Quick Tests for Sap Nitrate in Small Grains, Maricopa, 1997

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Interpretive Summary

Nitrate content of the lower stem tissue of small grains is used as a guideline for nitrogen fertilization. The turnaround time for nitrate analysis in a commercial lab is usually 1 to 3 days. Nitrate quick tests have been suggested as a means of obtaining results on a more timely basis. The quick tests analyze nitrate in the sap or juice squeezed out of the tissue. A nitrate test conducted by a commercial lab is performed on the dried and ground tissue. In this study, I found that the quick tests on plant sap are not as accurate as conventional tests on dried tissue since the moisture content of the fresh plant tissue varies depending on its nitrate content and the growth stage of the plant. We compared the following quick test methods: nitrate test strips, a colorimetric procedure, and a hand held nitrate electrode. Nitrate test strips were not sensitive enough to be useful and were difficult to compare to the color charts. An electronic strip reader could alleviate this difficulty and make the strips a viable option. Colorimetric procedures, or those that rely on nitrate producing a colored solution with certain chemicals added, are not adapted to analyzing plant sap since the green color and organics in the sap interfer with the color produced by the nitrate. The hand held nitrate electrode, or Cardi meter, was the simplest and most accurate method we experimented tested. Quick tests for nitrate in the sap have the following disadvantages: 1) It is not easy to squeeze the sap out of the plant tissue, 2) The sap needs to be diluted to fit into the analytical range of the test, and 3) The moisture content of the tissue needs to be accounted for somehow for the results to be most accurate.

Introduction

Nitrogen tissue tests are available as guidelines for nitrogen fertilization of small grains in Arizona. The laboratory test for nitrate in the lower stem tissue usually takes a few days, however, and tests for nitrogen that can be conducted in the field have the obvious advantage of timeliness. Several quick test methods are available and all rely on sap squeezed out of the plant tissue with a garlic press or hydraulic press: 1) Nitrate test strips - small strips of paper are impregnated with chemicals that turn color when reacting with nitrate. The nitrate level is determined by comparing the color developed on the strip with colors on a comparator chart indicating various nitrate levels or by using an electronic test strip reader that determines nitrate level automatically; 2) Colorimetric test kits - portable laboratories in a sense where the sap is added to a test tube, chemicals and water are added, the color developed is related to nitrate level using a color comparator wheel or a colorimeter which reads the color development directly; and 3) Portable nitrate electrode (Cardi meter) - a drop of the sap is placed directly on a spot on a hand held instrument about the size of a small calculator that reads nitrate level directly. These tests can be conducted in the field but it is generally more convenient to do them in an air-conditioned building. The portable nitrate electrode, in particular, is affected by temperature and results are more accurate at room temperature. The purpose of this study was to determine the ease of use of the various nitrate quick test methods and to determine how accurately the results from these tests correlate with the standard nitrate laboratory procedure that relies on dried stem tissue rather than sap extracted from the tissue.

Procedure

Field 117 at the Maricopa Agricultural Center was used for this study. The soil type at this location is a Casa Grande sandy loam. The field was in sudangrass the previous summer. Preplant soil phosphate was 8.1 ppm. Before planting, urea was spread by hand at rates of 0, 80, and 160 lbs N/acre to plots 16 ft. by 25 ft to establish deficient, adequate, and excessive levels of nitrogen. Phosphorus fertilizer was also applied at this time at a rate of 50 lbs P_2O_5/acre as 0-45-0. The fertilizer was worked into the soil with a spring tooth harrow. Seed was planted with a grain drill into dry soil on December 4, 1996, and a germination irrigation was applied on December 6. Gustoe barley and Kronos durum were planted in 12 ft wide strips at a seeding rate of 110 lbs/A for the barley and 130 lbs/A for the wheat in a randomized complete block design with the three nitrogen rates as subplots, and replicated four times. The plots were trimmed to 21 ft. with a rototiller. The plots were irrigated on December 6, January 31, February 26, March 19, April 1, and April 18. Urea was applied by hand during the season to maintain deficient, adequate, and excessive nitrogen levels. UAN32 was applied in the irrigation water at a rate of 25 lbs N/acre on April 1. See Table 1 for a schedule of nitrogen application. The lower part of the stem was sampled on Jan 23, Feb 18, and March 18 at the 5 leaf, 2 node, and late heading stages, respectively. The samples were refrigerated for one or two days after sampling and split for drying and sap analysis on the day the sap was to be extracted and tested. Half of each sample was kept for sap extraction and nitrate quick testing; the other half was dried in an oven at 65 degrees C and moisture determined, and then ground and analyzed for nitrate. Nitrogen quick testing methods used were the nitrate strip (EM strips), colorimetric testing (N trak by Hach), and a portable nitrate electrode. For sap extraction, the lower stem tissue was cut into small pieces and the sap was extracted with a hydraulic press. The nitrate in the sap was then analyzed according to the procedure for each test. The sap was diluted to fit into the analytical range for each test (Table 2). Heading, anthesis, and physiological maturity dates were noted. The plots were harvested with a small plot combine on May 21 from a 5 ft. x 21 ft area. Grain yield was adjusted to an 8% moisture basis and test weight, kernel weight, and plant height were also measured at harvest. No lodging occurred. Kernel weight was determined from 10 g of hand picked seed.

