased (Table 7). At the highest rate of P, N significantly increased yield and quality rating, but the DRIS analysis did not indicate a deficiency in the –N plot. Since the visual rating (7.4) of the –N plot was well above the level of minimum acceptability (6), it probably is good that the DRIS analysis did not call for N fertilization. Excessively lush growth, spurred by N fertilization, probably should be avoided. No responses were seen in this test to foliar applications of Fe and Mn, alone or in combination, and the DRIS indices for these nutrients were either posi-

Table 5. Tissue nutrient concentrations and DRIS indices for bahiagrass turf grown in solution culture by Knoop (1969).

Treatment	Item	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
–PK	Conc.[z]	2.33	0.14	0.53	0.15	0.40	56	37	67	36
	Index	+11	–62	–54	–85	+18	–34	+26	+19	+161
–NK	Conc.	1.63	0.44	1.45	0.07	0.35	61	52	93	43
	Index	–23	+17	+14	–273	+22	–44	+47	+36	+205
–NP	Conc.	1.33	0.09	1.00	0.13	0.14	37	46	21	21
	Index	–5	–61	+10	–58	–10	–38	+56	–21	+128
–K	Conc.	3.10	0.33	0.78	0.05	0.24	69	43	108	59
	Index	+39	–6	–37	–436	+3	–35	+50	+62	+359
–P	Conc.	2.33	0.07	1.27	0.14	0.21	51	43	57	32
	Index	+19	–138	+15	–86	–2	–38	+39	17	+173
–N	Conc.	1.17	0.16	1.40	0.07	0.11	45	44	40	24
	Index	–17	–26	+33	–150	–22	–34	+55	+9	+152

[z]N, P, K, Ca, and Mg are expressed as %. Fe, Mn, Zn, and Cu are expressed as mg kg^{-1}.

Table 6. Tissue nutrient concentrations and DRIS indices for St. Augustinegrass turf in an unpublished P-K study conducted on a mineral soil.

Treatment	Item	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
–P	Conc.[z]	2.20	0.11	1.00	0.40	0.35	110	319	130	6
	Index	–2	–18	–6	–2	0	–3	+31	+2	–2
–K	Conc.	2.70	0.31	0.55	0.40	0.35	80	210	70	7
	Index	0	–3	–10	–1	0	–3	+17	0	–1

[z]N, P, K, Ca, and Mg are expressed as %. Fe, Mn, Zn, and Cu are expressed as mg kg^{-1}.

Table 7. St. Augustinegrass clipping weights, quality ratings, tissue nutrient concentrations, and DRIS indices for the March 1989 evaluation of an unpublished study conducted on an organic soil[z].

Nitrogen level[z]	0	0	0	1	1	1
Phosphorus Level	0	1	2	0	1	2
Yield (g plot–1)	72	123	151	67	132	195
$LSD_{(0.05)}$ = 19						
Rating[y]	4.7	7.1	7.4	4.7	7.3	8.6
$LSD_{(0.05)}$ = 0.6						
Tissue N[x]	2.78	2.85	2.85	2.88	3.11	3.26
Index	+0.72	+0.50	+0.25	+0.77	+0.40	+0.29
P	0.16	0.24	0.35	0.16	0.25	0.37
Index	−4.99	−2.34	−0.95	−4.99	−2.64	−1.00
K	1.82	1.88	1.80	1.84	2.11	2.02
Index	+0.49	+0.36	−0.14	+0.50	+0.41	0.00
Ca	0.94	0.85	0.87	0.94	0.79	0.78
Index	+1.51	+0.70	+0.61	+1.50	+0.58	+0.23
Mg	0.28	0.28	0.30	0.28	0.29	0.31
Index	+0.32	+0.09	−0.03	+0.32	−0.16	+0.13
Fe	234	212	211	239	219	202
Index	+0.19	0.00	0.00	+0.20	−0.17	0.00
Mn	32	26	29	29	27	24
Index	+0.74	0.00	0.00	+0.65	0.00	0.00
Zn	63	73	67	70	73	71
Index	+0.13	−0.15	0.00	+0.16	−0.30	+0.16
Cu	13	16	13	13	22	16
Index	+0.89	+0.83	+0.27	+0.89	+1.89	+0.51

