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SOLVITA® SOIL TEST KITS TO CATEGORIZE TURFGRASS SITE RESPONSIVENESS TO NITROGEN FERTILIZATION – 2015 RESULTS

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INTRODUCTION

The ability to predict the nitrogen mineralization potential of any turfgrass site would be a valuable tool in nutrient management. Guiding nitrogen fertilization based on an objective soil test should help to avoid too little or too much nitrogen applied to turf that often occurs when using subjective criteria to determine how much nitrogen a turf needs. Insufficient or excessive nitrogen applications can lead to poor aesthetic and functional turf performance, increases in certain diseases and insects, and water quality problems when excess N is applied. The Solvita® company offers two field test kits that have been developed to measure the biologically-active C and N fractions in soil organic matter: the Soil CO_2-Burst and Soil Labile Amino Nitrogen (SLAN) Test Kits, respectively (http://solvita.com/soil). These kits are designed for on-site use, without the need to send soil samples to a laboratory. There is some preliminary evaluation of these kits for field crops that looks promising as guides to N fertilization, but currently there has been no evaluation of these kits on turfgrass soils. The Soil CO_2-Burst Test kit measures the amount of CO_2 that is presumably released from microbial respiration and degradation of the labile-C fraction of the soil organic matter. Soil microbial respiration is positively correlated to soil fertility and crop yield response. It should also function as the same indicator in turf soils with respect to turf growth and quality. The SLAN Test kit presumably measures the labile amino-N fraction of the soil organic matter which should indicate the mineralization potential of the soil. The objective of this research is to determine if these new commercially-available field test kits can categorize turf soils as to their responsiveness to N fertilization.

MATERIALS & METHODS

In September of 2007, an organic composted fertilizer (Suståne 5-2-4, all natural fine grade) was incorporated into the 15-cm depth of 1 × 1 m plots at two adjacent sites at 23 different rates ranging from 0 to 392 kg available N/ha/year. After compost incorporation, one site was seeded to tall fescue (*Festuca arundinacea* cvs. Shortstop II, Dynasty, Crossfire II), and the other was seeded to Kentucky bluegrass (*Poa pratensis* cv. America). The experiments were set out as randomized complete block designs with three replicates. In November of 2008, 2009, 2010, 2012, 2013, and 2014, plots were solid-tined aerified and compost was applied again to the same plots using the same rates, and brushed into the aerification holes. Additional treatments in each year include urea in split applications (May, June, Sept., Oct.) at 49, 98, 147, and 196 kg N/ha/year. The synthetic urea treatments were included so that response of the compost treatments could be matched to that of the synthetic N rate. Urea plots also received 98 kg of K_2O and P_2O_5 at the first urea application in the form of potassium sulfate and triple super phosphate. In early May of 2015 before urea application, soil samples were collected from each plot to a depth of 10-cm below the thatch layer, air-dried, then sieved to pass a 2-mm screen. These samples were analyzed with the Solvita® Soil CO_2-Burst and SLAN test kits. Four grams of soil were used for the SLAN test and 40 grams of soil were used for the CO_2-Burst test. Soils for the CO_2-Burst test were rewetting with 20 mls of deionized water, and incubated at room temperature for 24 hrs. At approximately every two weeks during the growing season, turf color quality was measured using Spectrum CM1000 Chlorophyll and TCM500 NDVI Turf Color meters (Spectrum Technologies, Inc., Aurora, IL). Typically, greener turf is related to higher reading values with these meters. Turf growth (yield of clippings) was collected monthly.

Linear regression models were applied to determine the response of Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N as a function of organic fertilizer rates. Linear and linear-response and plateau regression models were used to determine the relationship of mean NDVI readings, mean CM1000 readings and the sum of the clippings yields as a function of Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N. The REG procedure of SAS 9.4 (SAS Institute, Cary, NC) was used for the linear models, and the NLIN procedure was used for the linear-response and plateau models. Logistic curves of binary responses for the probabilities of organic fertilizer plot NDVI, CM1000, and clippings yield values equaling or exceeding the mean responses obtained from the 150 and 200 kg N ha^{-1} urea treatments (which would typically be the maximum recommended rates of N for lawns in our climate) in relation to Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations were determined with linear binary logistic models ($a + bx = \{\ln[\pi/(1-\pi)]\}$, where π is the probability of the organic fertilizer response being equal to or exceeding the mean response from the 150 and 200 kg N ha^{-1} urea treatments) using the LOGISTIC procedure of SAS 9.4.

