academicJournals

Vol. 10(52), pp. 4778-4782, 24 December, 2015
DOI: 10.5897/AJAR2013.8070
Article Number: 8F0973B56482
ISSN 1991-637X
Copyright ©2015
Author(s) retain the copyright of this article
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Use of a portable chlorophyll meter to evaluate leaf Nitrogen status of tropical carpet grass

Yu-Sen Chang[1], Yu-Shian Chung[1] and Yu-Jen Kuo[2]*

[1]Department of Horticulture, National Taiwan University, No.1, Sec. 4, Roosevelt Road, Taipei, Taiwan 106, Taiwan.
[2]Kainan University, College of Health Care and Management 33857 No. 1 Kainan Rd. Luzhu, Taoyuan, Taiwan.

Received 11 October, 2013; Accepted 21 August, 2015

The persistence of color response after fertilizer treatments is a key indicator of turfgrass performance. Tropical carpetgrass (*Axonopus compressus* (Swartz) Beauv.) is widely used throughout subtropical area, was selected as the subject of this study. Five nitrogen (N) treatments applied monthlyat the application rate of both 7.5 and 15.0 g N/m^2 as ammonium nitrate (AN), 2.5 and 7.5 g N/m^2 as a 14-6.2-11.6 (NPK) slow release fertilizer (SRF), and 7.5 g N/m^2 as AN+2.5 g N/m^2 as SRF. The trial was performed twice in the greenhouse over 9 week period in two growing seasons. Leaf chlorophyll content, N content, leaf area, plant biomass, and the growth characteristics were measured. Results indicated that the first leaf, third leaf, and third/first leaf ratios of chlorophyll meter readings (CMR) increased with N treatments to the control. Linear regressions indicated that dry weight-based (N_{dw}) or leaf area-based N (N_a) concentrations were highly correlated with CMR during both growing seasons. However, CMR correlated better with N_{dw} better than with N_a. According to the regressions of leaf N and total dry weight, the critical range of N could be 2.6 to 3.1%. If based on the regressions of leaf N and CMR 3/1, the range of N could be 2.7 to 3.0%. Both ranges are very close. Therefore, CMR3/1 could be a criterion to measuring the N status in tropical carpet grass. This investigation showed that CMR offer an alternative to tissue testing for N status and can be used to identify fertilizer N recommendations.

Key words: Carpetgrass, chlorophyll meter readings, N content, dry weight, leaf area.

INTRODUCTION

Tropical carpetgrass (*Axonopus compressus* (Swartz) Beauv.) is a native of Central America and the West Indies (Turgeon, 2007). Tropical carpet grass is an extremely popular turf grass species throughout the world because of its low growing, mat-like grass, and low maintenance characteristics. Soil contamination caused by excessive chemical use is a typical problem in farmlands all over the world (Kuo et al., 1999; Sharma et al., 2011). Efficient use of N fertilizer is important to economical and environmentally sounds turfgrass production and ground and surface water quality (Kooistra, 2004). While the field performance of various Nsources varies, forecasting performance is difficult of given unknown temperature and precipitation (Turner, 1991). Assessment of fertilizer performance under controlled conditions is potentially useful method for prescreening of turfgrass response to fertilizer treatment before actual field trials (Horst et al., 1994). Turfgrass quality is still determined largely through visual assessment. However, visual assessment is imprecise

---

*Corresponding author. E-mail: kuoyj@mail.knu.edu.tw

Table 1. Composition of modified Johnson's solution.