[z]Nitrogen was applied at 0 or 50 kg ha^{-1} bimonthly. Phosphorus was applied at 0, 32, or 68 kg ha^{-1} on 15 June 1988.
[y]Visual quality ratings combining color and density on a 0 to 10 scale with 10 = best possible and 6 = minimum acceptable.
[x]N, P, K, Ca, and Mg are expressed as %. Fe, Mn, Zn, and Cu are expressed as mg kg^{-1}.

tive or close to zero, indicating that these nutrients were present in adequate supply.

The DRIS analyses appear to identify known nutrient deficiencies in bahiagrass and St. Augustinegrass. However, the data bases on which the DRIS programs were based were relatively small. No doubt, the analyses can be improved as larger data bases become available. The DRIS computer program used for this study is a modification of a program written in BASIC for IBM-compatible computers by Dr. B. Shafer (University of Florida, Tropical Research and Education Center at Homestead), based upon one written for another computer system by Elwali and Gascho (2). The present program represents a condensation of the Shafer program, made so the program can be modified relatively easily when additional data are secured. For example, considering the program developed for the bahiagrass data set (Fig. 1), program lines 350 through 370 list the nutrient ratios presented in Table 2, i.e., A(1) = N/K, A(2) = 100*N/Zn, A(3) = 10*N/Cu, etc. These easily can be changed as dictated by another data set. Lines 160 through 180 list the nutrient ratio means and SD's presented in Table 2, in the same order that the ratios were defined in lines 350 through 370. This information is placed at the beginning of the program so it is only loaded into the computer memory one time, since the act of loading may be slow on some computers. Lines 600 through 680 are used in the calculation of the DRIS indicies, which occurs in lines 380 through 590. Line 600 is for N, line 610 is for P, line 620 is for K, etc.; the nutrients being in the order listed in line 710. The numbers listed in each line of this portion of the program identify the

```
10 CLS
20 WIDTH "LPT1:",255
30 DIM A(50),B(50),C(50),AA(50,2),X(10)
40 LPRINT "*****************************************************************"

50 LPRINT "DIAGNOSIS AND RECOMMENDATION INTEGRATED SYSTEM (DRIS)- FLORIDA"
60 LPRINT "Bahia Turfgrass Nutrient Concentrations and Indices"
70 LPRINT "*****************************************************************"

80 LPRINT"SAMPLE ID";"     N     ";"     P     ";"     K     ";"    CA    ";"    MG
    ";"    FE    ";"    MN    ";"    ZN    ";"    CU    ";" ABS. SUM"
90 LPRINT "-----------------------------------------------------------------
-----------------------------------"
100 DEFINT I,J,T
110 T=9
120 FOR I=1 TO (T*(T-1))/2