RESULTS

Soil CO_2-C and NH_3-N Concentrations as a Function of Organic Fertilizer Rate

Increasing organic fertilizer rates were generally well correlated with increasing Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations in a significant ($P < 0.001$) linear response (Fig. 1, panels A and B; and Fig. 2, panels A and B). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

Turfgrass Color as a Function of Soil CO_2-C and NH_3-N Concentrations

Turfgrass color, as measured by NDVI and CM1000 meters, was significantly ($P < 0.001$) and linearly associated with Solvita® CO_2-Burst CO_2-C concentrations (Fig. 1, panels C, D, E, and F). In response to increasing SLAN NH_3-N concentrations, NDVI for both Kentucky bluegrass and tall fescue increased linearly before plateauing at 190 and 157 mg NH_3-N kg^{-1}, respectively ($P < 0.001$) (Fig. 2, panels C and D). Relative chlorophyll index (CM1000) increased linearly ($P <$ 0.001) with increasing SLAN NH_3-N concentrations (Fig. 2, panels E and F). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

Turfgrass Clipping Yield as a Function of Soil CO_2-C and NH_3-N Concentrations

Turfgrass clippings yield was significantly ($P < 0.001$) and linearly associated with Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations for Kentucky bluegrass and tall fescue (Figs. 1 and 2, panels G and H). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

Predicting Turfgrass Response as a Function of Soil CO_2-C and NH_3-N Concentrations

Inclusion of the urea treatments provide a convenient way to determine an equivalent response obtained from the organic fertilizer treatments, and to predict turfgrass response based on these equivalent responses. Using binary logistic regression, we were able to calculate the probability of equaling or exceeding the mean response of that obtained from the urea 150 and 200 kg N ha^{-1} yr^{-1} rates. These urea rates are typically the maximum recommended seasonal N loading amounts for cool-season turfgrass lawns in our climate; N rates above 200 kg N ha^{-1} yr^{-1} generally would not be recommended for established lawns.

Estimates of the binary logistic regression coefficient parameters and their associated *P*-values are given in Table 1. As a guide for the reader, the Wald *P*-values are used to determine the significance of the slope for the logistic regression (considered significant when $P < 0.05$). The Hosmer-Lemeshow *P*-value indicates the significance of the goodness-of-fit test. The model is considered a good fit for the data when the Hosmer-Lemeshow *P*-value >0.05.

Significant ($P < 0.001$) logistic regression models were found for all variables (NDVI, CM1000, and clippings yield) for both Kentucky bluegrass and tall fescue, and when both species were combined as a function of soil CO_2-Burst CO_2-C concentrations (Table 1). Probability curves indicated that when mean soil CO_2-Burst CO_2-C concentrations were $\leq$ 66 and $\leq$ 77 mg kg^{-1}, there was a low probability ($P \leq 0.33$) of response equal to or exceeding that of 150-200 kg N ha^{-1} from urea for Kentucky bluegrass and tall fescue, respectively, across the three measured variables (Fig. 3 panels A and B, and Table 2). When mean CO_2-C concentrations were > 66 to 81 mg kg^{-1} for Kentucky bluegrass and > 77 to 112 mg kg^{-1} for tall fescue, there was a moderate probability ($P > 0.33$ to 0.67) of equaling or exceeding the response obtained from the 150-200 kg N ha^{-1} urea treatments. Mean soil CO_2-C concentrations were $\geq$ 97 and $\geq$ 151 mg kg^{-1} were associated with a high probability ($P \geq 0.90$) of Kentucky bluegrass and tall fescue responses equaling or exceeding that of 150-200 kg N ha^{-1} from urea, respectively.

