Comparing the Accuracy of the Cardy Portable Nitrate Meter with Laboratory Analysis of Nitrate Concentrations in Summer Annual Forages

G.E. Selk, R.C. LeValley, G.A. Highfill, and D.S. Buchanan

Story in Brief

Fifty-two samples of forage sorghum summer annuals were evaluated for nitrate concentration by a Cardy Nitrate field test meter and then sent to the OSU Soil, Water and Forage Testing Laboratory for quantitative analysis. The samples were collected across two summers from five different counties in northwest Oklahoma. The correlation between the Cardy meter predicted nitrate concentration and laboratory analysis was r = 0.659. Average laboratory nitrate concentrations in year 1 (5368 ppm) were similar compared to year 2 (7463 ppm). The mean predicted nitrate concentrations from the Cardy meter were much greater in year 2 (14411 ppm) than year 1 (5771 ppm). The average deviation of the Cardy meter from the laboratory result was much greater in year 2 (7466 ppm) compared to year 1 (3018 ppm). As nitrate levels in the forages increased to very high levels, the deviation of the Cardy meter as compared to the laboratory analysis increased. The Cardy Nitrate field test meter appeared to be very sensitive to year-to-year variation.

Key Words: Nitrate, Cardy, Testing, Forage Sorghums, Cattle

Introduction

Toxicity from nitrate is an occasional problem in ruminants consuming certain annual forages, particularly sorghum hybrids. Nitrate accumulation usually results from plant stress such as drought and is accentuated by excessive soil nitrogen. Accumulation is usually triggered by some environmental stress, where plant growth is restricted but absorption of nitrate from soil continues. Other stress factors which favor buildup are reduced sunlight from cloudiness or shading, frost, certain herbicides including 2,4-D, acid soils, low growing temperatures, and deficiencies of essential nutrients like phosphorus and sulfur.

These high nitrate plants, either standing in the field, or fed as hay, can cause abortion in pregnant cattle or death, if consumed in great enough quantities. Nitrates do not dissipate from suncured hay (in contrast to prussic acid), therefore once the hay is cut, the nitrate levels remain constant. Therefore, producers should test fields before they cut them for hay. Many county extension educators and veterinarians routinely conduct qualitative diphenylamine tests for the presence or absence of nitrate in forage samples. The "Cardy NO_3 Nitrate Meter" is a small digital readout meter used frequently for testing nitrate concentrations in water. It has been used in other states for testing the nitrate content of sap from fresh forage samples. Therefore five Cardy meters were placed in five northwest Oklahoma county extension offices for use by OSU County Extension Agriculture Educators. The educators determined quantitatively the nitrate content of forage samples using the Cardy meter and those results were compared with the concentration found in the same samples by the OSU Soil, Water, and Forage Testing laboratory. This study was conducted to evaluate the "Cardy" meter as a replacement for the diphenylamine qualitative test for nitrate.

Materials and Methods

Five OSU County Extension Agriculture Educators from northwest Oklahoma were trained to use the "Cardy NO_3 Nitrate Meter" (Spectrum Technologies, Inc., Springfield, IL.) . The five meters were available in the County Extension offices for two summers. Fifty-two summer annual sorghum forage samples were tested using the Cardy meter and then the samples were sent to Stillwater to the Oklahoma State University Soil, Water, and Forage Analytical Laboratory (SWFAL). Four counties submitted samples in year 1. Three counties submitted samples in year 2. Only two counties submitted samples both years. After the meter is calibrated using appropriate standard solutions, the measurement can be taken. Five plants from each sample

were randomly selected and cut at a similar height to that of harvest. The plant samples were cut into 6-inch long pieces and cut again to shorter one-inch pieces. These pieces were then mixed into a small pile. A portion of the fresh forage pieces consisting of leaves and stems were then placed in a garlic press. The garlic press then was squeezed so that sap from the forage could be collected in small clean dry container. With an eye-dropper, 3 or 4 drops of sap are placed onto the sampling sheet. The saturated sampling sheet is then transferred with tweezers to cover the electrodes on the meter. Once the reading is stabilized, the number is recorded. The electrodes are then rinsed with distilled water and blotted dry. A multiplicative conversion factor is used to convert the meter reading to nitrate concentration in part per million. Nitrate concentrations in Sudangrass hybrids were predicted by multiplying the Cardy readout by 3.64 and the concentrations in Pearl Millets were estimated by multiplying the Cardy readout by 4.40. (Zhang, 1998 et al.) The method used to determine nitrate concentration in forage samples at SWFAL was a colorimetric procedure using a Lachat Flow Injection Auto Analyzer. All of the nitrate concentrations (both in the field test and the laboratory analysis) were calculated to a 100% dry matter basis. The deviation of the Cardy meter predicted nitrate concentration from the SWFAL nitrate concentration was calculated on each sample by using the absolute value of the difference of the Cardy predicted value from the SWFAL value.

The data were analyzed using ordinary least squares (PROC GLM, SAS Institute, Cary, NC). The model included year as a main effect and county within year as a nested effect. Correlations reported are pooled within-class (county, year) correlations.