Chemical composition	Elements	Concentration (ppm)
		Macro nutrient (M)
$Ca(H_2PO_4)_2 \cdot H_2O$	P	62
	Ca	80
K_2SO_4	K	235
	S	32
$MgSO_4 \cdot 7H_2O$	Mg	24
	S	32
		Micro nutrient (μM)
KCl	Cl	1.77
H_3BO_3	B	0.27
$MnSO_4 \cdot 7H_2O$	Mn	0.11
$ZnSO_4 \cdot 5H_2O$	Zn	0.13
$CuSO_4 \cdot 5H_2O$	Cu	0.03
H_2MoO_4（85%）	Mo	0.05
Fe-EDTA	Fe	1.12

and dependent on evaluator prejudice. Turfgrass quality cannot be measured by employing the same method employed for other agricultural crops (Morris, 2001). Efficient, low-cost, and non-destructive methods for pre-screening turfgrass growth to fertilizer are required to help tackle the problem of excessive fertilizer use in intensively cultivated areas. The common method of extraction and quantifying plant N concentration is both times consuming and destructive to plants. In contrast, chlorophyll meters enable quick and easy measurement ofleaf blade greenness, which is an indicator of shoot chlorophyll content (Rodriguez et al., 2000). Numerous researchers have studied the relationship between tissue N status and chlorophyll meter readings (CMR) in some crops (Kantety et al., 1996). Moreover, conditions for the use of chlorophyll meters have recently have been clarified for some crops (Denuit et al., 2002; Giunta et al., 2002). However, the application of chlorophyll meters to tropical carpet grass has not been explored. The present experiment comprised two parts. First, tropical carpet grass response to fertilizer rates and sources was screened;second, the relationship between Minolta SPAD-502 chlorophyll meter readings and plant biomass, plant growth characteristics, leaf area, and N status in leaf was investigated.

MATERIALS AND METHODS

Tropical carpetgrass sods (from the Rose Extension Center, Taipei, Taiwan) were grown in 15 cm diameter* 20 cm deep plastic pots containing loam, peat moss and vermiculite (2:2:1= v:v:v) medium. The greenhouse study was conducted in the climate-controlled greenhouse as spring season (28/23°C day/night, 4.86·MJ $m^{-2} \cdot d^{-1}$) (Model LX-102 potable light meter, Alfa Electronics inc., NJ.), and as winter season (22/20°C day/night, 3.64·MJ $m^{-2} \cdot d^{-1}$) for a 9 weeks period, respectively. Pots were watered 125 ml by potable water twice a week. Five N treatments were applied as follows: slow-release resin-coated fertilizer (SLW) (Osmocote, contain of 14: 6.2: 11.6 (NPK); Tai-Ho Company, Taipei, Taiwan) at N rate of both 2.5 and 7.5 g N /m^2 per month; fast-release fertilizer ammonium nitrate (NH_4NO_3(AN); Tai-Fertilizer Company, Taipei, Taiwan) at N rate of both 7.5, and 15.0 g N/m^2 per month; and mixed fast- and slow-released fertilizer at N rate 7.5g N/m^2 per month as NH_4NO_3 5.0+Osmocote2.5 g N/m^2 per month after seed germination. A modified N-deficient full-strength Johnson'snutrientsolution was applied weekly to prevent deficiency in the other essential elements (Table 1). Potable water was adopted as a control.The first and third fully expanded leaves (those with collars surrounding the stem) from the apex of the plant weresampledfrom each pot for chlorophyll and chlorophyll meter readings (CMR) measurement. CMR were assessedwith a chlorophyll meter (Model Minolta SPAD-502, Minolta Co. Ltd., Japan). This SPAD-502 chlorophyll meter uses a silicon photodiode to detect transmittance though a leaf sample of light emitted from two light emitting diodes: one with a peak emittance at 650 nm, where absorptance by chlorophyll is a high and relatively unaffected by carotene, and one with a peak emittance at 940 nm, where absorptance by chlorophyll is negligible. The third/first leaf CMR ratio was identified as CMR 3/1. Harvested samples were divided into root and shoot portions and oven dried at 7°C for 48 h. The root and shoot dry weight and the length and width of the largest fully expanded leaf were measured, and stolon numbers were counted. The specific leaf weight (SLW) of the fully expanded leaf was calculated as the ratio of leaf weight to area. Leaf area was measured with an LI-COR Area Meter, (Model LI-3000, LI-COR, Inc., Lincoln, Nebraska, USA). Leaf N content was analyzed with semi-micro Kjeldahl digestion and distillation (Kuo et al., 1999). Leaf N concentration was derived withdry weight (N_{dw}) and leaf area (N_a). The experimental design was completely randomized with six replications. Mean separation was evaluated at the 0.05 probability level using Duncan's multiple range tests.