Probability curves indicated that when mean SLAN NH_3-N concentrations were $\leq$ 144 and $\leq$ 132 mg kg^{-1}, there was a low probability ($P \leq 0.33$) of response equal to or exceeding that of 150-200 kg N ha^{-1} from urea for Kentucky bluegrass and tall fescue, respectively (Fig.3 panels D and E, and Table 2). When mean NH_3-N concentrations were >144 to 158 mg kg^{-1} for Kentucky bluegrass and > 132 to 159 mg kg^{-1} for tall fescue, there was a moderate probability ($P > 0.33$ to 0.67) of equaling or exceeding the response obtained from the 150-200 kg N ha^{-1} urea treatments. Mean soil CO_2-C concentrations $\geq$ 172 and $\geq$ 196 mg kg^{-1} were associated with a high probability ($P \geq 0.90$) of Kentucky bluegrass and tall fescue responses equal to or exceeding that of 150-200 kg N ha^{-1} from urea, respectively.

When responses from both species were combined, there was a high probability ($P \geq 0.90$) of Kentucky bluegrass and tall fescue responses equaling or exceeding that of the 150-200 kg N ha^{-1} urea treatments when mean soil CO_2-Burst CO_2-C concentrations were $\geq$ 126 mg kg^{-1} and when mean SLAN NH_3-N concentrations were $\geq$ 198 mg kg^{-1} (Fig. 3 panels C and F, and Table 2).

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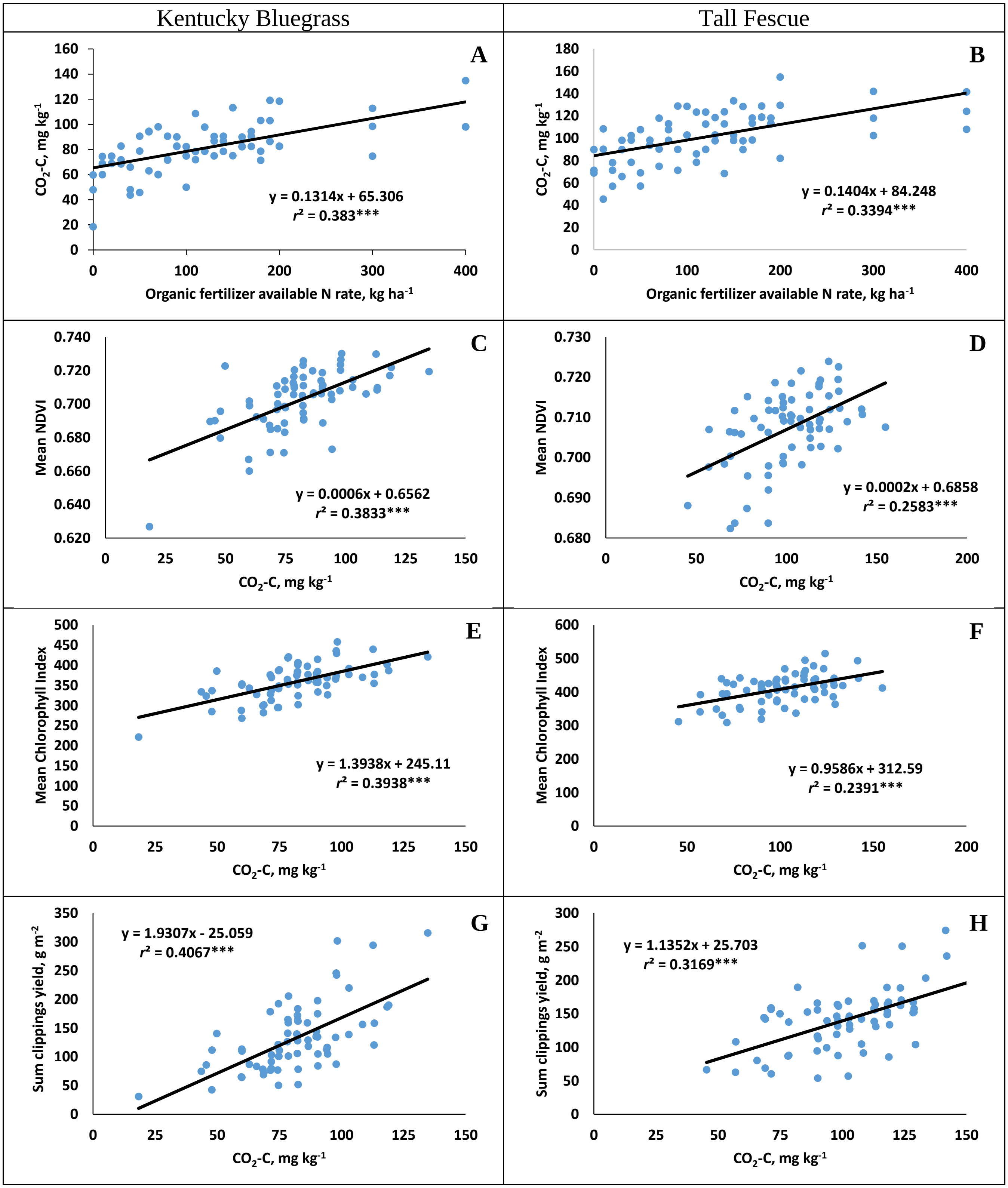

