Plant Sap Test for Foliar N, K, Mn, and Lime on Soybean and Cotton

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Objective and Relevance: Soybean and cotton farmers could benefit from rapid, inexpensive methods to evaluate crop tissue or sap to determine when mid-season foliar sprays are needed to maximize yields. Horticulture crop growers measure plant sap in tomatoes, potatoes, and lettuce as a tool for managing N. Water districts in California published leaf sap nitrate-nitrogen sufficiency guide sheets for testing fresh sap from broccoli, brussel sprouts, cabbage, cauliflower, celery, lettuce, spinach, and onions.

The objective of this study is to evaluate field ion-selective electrode meters, colorimeters, and color indicator strip tests on soybean and cotton plants growing on a range of soil test levels and foliar fertilizer N, K, and Mn applications. We hope to develop a fast testing process which works like a diabetic person pricking his finger and testing for blood sugar.

Procedure: Soil samples were collected from fields at the Fisher Delta Center at Portageville, Rhodes Farm at Clarkton, Greenley Center at Novelty, and Missouri Rice Research Farm at Qulin, Missouri. Soybean and cotton was planted in small plots in fields with soil test levels in the low and medium ranges for potassium and manganese. Cotton was also planted at Clarkton to evaluate N quick tests. Fertilizer treatments for K , Mn, and N included a untreated check, recommended dry preplant fertilizer and several timings and sources of foliar fertilizer. Each treatment was replicated five times. Leaves and petioles from each soybean and cotton plot were collected. Samples were collected at V7, R1, and R1+ 1 week growth stages followed by foliar sprays of each nutrient on treatments using a CO_2 backpack sprayer. Plots were visually rated for leaf burn at 3, 7, and 14 dates after foliar applications. Leaf and petiole samples were frozen in plastic bags until they could be processed. A garlic press was used to squeeze leaf and petiole sap. Cotton tissue nitrate-N was measured by Horiba® Cardy nitrate meter, Hach® Colorimeter, and Quant® Nitrate test Strips. Duplicate samples were oven dried and tested in the Delta Center Lab with a nitrate ion-selective electrode. A plot combine and cotton picker were used to mechanically harvest plots. Yield response to foliar spray will be correlated with leaf sap meter reading to determine best growth stages and leaf stems to sample.

Preliminary Results: Several of the "soluble' potassium fertilizers did not dissolve sufficiently in 15 gallons per acre. To apply the targets amounts, we had to apply more water and spray some plots twice. This would not be practical for farmers. A significant soybean yield increase was found at Novelty and Qulin from applying preplant potash (Table 1). In soybean plots, none of the foliar K treatments produced significant yield increases compared to the untreated check. At Novelty, significant leaf burn occurred with Re-NforceK. For cotton, most of the K treatments showed no yield increases, but three application of KNO_3 did significantly increase lint yield compared to the check. No significant soybean yield increases were found from Mn soil or foliar fertilizers at Novelty or Clarkton (Table 2). Likewise, N did not increase cotton lint yields at Clarkton (Table 3). This field had been used in winter legume cover crop research in the past and may have N released from organic matter during the year. We are currently in the process of making quick test measurements from frozen samples collected during the season and comparing the results to duplicate leaf and petiole samples test at the Delta Center Soil Lab (Figure 1, Table 4). This winter we are going soybean and cotton in vermiculite pots in the greenhouse with nutrient solutions formulated to create deficiencies in N, P, and K. Toxic levels of Mn and Al are also being studied. Quick tests will be used on these plants.

Table 1. Soybean and cotton yield response to soil and foliar potassium treatments at Novelty, Qulin, and Clarkton, Missouri in 2011.

Trt	Fertililizer	Preplant	V7	R1	R1 + 1 wk	Novelty	Qulin	Clarkton
						soybean		cotton
		----------lb K20/a----------				--------bu/a----------		lb lint /a
Check			0	0	0	44 ab†	53 cd	987 b
Soil	Potash	120	0	0	0	47 a	61 a	930 b
Bdcst	Potash	0	0	0	60	45 ab	53 cd	911 b
Foliar	White Sol Potash	0	19	19	19	43 bc	53 cd	1039 b
Foliar	White Sol Potash	0	0	19	19	43 bc	52 cd	1010 b
Foliar	White Sol Potash	0	0	0	19	44 ab	57 abc	949 b
Foliar	KNO3	0	4.62	4.62	4.62	46 ab	55 abc	1217 a
Foliar	KNO3	0	0	4.62	4.62	44 ab	56 abc	970 b
Foliar	KNO3	0	0	0	4.62	43 bc	60 ab	960 b
Foliar	Re-NforceK	0	4.68	4.68	4.68	38 e	54 bc	985 b
Foliar	Re-NforceK	0	0	4.68	4.68	41 cd	48 d	1048 b
Foliar	Re-NforceK	0	0	0	4.68	39 de	52 cd	963 b

†Yields followed by the same letter were not significantly different at the 0.05 level.

Table 2. Soybean yield response to soil and foliar manganese treatments at Novelty and Qulin, Missouri in 2011.

Trt	Fertililizer	Preplant	V7	R1	R1+1 wk	Novelty	Clarkton
			----------lb Mn/acre--------			-----bu/acre----	
Check		0	0	0	0	43 a†	43 a
Soil	Mn sulfate 6%	4	0	0	0	43 a	40 ab
Foliar	Chelated EDTA Mn	0	0.25	0.25	0.25	43 a	31 cd
Foliar	Chelated EDTA Mn	0	0	0.25	0.25	43 a	40 ab
Foliar	Chelated EDTA Mn	0	0	0.5	0	42 a	32 cd
Foliar	Chelated EDTA Mn + glyphosate	0	0	0.5	0	42 a	28 d
Foliar	Mn sulfate + glyphosate	0	0	0.5	0	44 a	35 bc
Foliar	Gluco Mn + glyphosate	0	0	0.5	0	43 a	39 ab
Foliar	glyphosate alone	0	0	0.5	0	44 a	42 a

†Yields followed by the same letter were not significantly different at the 0.05 level.