RESULTS AND DISCUSSION

Regardless of N fertilizer concentrations, the first leaf,

Table 2. Effect of N applications on chlorophyll meter reading (CMR) value of first and third fully expanded leaf, CMR 3/1 value, specific leaf weight (SLW) and dry weight based N (Ndw) of tropical carpetgrass during winter season.

Nitrogen rate (g N/ m^2 per month)	CMR		CMR 3/1	SLW	N_{dw} (%)
	First leaf	Third leaf			
Control	24.8 ^{c*}	16.8 ^{c}	0.66 ^{c}	21.7 ^{a}	1.4 ^{e}
SLF 2.5	35.1 ^{b}	36.3 ^{b}	1.03 ^{b}	22.3 ^{a}	2.1 ^{d}
SLF 7.5	38.8 ^{ab}	43.2 ^{a}	1.12 ^{ab}	19.6 ^{a}	3.1 ^{b}
AN 7.5	38.0 ^{ab}	42.6 ^{a}	1.12 ^{ab}	19.4 ^{a}	2.6 ^{c}
AN15.0	39.8 ^{a}	45.2 ^{a}	1.14 ^{ab}	20.7 ^{a}	3.4 ^{a}
AN 5.0 + SLF 2.5	38.3 ^{ab}	44.7 ^{a}	1.17 ^{a}	21.4 ^{a}	3.0 ^{c}

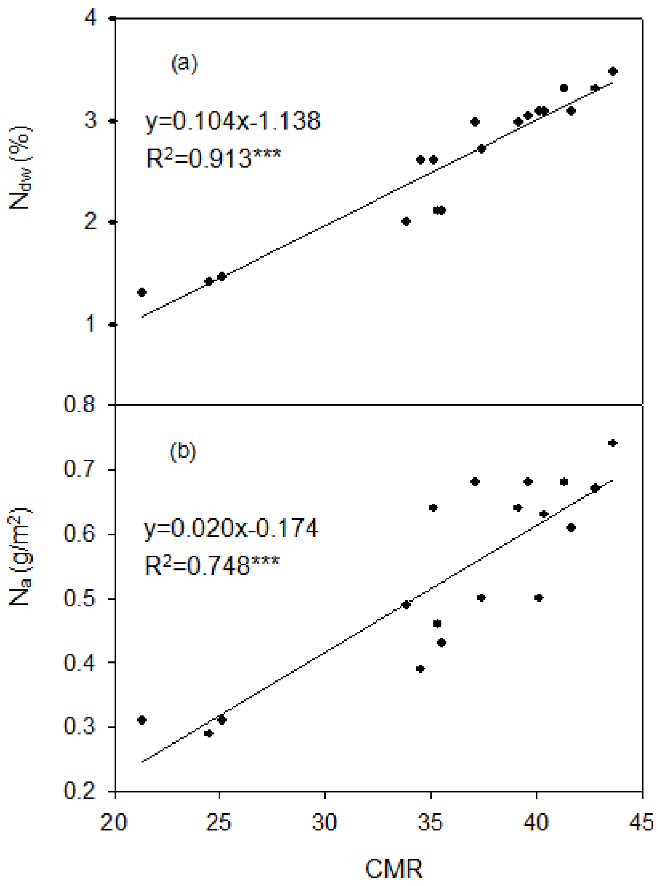

Figure 1. Regression between (a) dry weight-based (Ndw) and (b) area-based (Na) leaf nitrogen concent on chlorophyll meter readings (CMR) of tropical carpetgrass in spring season.

third leaf, and third /first leaf ratios of CMR increased with N treatments compared to the control in both experiments (Tables 2 and 3). The comparison of specific leaf weight (SLW) in the fertilizer treatments showed no significantly difference. These results confirmed that the potential use of SLW as a screening criterion for tropical carpetgrass was small under both growing seasons. The analysis of N content of different fertilizer concentration treatments showed a very significant difference (Tables 2 and 3).