Fig. 1. Effects of organic fertilizer rate (panels A and B) on the production of CO_2-C as measured with the Solvita® CO_2-Burst Test Kit, and relationship between Solvita® CO_2-Burst Test CO_2-C and: NDVI readings from organic fertilizer plots (panels C and D); CM1000 readings from organic fertilizer plots (panels E and F); and clippings yield from organic fertilizer plots (panels G and H). The first column of panels correspond to Kentucky bluegrass (*Poa pratensis*), and the second column of panels correspond to tall fescue (*Festuca arundinacea*). Significance of coefficient of determination (r^2) for the linear response: *** ($P < 0.001$).

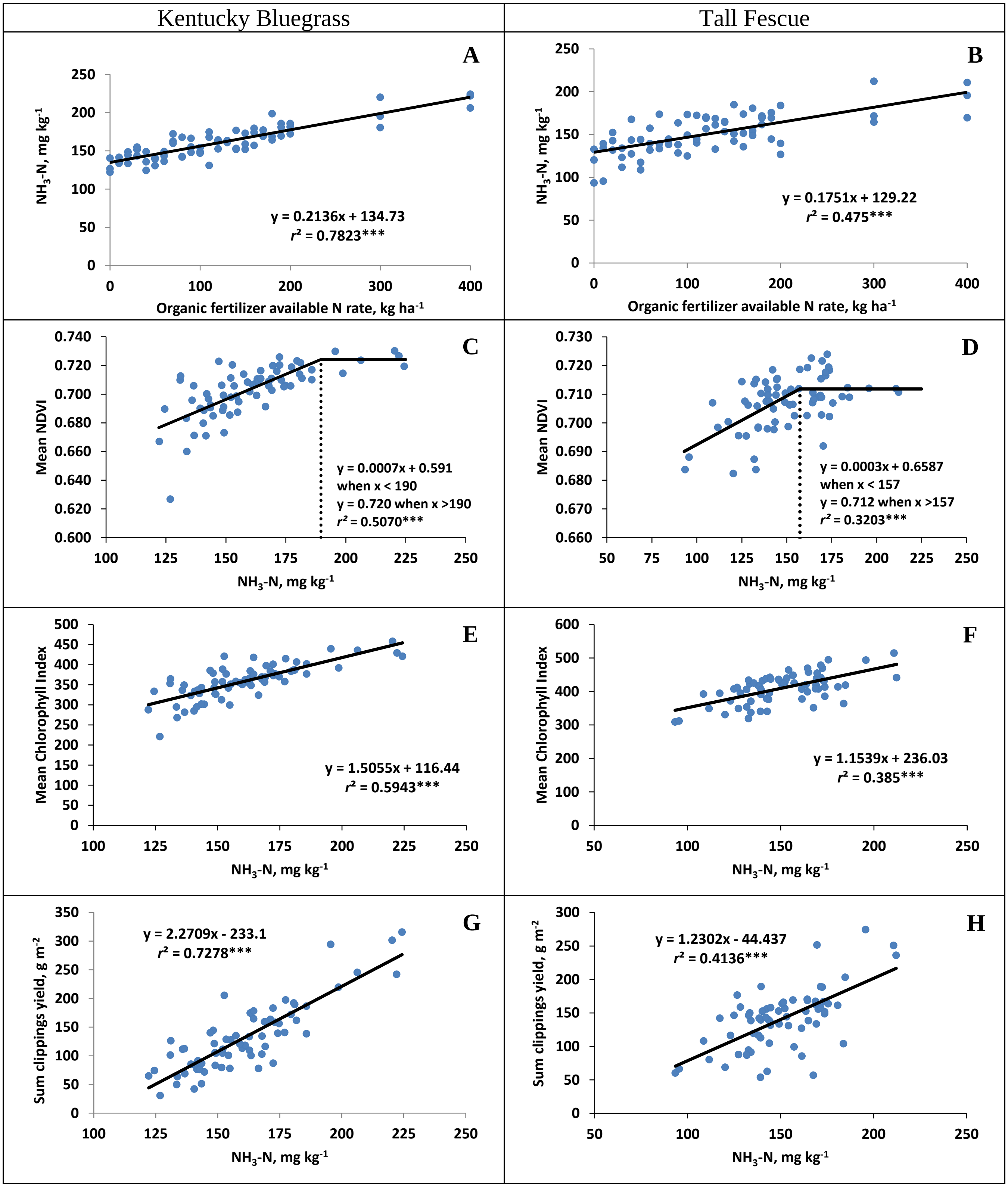

Fig. 2. Effects of organic fertilizer rate (panels A and B) on the production of NH_3-N as measured with the Solvita® Soil Labile Amino Nitrogen (SLAN) Test Kit, and relationship between Solvita® SLAN Test NH_3-N and: NDVI readings from organic fertilizer plots (panels C and D); CM1000 readings from organic fertilizer plots (panels E and F); and clippings yield from organic fertilizer plots (panels G and H). The first column of panels correspond to Kentucky bluegrass (*Poa pratensis*), and the second column of panels correspond to tall fescue (*Festuca arundinacea*). Significance of coefficient of determination (r^2) for the linear or linear plateau response: *** ($P < 0.001$).