130 READ AA(I,1),AA(I,2)
140 C(I)=(AA(I,2)/AA(I,1))*100
150 NEXT I
160 DATA 1.61,.45,4.45,2.40,3.06,1.01,1.71,.48,2.69,.90,5.13,2.04,2.50,.94,1.58,
.75,3.88,1.54,2.09,.80,7.75,3.92,1.07,.60
170 DATA 1.35,.59,8.55,5.07,2.24,1.29,4.14,2.27,6.97,4.91,4.20,2.46,1.02,.53,2.8
5,1.44,6.05,4.77,2.80,1.60,1.13,1.06,6.58,5.06
180 DATA 1.70,1.26,4.41,2.71,8.79,7.90,3.53,3.70,4.32,3.06,1.71,.96,1.67,.70,4.4
0,2.28,2.30,1.11,5.80,2.51,1.58,.94,6.52,3.19
190 INPUT"ENTER TREATMENT OR SAMPLE (if you want to quit enter 'end'): ";T0$
200 IF T0$="end" OR T0$="END" THEN 210: ELSE 220
210 END
220 INPUT"ENTER % N                  : ";N
230 INPUT"ENTER % P                  : ";P
240 INPUT"ENTER % K                  : ";K
250 INPUT"ENTER % CA                 : ";CA
260 INPUT"ENTER % Mg                 : ";MG
270 INPUT"ENTER ppm Fe               : ";FE
280 INPUT"ENTER ppm Mn               : ";MN
290 INPUT"ENTER ppm Zn               : ";ZN
300 INPUT"ENTER ppm Cu               : ";CU
310 INPUT"ARE THE ENTRIES CORRECT (Y/N)? :";A$
320 IF A$="N" OR A$="n" THEN GOTO 190
330 IF A$="YES" OR A$="Y" THEN 350
340 PRINT"YES"
350 A(1)=N/K:A(2)=100*N/ZN:A(3)=10*N/CU:A(4)=10*P/N:A(5)=10*P/K:A(6)=100*P/CU:A(
7)=10*CA/N:A(8)=CA/P:A(9)=10*CA/K:A(10)=CA/MG:A(11)=100*CA/CU:A(12)=100*CA/ZN
360 A(13)=10*MG/N:A(14)=10*MG/P:A(15)=10*MG/K:A(16)=100*MG/CU:A(17)=.1*FE/N:A(18
)=.01*FE/P:A(19)=.01*FE/K:A(20)=.01*FE/CA:A(21)=.01*FE/MG:A(22)=FE/ZN:A(23)=.1*M
N/N:A(24)=.1*MN/P
370 A(25)=.1*MN/K:A(26)=.1*MN/CA:A(27)=.1*MN/MG:A(28)=MN/CU:A(29)=10*MN/ZN:A(30)
=10*MN/FE:A(31)=.01*ZN/P:A(32)=.1*ZN/K:A(33)=.01*ZN/MG:A(34)=CU/K:A(35)=10*CU/ZN
:A(36)=100*CU/FE
380 FOR I=1 TO (T*(T-1))/2
390 IF A(I)>(AA(I,1)-AA(I,2)) THEN 410
400 GOTO 450
410 IF A(I)<(AA(I,1)+AA(I,2)) THEN 430
420 GOTO 470
430 B(I)=0
440 GOTO 480
450 B(I)=100*(1-AA(I,1)/A(I))
460 GOTO 480
470 B(I)=100*(A(I)/AA(I,1)-1)
480 NEXT I
490 B(0)=0:C(0)=1
500 FOR J=1 TO T
510 FOR I=1 TO T-1
520 READ M
530 IF M<0 THEN 550
540 X(J)=X(J)+B(M)/C(M):GOTO 570
550 M=M*-1
560 X(J)=X(J)-B(M)/C(M)
570 NEXT I
580 X(J)=X(J)/((T-1)/10)
590 NEXT J
600 DATA 1,2,3,-4,-7,-13,-17,-23
610 DATA 4,5,6,-8,-14,-18,-24,-31
620 DATA -1,-5,-9,-15,-19,-25,-32,-34
630 DATA 7,8,9,10,11,12,-20,-26
640 DATA 13,14,15,16,-10,-21,-27,-33
650 DATA 17,18,19,20,21,22,-30,-36
660 DATA 23,24,25,26,27,28,29,30
670 DATA 31,32,33,-2,-12,-22,-29,-35
680 DATA 34,35,36,-3,-6,-11,-16,-28
690 O=ABS(X(1))+ABS(X(2))+ABS(X(3))+ABS(X(4))+ABS(X(5))+ABS(X(6))+ABS(X(7))+ABS(
X(8))+ABS(X(9))
700 LPRINT USING "\                \";T0$;
710 LPRINT USING "  ####.## ";N,P,K,CA,MG,FE,MN,ZN,CU
720 LPRINT "                ";:FOR I=1 TO T:LPRINT USING "+#####.## ";X(I);:NEXT I:LPRIN
T USING " +#####.## ";O
730 LPRINT
740 FOR I=1 TO T:X(I)=0:NEXT I:RESTORE 600
750 GOTO 190
760 END
```