Linear regression of dry weight-based (N_{dw}) or leaf area-based (N_a) N concentration on leaf CMR values was extremely significant ($P<0.001$) for both growing seasons (Figures 1 and 2). Figures 1 and 2 showed that CMR values were better correlated with N_{dw} than with N_a at both growing season, indicating that CMR estimated N_{dw} (R^2 values of 0.913, and 0.861) better than N_a (R^2

Table 3. Effect of nitrogen applications on chlorophyll meter reading (CMR) value of first and third fully expanded leaf, CMR 3/1 value, specific leaf weight (SLW) and dry weight based N (Ndw) of tropical carpetgrass during spring season.

Nitrogen rate (g N/m^2 per month)	**CMR**		**CMR 3/1**	**SLW**	**N_{dw}(%)**
	First leaf	**Third leaf**			
Control	26.7 ^{c*}	24.1 ^{d}	0.90 ^{c}	34.3 ^{a}	1.77 ^{c}
SLF 2.5	26.8 ^{c}	27.2 ^{d}	1.03 ^{b}	32.5 ^{ab}	1.93 ^{c}
SLF 7.5	39.8 ^{b}	44.8 ^{b}	1.13 ^{a}	28.7 ^{c}	2.51 ^{b}
AN 7.5	37.0 ^{b}	40.3 ^{c}	1.09 ^{ab}	28.5 ^{c}	2.62 ^{b}
AN15.0	44.0 ^{a}	48.4 ^{a}	1.10 ^{ab}	29.7 ^{bc}	3.56 ^{a}
AN 5.0 + SLF2.5	40.3 ^{ab}	40.3 ^{c}	1.00 ^{b}	29.5 ^{bc}	3.41 ^{a}

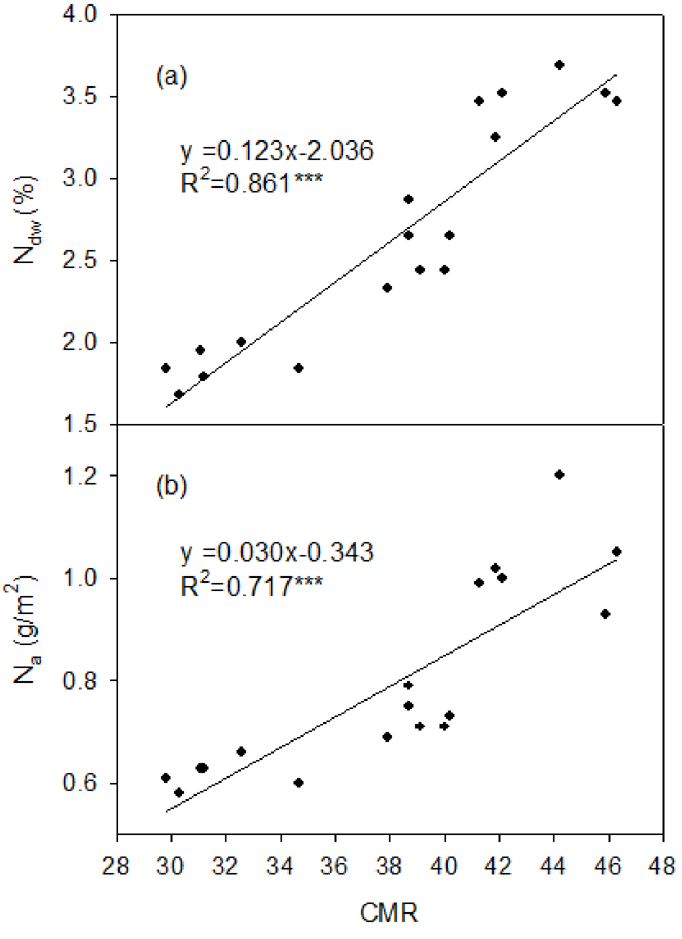

Figure 2. Regression between (a) dry weight-based (Ndw) and (b) area-based (Na) leaf nitrogen content on chlorophyll meter readings (CMR) of tropical carpetgrass in winter season.

values of 0.748, and 0.717) as a screening criterion. Thus, this study suggested that the N_{dw} is responsible for a significant amount of the variation in CMR.