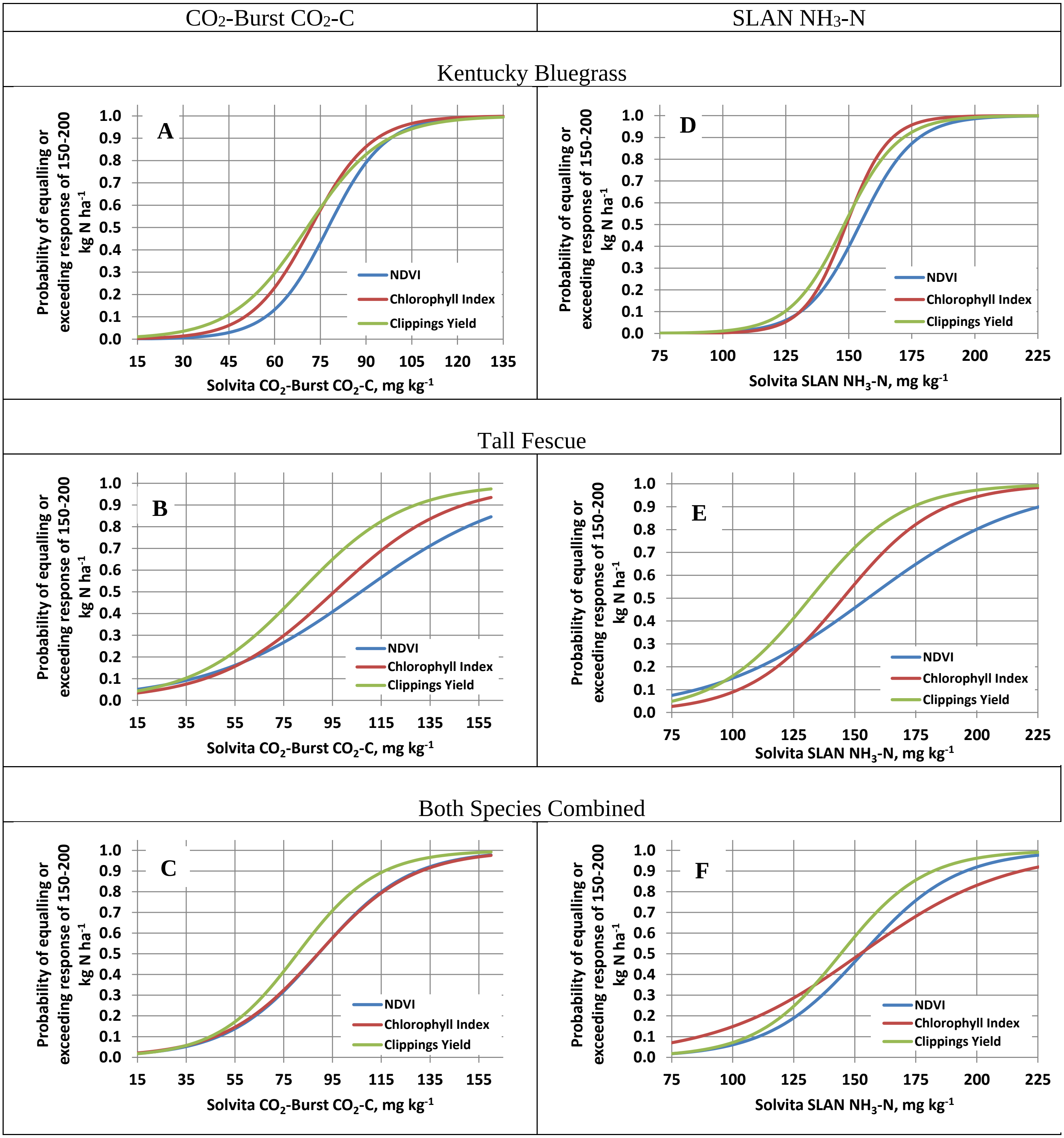

Fig. 3. Probability curves of equaling or exceeding the NDVI, CM1000, and clippings yield values of that obtained from the mean response of urea at the 150 and 200 kg N ha^{-1} rates in relation to Solvita® Soil CO_2-Burst CO_2-C concentrations (panels A, B, and C) and SLAN NH_3-N concentrations (panels D, E, and F) for the 2014 growing season. Mean urea response at the 150 and 200 kg N ha^{-1} rates for NDVI, CM1000, and sum of the monthly clippings yield (g m^{-2}) values were 0.706, 349, and 105 for Kentucky bluegrass, respectively; 0.710, 411, and 129 for tall fescue, respectively; and 0.708, 380, and 117 across both species combined, respectively.

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Table 1. Logistic regression coefficients for binary response of NDVI, Chlorophyll Index (CM1000), and clippings yield values being equal to or exceeding the mean response for the urea 150 and 200 kg ha^{-1} treatments for Kentucky bluegrass and tall fescue lawns in relation to Solvita® Soil CO_2-Burst CO_2-C and SLAN NH_3-N concentrations for the 2015 growing season.

	CO_2-Burst Test CO_2-C Concentrations									
	Kentucky bluegrass					Tall fescue				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-8.3070	0.1071	0.0002	0.4675	0.2213	-3.4016	0.0319	0.0114	0.1360	0.3504