Fig. 1 Computer program written in IBM-PC compatible BASIC for calculating DRIS indices for the bahiagrass data set.

position of the nutrient in the nutrient ratios presented in lines 350 through 370, and the sign identifies whether the nutrient is in the numerator (+) or the denominator (–) of the nutrient ratio. For example, the numbers 1, 2, and 3 in line 600 indicate that A(1), A(2), and A(3) in line 350 each have N in the numerator. The numbers –4, –7, and –13 in line 600 indicate that A(4), A(7), and A(13) each have N in the denominator. By making changes in these three locations in the program, allowance can be made for changes in the data set. Somewhat more extensive modification is needed if nutrients other than the ones used in this analysis are to be examined. In addition to the obvious changes that will be needed in the portions of the program that control input and output functions, and any increases in the dimension statement (line 30) made necessary because of an increase in the number of nutrients considered, the value of "T" in line 110 must be changed to correspond to the number of nutrients used in the analysis (9 in the present example). The program also calculates the "absolute sum" (line 690), which is a measure of the overall imbalance among nutrients. A lower absolute sum indicates reduced imbalance among nutrients. The number of X's listed in line 690 must correspond to the number of nutrients in the analysis. With these simple changes, the program can be modified to suit various data sets.

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TURFGRASS PROVING GROUNDS

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Abstract. **New turfgrass varieties must provide acceptable consumer quality and permanence in the landscape, and field evaluation is essential in their assessment. Public and private sectors are working together on field evaluation of new varieties. Sod variety trials have provided data as well as plant material used in urban trials. Such tests simulate in pilot scale the typical economic path of a new grass. A study was recently initiated to obtain regional cold tolerance data on 5 St. Augustinegrasses in 34 Florida counties. Under the sponsorship of the National Turfgrass Evaluation Program at Beltsville, MD, the University of Florida has distributed genetic material for 25 grasses in the National St. Augustinegrass Test—1989, installed at 15 locations from California to South Carolina, with 4 more locations pending. The purpose of these tests is to better assess the risks and potentials of present and future turf varieties, over a range of conditions, so that better value can be assured for the consumer.**

The testing of turfgrass varieties can help the consumer in the same way as do evaluations of other products. Knowledgeable prediction of benefits and risks allows for the selection of a turfgrass satisfying individual needs and resources. Knowledge of turfgrass variety response to different environments allows for the tailoring of management options to best utilize a particular turf variety. While the turf field test is often conducted during new variety development, it is also an ongoing process which can provide useful knowledge for previously-released varieties. Unfortunately, turfgrass field tests are but surrogate end-points for evaluating perennial grasses designed for 10- to 20-year life expectancies. Another limitation in the design of traditional field tests is an emphasis on statistical precision at the expense of practical relevance. This paper discusses turfgrass field evaluation and shows how to improve the testing process.

The Traditional Field Trial

Most turfgrass product evaluations involve a comparison of treatments applied in relatively small plots at a single field location. Sufficient number of replications and local control (blocking of replications) ensures that unexplained variability (error variance) is minimal, and that error variance and treatment means are accurately measured. Treatment means are compared relative to a standard. For a

Florida Agricultural Experiment Stations Journal Series No. N-00064. I thank Cooperative Extension Service Faculty throughout Florida, members of the Turfgrass Producers Association of Florida, and colleagues throughout the southern United States, for participation in regional tests. The National St. Augustinegrass Test is coordinated by the National Turfgrass Evaluation Program; the Florida Department of Agriculture and Consumer Services, Division of Plant Industry cooperated with phytosanitary inspections; and the South Florida Water Management District sponsored its distribution. A special thanks to Bonnie L. Coy and Mickey A. Stanaland, for their expert technical help in propagation and distributing these tests.