The critical range of N was often estimated by the regression between total weight and the N quantity of leaves (Ulrich and Hills, 1976). The increase of N content can result in the growth of stolon dry weight, shoot dry weight, and total dry weight. The total dry weight was at the maximum when N_{dw} was 3.1%. On the other hand, the minimum of the critical range of N is 2.6% of the N content when total dry weight decreasing by 10% (Ulrich and Hills, 1976). From the measurement of CMR 3/1 in tropical carpetgrass, the CMR 3/1 of the samples with N are larger than 1, which means that the third leaf is greener than then the first leaf. According to Cheng (1996), when the first leaf was greener than the third leaf, it indicated an N deficiency. The CMR 3/1 of the samples without N in fall and spring are 0.66 (Table 1) and 0.90 (Table 2), respectively.

According to the regressions of the leaf N_{dw} and total dry weight, the critical range of N could be 2.6-3.1% (CMR is between 35 to 41). If based on the regressions of leaf N and CMR 3/1, the range of N could be 2.7-3.0% (CMR is between 39 to 42). Both ranges are close correlated. CMRoffer an alternative to tissue tests, and can aid in determining effective for application rates of N for turfgrass. Experimental data demonstrates that the use of chlorophyll meter to measure tropical carpetgrass growth and development is simple and effective. Future field evaluations should assess the association between CMR and the reference indicator of turfgrass N nutrition status, the Nitrogen Nutrition Index.

Conflict of Interests

The authors have not declared any conflict of interest.

REFERENCES

Cheng ZY (1996). Turfgrass Management. Shu-Xin Press, Taipei (In Chinese). pp. 211-212.

Denuit J, Olivier M, Goffaux M, Herman J, Goffart J, Destain J, Frankinet M (2002). Management of nitrogen fertilization of winter wheat and potato crops using the chlorophyll meter for crop nitrogen status assessment. Agronomie 22:847-853.

Giunta F, Motzo R, Deiddda M (2002). SPAD readings and associated leaf traits in durum wheat, barley and triticale culivars. Euphytica 125:197-205.

Kantety RV, Santen VE, Woods MF, Wood WC (1996). Chlorophyll meter predicts nitrogen status of tall fescue. J. Plant Nutr. 19:881-899.

Kooistra L, Salas EAL, Clevers JGPW, Wehrens R, Leuven RSEW, Nienhuis PH, Buydens LMC (2004). Exploring field vegetation reflectance as an indicator of soil contamination in river floodplains. Environ. Pollut. 127(2):281-290.

Kuo Y, Fermanian WT, Wehner JD (1999). Nitrogen utilization in creeping bentgrass. J. Turfgrass Manag. 3:31-48.

Morris KN (2001). A guide to NTEP turfgrass ratings. Retrieved date at Nov 11, 2007 at http://www.ntep.org/reports/ ratng.htm

Rodriguez IR, Miller LG (2000). Using a hand-held chlorophyll meter to determine the nitrogen status of St. Augustine grass. Hortic. Sci. 35:751-754.

Sharma TR, Pandey AK, Upadhyaya SD, Agrawal SB (2011). Effect of sources of nutrients and their levels on yield, quality and economics of summer season okra. Indian J. Hortic. 68:498-502.

Turner FT, Jund FM (1991). Chlorophyll meter to predict nitrogen topdress requirement for semidwarf rice. Agron. J. 83:926-928.

Turgeon AJ (2007). Turfgrass Management. 8th ed. Prentice-Hall Inc. New Jersey, USA.

Ulrich A, Hills JF (1976). Soil nitrate and the response of sugarbeets to fertilizer nitrogen. J. Am. Soc. Sugar Beet Technol. 19:118-124.

Wood CW, Reeves WD, Duffield RR, Edmisten LK (1992a). Field Chlorophyll measurements for evaluation of corn nitrogen status. J. Plant Nutr. 15:487-500.