CM1000	-7.2832	0.1013	0.0002	0.4438	0.2909	-3.9600	0.0414	0.0023	0.2062	0.9922
Yield	-5.7404	0.0812	0.0005	0.3632	0.2560	-3.789	0.0464	0.0015	0.2361	0.7855

	SLAN NH_3-N Concentrations									
	Kentucky bluegrass					Tall fescue				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-14.409	0.0933	<0.0001	0.4731	0.6073	-4.8640	0.0313	0.0108	0.1412	0.7354
CM1000	-17.824	0.1196	<0.0001	0.5491	0.7660	-7.4608	0.0514	0.0006	0.2847	0.0796
Yield	-13.813	0.0932	0.0001	0.4486	0.8692	-6.8893	0.0523	0.0012	0.2747	0.2808

	CO_2-Burst Test CO_2-C Concentrations					SLAN NH_3-N Concentrations				
	Kentucky bluegrass + Tall fescue combined					Kentucky bluegrass + Tall fescue combined				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-4.7788	0.0536	<0.0001	0.3041	0.3293	-7.924	0.0518	<0.0001	0.2804	0.3022
CM1000	-4.6299	0.0520	<0.0001	0.2925	0.9284	-5.0858	0.0334	0.0002	0.1524	0.3513
Yield	-4.9621	0.0616	<0.0001	0.3467	0.4631	-8.3650	0.0580	<0.0001	0.3087	0.8860

Table 2. Concentrations of Solvita CO_2-Burst CO_2-C and SLAN NH_3-N at selected probabilities of equaling or exceeding the response of 150-200 kg N ha^{-1} using urea for NDVI, Chlorophyll Index (CM1000), and clippings yield (ClipYield) for 2015.