Results and Discussion

The mean nitrate for all counties was 5368 ppm in year 1 and 7463 ppm in year 2. Year was not a statistically significant source of variation in the SWFAL nitrate readings. The mean predicted nitrate concentration from the Cardy meters was similar (to SWFAL report) in year 1 (5771 ppm) but much greater ($p<.01$) in year 2 (14412 ppm). The deviations were greater ($p<.01$) in year 2 than in year 1. Only in one county in 1999 were the deviations of the Cardy from the SWFAL not statistically different from zero. The statistically significant correlation between the Cardy meter and the SWFAL analysis for all 52 samples was $r = 0.659$. Table 1 contains the mean Cardy predicted nitrate concentrations and the SWFAL nitrate concentrations in parts per million for each county each year. Table 1 also contains the deviation of the Cardy predicted nitrate concentrations from the SWFAL concentrations.

Table 1. Least square means of nitrate concentrations (ppm) as predicted by Cardy meter, by OSU Soil, Water, and Forage Analytical Laboratory (SWFAL) and the deviation of between the two reports

	Cardy predicted nitrate (ppm)	SWFAL nitrate concentration (ppm)	Deviation of SWFAL – Cardy (absolute value)
Year 1 (1999)			
County 1 (n=8)	7689	7413	4061*
County 2 (n=4)	5888	7153	4700*
County 3 (n=12)	7699	5932	2447*
County 4 (n=3)	1808	973	864
Mean for Year (n=27)	5771	5368	3018*
Year 2 (2000)			
County 1 (n=16)	6502	3623	3180*

County 3 (n=3)	20141	4933	15208*
County 5 (n=6)	16592	13832	4010*
Mean for Year (n=25)	14412	7462	7466*
			*different from zero (p<.05)

In figure 1 is a graphic depiction of the Cardy nitrate meter predicted value plotted against the SWFAL result for each of the 52 samples. The correlation of the Cardy meter (r= 0.55) with the absolute value of the deviation indicated that as the nitrate concentration increased the deviation increased.

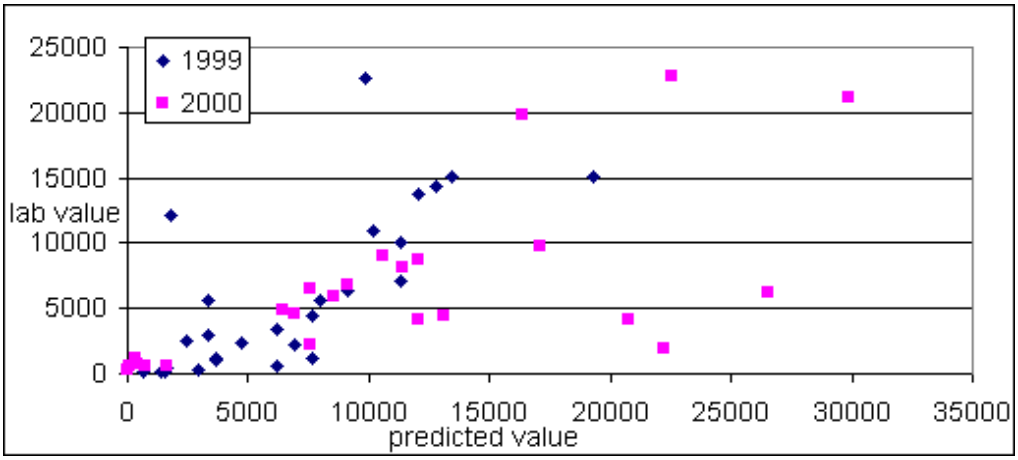

Figure 1. Cardy meter predicted nitrate value (horizontal axis) plotted against SWFAL value for 52 forage sorghum samples in 1999 and 2000. R=0.659

Implications

The Cardy nitrate meter has been shown in previous work to adequately predict the nitrate concentration in fresh forage plants. The previous work was conducted by one trained individual on fewer samples and with a new well-maintained meter (Zhang, et al., 1998). The current study indicated that the Cardy meter was sensitive to individual technician differences and may have been less effective the second year of use as compared to the first year. As the nitrate concentration being measure by the Cardy meter increased, the deviation from the SWFAL lab report increased. This may indicate that the Cardy is not well suited for reading very high nitrate concentrations with accuracy. Better care in meter handling and sample preparation may have produced more accurate readings. Improved maintenance of the meters may also have improved their accuracy the second year.

Literature Cited

Zhang, et al. 1998. Quick Nitrate Test for Hybrid Sudangrass and Pearl Millet Hays. 1998 Forage Management College. Stillwater, Ok. PT Vol. 10, No. 31:2127

Author's List

Selk, Glenn-Extension Animal Reproduction Specialist, Animal Science, OSU

LeValley, Robert-Area Extension Livestock Specialist

Highfill, Greg-Area Extension Livestock Specialist

Buchanan, David-Professor, Animal Science, OSU