Results and Discussion

The influence of the plant nitrogen status due to nitrogen rate on grain yield and other characteristics is presented in Table 3. The intended adequate nitrogen level was indeed adequate since grain yields were maximized at this level. Excessive nitrogen decreased yield of Gustoe. The higher nitrogen rates resulted in taller plants, delayed maturity, and affected other characteristics.

The nitrate content in the stems and sap for three sampling dates is presented in Table 4. Stem and sap nitrate were greatly influenced by sampling date, variety, and nitrogen level as expected and intended. The moisture content of the plant tissue also varied considerably. Stem moisture content was lower for the deficient nitrogen rates compared to the adequate and excessive rates. Also, stem moisture tended to decrease with time as the plant developed. The sap was not easily extracted from the stem samples. A garlic press was tried but not very effective in extracting the sap, so a hydraulic press was used instead. A problem with all the quick test procedures was that the sap had to be diluted to fit within the working range of each procedure. The working ranges for nitrate-N were 0 to 100 ppm for the EM strips, 0 to 45 ppm for N-trak, and 0 to 400 ppm for the Cardi meter while the sap was in the range of near 0 to above 1000 ppm. The EM strips were very difficult to read. The difference in color between low and high nitrate levels obtained with these strips was not great and was difficult to distinguish. Also, the color was sometimes mottled which increased the difficulty of assigning a nitrate value based on the color chart. An automatic color strip reader would probably eliminate this problem. The N-trak test kit was not accurate since the green color of the sap interfered with reading the brown color that developed as a result of the presence of nitrate. Any colorimetric method would have this problem. The N-trak test kit was actually designed for soils. Another problem with the N-trak procedure is that color development was suppressed at high nitrate levels possibly due to organics in the sap coating and reducing the effectiveness of the reducing agent in the test kit. The Cardi meter was the easiest quick test method for nitrate to use and seemed the most reproducible. Some dilution of the sap sample was necessary and the meter had to be standardized, but no comparator chart was necessary, no chemicals needed to be mixed, and the nitrate level is presented on an LCD readout.

Regressions of stem nitrate on a wet or dry basis with sap nitrate concentration as determined by the various methods is presented in Figure 1. The relationship between stem nitrate concentration and sap nitrate as determined by the various methods is not strong enough to substitute sap nitrate for stem nitrate in our current tissue testing recommendations. However, it appears that if the moisture content of the stem is taken into account as is done

when stem nitrate on a wet basis is compared to sap nitrate, then using sap nitrate concentration may be a viable alternative to stem nitrate concentration as typically measured by a commercial lab. The Cardi meter is the most accurate of the methods we tested to measure sap nitrate.

Acknowledgments

The technical assistance of Mike Sheedy and Dave Parsons is greatly appreciated. This projected was funded by the Arizona Grain Research and Promotion Council.

Table 1. Nitrogen fertilizer schedule.

Date	Stage	Fertilizer	Deficient	Adequate	Excessive
			———	lbs N/acre	———
Dec 3	Planting	Urea	0	80	160
Jan 27	5 leaf	Urea	50	50	75
Feb 25	2 node	Urea	25	50	75
Apr 1	Kernel watery	UAN32	25	25	25
TOTAL			100	205	335

Table 2. Sap dilution used at the various sampling dates for the three nitrate quick testing methods. These dilutions were not necessarily optimum.

Date sampled	EM strip	N-trak	Cardi meter
	———	sap dilution	———
Jan 23	1:21	1:42	1:21
Feb 18	1:70	1:28	1:7
Mar 18	1:40	1:16	1:4

Table 3. The influence of nitrogen on grain yield and other characteristics.

Variety	Nitrogen	Grain Yield[a]	Test Weight	1000 Kernel Weight	Plant Height	Heading	Anthesis	Physio-logical Maturity
		lbs/A	lbs/bu	grams	inches			
Gustoe	Deficient	4211	51.9	43.9	22	3-20	3-20	4-20
	Adequate	5041	51.8	38.6	26	3-22	3-22	4-23
	Excessive	3713	—	43.3	29	3-23	3-23	4-27
Kronos	Deficient	4854	61.8	60.3	30	3-15	3-21	4-26
	Adequate	7364	62.0	55.7	33	3-13	3-20	4-27
	Excessive	7208	61.0	55.4	31	3-13	3-20	4-28

[a] The least significant difference at the 5% probability level ($LSD_{.05}$) for grain yield is 944 lbs/acre for Gustoe and 673 lbs/acre for Kronos.

Table 4. Moisture content, stem nitrate on a wet and dry basis, and sap nitrate concentration using various quick testing methods as influenced by date, variety, and nitrogen level. Nitrate is expressed as nitrate-N. Each number is an average of four replications.