CO_2-Burst CO_2-C concentrations, mg kg^{-1}												
	Kentucky bluegrass				Tall fescue				Both species			
P	NDVI	CM1000	ClipYield	Mean	NDVI	CM1000	ClipYield	Mean	NDVI	CM1000	ClipYield	Mean
0.33	71	65	62	66	85	79	67	77	76	76	69	74
0.67	84	79	79	81	128	112	97	112	102	102	92	99
0.90	98	94	98	97	176	149	129	151	130	131	116	126
0.95	105	101	107	104	199	167	145	170	144	146	128	139
SLAN NH_3-N concentrations, mg kg^{-1}												
	Kentucky bluegrass				Tall fescue				Both species			
P	NDVI	CM1000	ClipYield	Mean	NDVI	CM1000	ClipYield	Mean	NDVI	CM1000	ClipYield	Mean
0.33	147	143	141	144	133	145	118	132	140	132	132	135
0.67	162	155	156	158	178	153	145	159	166	173	156	165
0.90	178	167	172	172	226	188	174	196	195	218	182	198
0.95	186	174	180	180	249	202	188	213	210	240	195	215

SUMMARY AND CONCLUSIONS

The second-year results of this study suggest that the Solvita® CO_2-Burst and SLAN Test kits show promise in estimating cool-season turfgrass lawn response as a function of CO_2-C and NH_3-N concentrations in soil samples collected in the spring prior to fertilization. Better fits of the data were obtained with the SLAN test kit compared to the results of the CO_2-Burst test kit, but both did reasonably well. The second-year results for SLAN were similar to 2014 results, but 2015 results for the CO_2-Burst test were much better than 2014.

One objective of the research is to establish response categories (Low, Moderate, or High) to guide N fertilization of turfgrass lawns based on concentrations of CO_2-Burst CO_2-C and SLAN NH_3-N concentrations. Concentrations presented in Table 2 can be used as starting benchmark values for these categories for equaling or exceeding the response of 150-200 kg N ha^{-1} urea treatments. When concentrations have $P \leq 0.33$, then the category would be considered 'Low'; when concentrations have $P > 0.33$ to 0.67, then the category would be 'Moderate'; and when concentrations have $P > 0.67$, then the category would be 'High'.

Using Kentucky bluegrass NDVI response for turfgrass color as an example, it would be unlikely that much N fertilizer would be needed when soil CO_2-C concentrations are ≥ 84 mg kg^{-1}, or when SLAN NH_3-N concentrations are ≥ 162 mg kg^{-1} ($P \geq 0.67$, Table 2). When CO_2-C and NH_3-N concentrations exceed 98 and 178 mg kg^{-1}, respectively, there would be only a 10% chance or less that the Kentucky bluegrass NDVI would increase in a response equivalent to 150-200 kg N ha^{-1} to added N fertilization. In these cases, supplemental N should be withheld and applied only in special cases where turf response is less than optimum after growth is monitored before applying N. Application of supplemental N in areas when soil CO_2-Burst and SLAN test kits read high increases the likelihood of N losses from the system and more problems with insect and disease pests.

The 2015 CO_2-Burst SLAN responses are very similar to the trends obtained in previous research on these same plots when predicting turfgrass response to the soil permanganate-oxidizable carbon (POXC) and Illinois Soil N Test (ISNT)-N concentrations obtained from a spring soil sample across 5 years (2008-2012; Geng et al., 2014). SLAN NH_3-N concentrations obtained from archived soil samples from the Geng et al., 2014 study are highly correlated ($P < 0.01$) with the respective ISNT-N concentrations (data not shown). This suggests that the Solvita® SLAN test may have similar predictive power in guiding N fertilization as does the ISNT.

The 2015 data showed consistent results with 2014 data for SLAN NH_3-N concentrations, but CO_2-Burst CO_2-C concentrations were different between 2014 and 2015, with better fits of the data for 2015. As more data are collected, different conclusions and delineation ranges may come forth. However, we are encouraged with the results across two years, and think that the Solvita® tests (especially the SLAN) could provide an objective guide for N fertilization of cool-season turfgrass lawns.

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