Table 3. Cotton yield response to soil and foliar nitrogen treatments at Clarkton, Missouri in 2011.

Treatment	Fertilizer	Preplant	V12	First Blm	Blm +1 wk	Cotton
		----------lb N/acre----------				lb lint/acre
Check	----	0	0	0	0	959 a†
med N	soil	40	0	0	0	1120 a
high N	soil	120	0	0	0	994 a
low N foliar	Foliar KNO3	0	4.62	4.62	4.62	1082 a
low N foliar	Foliar KNO3	0	0	4.62	4.62	1070 a
low N foliar	Foliar KNO3	0	0	0	4.62	1106 a
med N foliar	Am nitrate + foliar KNO3	40	4.62	4.62	4.62	1136 a
med N foliar	Am nitrate + foliar KNO3	40	0	4.62	4.62	1032 a
med N foliar	Am nitrate + foliar KNO3	40	0	0	4.62	1122 a

†Yields followed by the same letter were not significantly different at the 0.05 level.

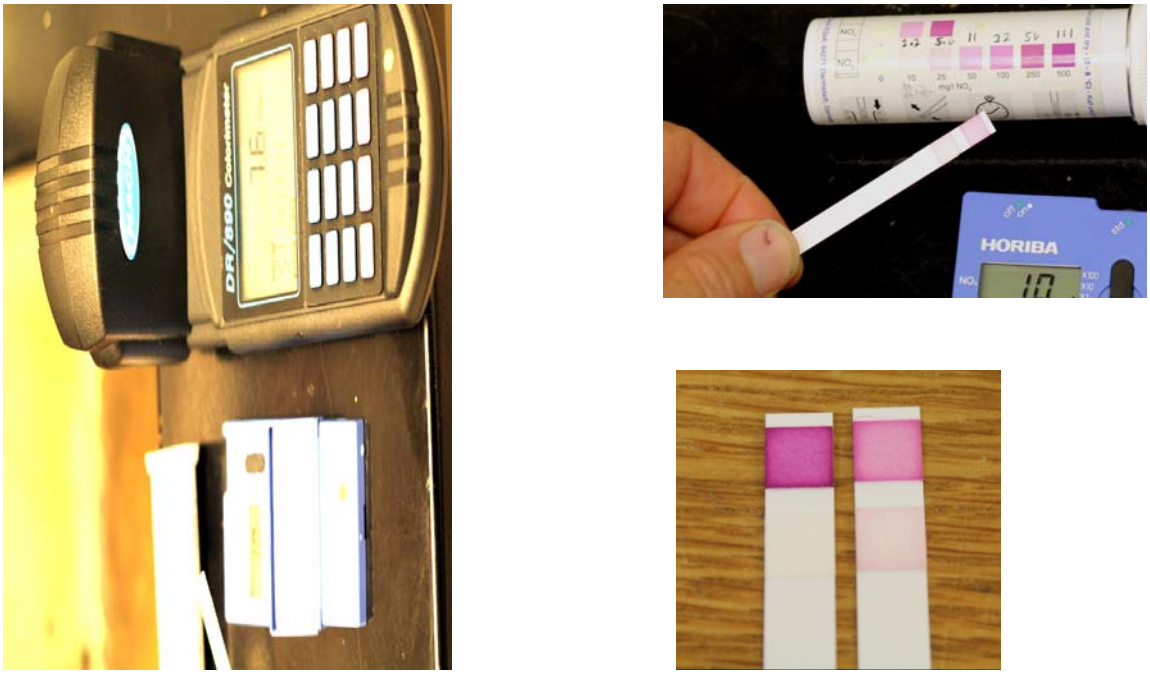

Figure 1. Portable nitrate meter, colorimeter, and nitrate test strips used to measure sap nitrate.

Table 4. Cotton tissue nitrate-N measured by ion selective electrode (ISE) from oven dried and ground leaves and petioles and quick test sap squeezed from frozen green leaves and petioles collected at V7, first bloom, and R1+ 1 week and measure by Horiba® Cardy nitrate meter, Hach® Colorimeter, and Quant® Nitrate test Strips.

Plant N	Plant part	Growth stage	Cardy meter	Hach colorimeter	Quant strip	Soil Lab ISE meter
			----------sap ppm Nitrate-N----------			dry sample
0	Leaves	V12	767 a†	760 a	1116 a	44,833 b
120		V12	1366 a	757 a	753 a	103,485 b
0		1st Bloom	1233 a	477 a	146 a	10,055 b
120		1st Bloom	1100 a	263 a	3866 a	22,706 b
0		R1+1week	733 a	453 a	183 a	12,197 b
120		R1+1week	666 a	66 a	440 a	20,848 b
0	Petioles	V12	1233 a	387 a	2586 a	1,809,325 a
120		V12	700 a	223 a	1387 a	2,159,460 a
0		1st Bloom	267 a	73 a	67 a	13,177 b
120		1st Bloom	1133 a	220 a	100 a	443,000 b
0		R1+1week	300 a	240 a	107 a	36,649 b
120		R1+1week	1316 a	433 a	1727 a	545,864 b

†Yields followed by the same letter were not significantly different at the 0.05 level.

Budget:

	2012	2013
Labor- research assistant	$15,000	$15,000
MU Soil Lab tissue testing	$2500	$3000
Supplies and travel	$2000	$2000
Total	$19,500	$20,000