Date	Variety	Nitrogen	Moisture	Stem nitrate on "dry" basis	Stem nitrate on "wet" basis	Sap nitrate by EM Strip	Sap nitrate by N-trak	Sap nitrate by Cardi meter
			%	ppm	ppm	ppm	ppm	ppm
Jan 23	Gustoe	Deficient	77	321	75	24	105	142
		Adequate	87	3034	391	261	221	436
		Excessive	88	6105	755	533	326	625
	Kronos	Deficient	76	337	82	53	147	179
		Adequate	84	6104	987	1008	462	1024
		Excessive	84	7077	1131	1511	504	1307
Feb 18	Gustoe	Deficient	80	1242	146	138	175	210
		Adequate	83	1611	159	138	175	205
		Excessive	84	7362	619	395	385	572
	Kronos	Deficient	79	2013	275	356	308	483
		Adequate	80	2941	378	356	287	529
		Excessive	81	7437	909	711	625	1050
Mar 18	Gustoe	Deficient	83	207	36	0	—	102
		Adequate	79	305	62	10	—	137
		Excessive	81	3165	591	244	—	424
	Kronos	Deficient	77	179	40	4	—	122
		Adequate	77	615	134	55	—	196
		Excessive	80	3741	754	478	—	819

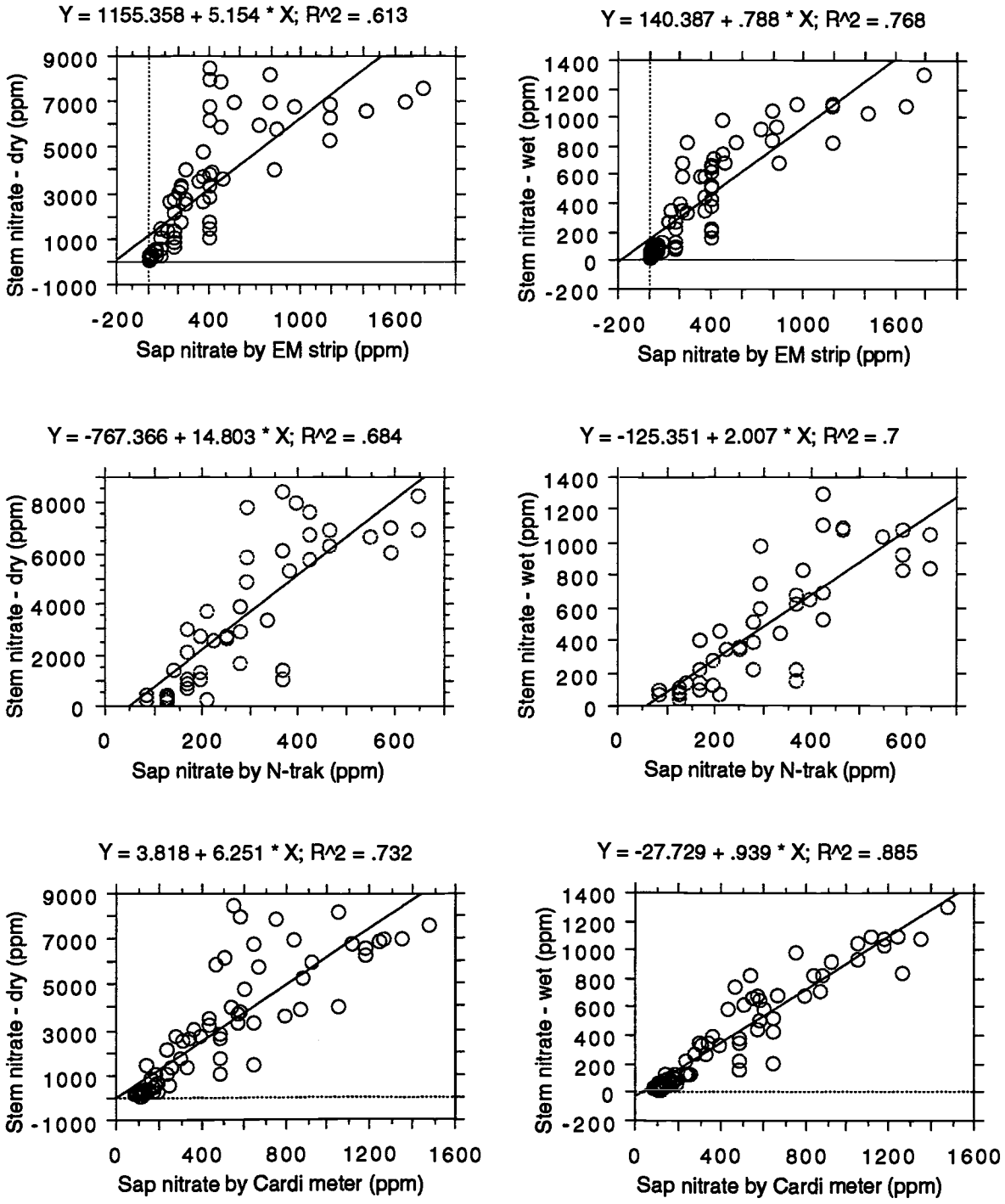

Figure 1. Regressions of stem nitrate on a dry or wet basis with sap nitrate concentration as determined by EM strips, N-trak, and the Cardi meter.