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

Gene Stevens, Matt Rhine, Jim Heiser, and David Dunn

Current status/importance of research area: This project will address three questions concerning fertilizer and lime- (1) What are the critical leaf stem sap N, K, and Mn ranges, at different growth stages, for applying foliar fertilizer on cotton and soybean? (2) Can high Mn or Al concentrations in leaf or root sap be used as an indicator that lime is needed in the field? (3) Which leaf or stems are best to sample for testing nutrients in sap for soybean and cotton plants?

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 (Burns and Hutsby, 1986; Prasad and Spiers, 1985; Moraghan, 1985; and Nitsch and Varis, 1991). 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 (Monterey Co. Water Resources Agency, 1999).

Objective: To evaluate field ion-selective electrode meters, reflectometers, and rapid chemical tests on soybean and cotton plants growing on a range of soil test levels and foliar fertilizer N, K, and Mn applications. The testing process will be similar to a diabetic person pricking his finger and testing for blood sugar. A garlic press or similar device will be used to squeeze leaf petiole sap on an ion-selective sensor or colored test strip that is inserted in a meter (size of cell phone). Duplicate samples will also be tested in the Delta Center Lab to strengthen our understanding of conventional lab tissue testing for farmers that bring in samples.

Procedure: Soil samples submitted by farmers to the Delta Center Soil Test Lab will be screened to find potential cooperators with soybean and cotton fields with low soil K, Mn, and pH. Small plot replicated trials on each site will be conducted with five rates each of K, N on cotton and K, Mn on soybean. During the growing season, leaf petioles will be collected and tested using methods described in paragraphs below followed by foliar sprays of each nutrient using a CO_2 backpack sprayer. A plot combine and cotton picker will mechanically harvest plots for yield. Yield response to foliar spray will be correlated with leaf sap meter reading to develop critical levels and determine the best time and leaf stems to sample from plants.

<u>Potassium</u> is a regulator nutrient which controls opening and closing of stomata (pores) on the underside of leaves of all crops. Plant failure to control stomata opening negatively impacts carbon dioxide intake needed for photosynthesis and water leaf transpiration to cool the plant. Potassium does not become part of the structural tissues of the plant but remains mobile in the plant sap. At the University of Missouri-Delta Center, we developed an effective procedure for measuring basal stem sap in rice plants using a portable ion specific electrode (Horiba® Cardy K^+ meter). This was correlated with yield response in plots to determine if mid-season K fertilizer is needed (Dunn et al. 2004). We proposed to do the same thing with soybean and cotton using a Cardy K^+ meter. Burns and Hutsby (1986) found K analysis with immature lettuce leaves gave the best results. We will test sap from different soybean and cotton leaves.

<u>Nitrogen.</u> Measuring leaf N sap with a Cardy nitrate-N meter (another ion selective electrode) is less reliable than measuring sap on N test strips read with a reflectometer (Nitsch and Varis, 1991). For nitrate, a reflectometer (Reflectoquant®) measures the intensity of red-violet azo dye when a drop of plant sap is squeezed on a test strip. Disposable test strips contain a chemical which reduces nitrate to nitrite. In the presence of an acid buffer, the nitrite is

converted to nitrous acid, which diazotizes an aromatic amine. Coupling with N-(1-naphthyl) ethylenediamine produces a violet color as N content in sap increases.

Manganese is required in moderation by crops. Excessive soluble Mn, common on acid soils, causes toxicity indicating lime is needed. Soybeans on black sands around Benton, Missouri often show Mn deficiency symptoms. Mn deficiency and glyphosate-resistant soybean have been linked. Manganese is an enzyme activator for photosynthesis and nitrogen metabolism in plants. In some soybean varieties, Mn deficiency causes “yellow flash” on leaves after spraying with glyphosate. Scientists have speculated that soybean root uptake and/or metabolism of Mn is reduced by either the glyphosate gene in soybean, the glyphosate application itself, or a combination of both (Conley and Laboski, 2008). O’Sullivan and Flynn (1974) reported on a simple method of identifying Mn deficiency in the field my measuring peroxidase enzyme activity. Peroxidase content in soybean plants increases as Mn decreases. In field tests, time is recorded, in seconds, for blue color to appear after chemical is added to react with tissue peroxidase. A lookup table will be made to correlate reaction time with leaf Mn.

Aluminum is not an essential plant nutrient but can be absorbed by roots and cause toxicity in soybean and cotton. In low pH soils, Al becomes highly soluble, like Mn. Al^{+3} in acid soil primarily accumulate in soybean roots (Yang et al., 2009). A test strip is sold to measure Al^{+3} with a reflectometer. In the test, Al^{+3} ions are transformed into aluminate, which in turn reacts with aurin tricarboxylic acid to form a red complex. Intensity of the red color on test strips will be measured with the same reflectometer. We will test cotton and soybean sap from leaf stems and tap roots from acid fields to determine if test strip can be indicators of low soil pH.

Timetable for proposed research: This will be a three-year project (2011-2013).

February-March	Screen soil test results from Delta Center Lab. Also sample ranges at Delta Center. Contact growers with fields low in K, Mn or pH. Resample fields to confirm diagnosis, measure plots and weigh fertilizer and lime.
April-September	Plant plots, soil apply nutrients and lime, measure leaf stems with meters, and foliar spray fertilizers.
October-January	Harvest plots and correlate yields with meter readings.

Strategy for application/transfer of knowledge: Results will be presented at field days and extension crop production conferences. Information will be posted on the Delta Center Crop Production website (http://plantsci.missouri.edu/deltacrops). Articles will we written for Mid-America Farmer magazine. When the study is completed a final report will be written and a manuscript submitted to scientific journal such as the Journal of Plant Nutrition.

Budget:

	2011	2012	2013
Labor- research assistant	$15,000	$15,000	$15,000
MU Soil Lab tissue testing	$2000	$2500	$3000
Supplies and travel	$1500	$2000	$2000
Total	$18,500	$19,500	$20,000

Literature Cited

Burns, I. and W. Hutsby. 1986. Choice of leaf for estimation of K status by analysis of petiole sap. J. Sci of Food and Agric. 37:115-128.

Conley, S.P., and C.A.M. Laboski. 2008. Does glyphosate interact with Mn in soybean? *In:* Proc. Wis. Fertilizer, Aglime and Pest Mgmt. Conf., Madison, WI, Jan. 15-17, 2008.

Dunn, D. and J. Wrather, G. Stevens, M. Kenty, D. Beighley, and M. Aide. 2004. Measuring K+ in rice basal sap with a Cardy meter. Online 10.1094/CM-2004-1006-01-RS.

Moraghan, J.T. 1985. Plant tissue testing for micronutrient deficiencies and toxicities. Fertilizer Research, 7:201-219.

Monterey County California Water Resources Water Resources Agency. 1999. On-farm nitrogen determination in plant sap, soil, and water. Fact Sheet 5.

Nitsch, A. and E. Varis. 1991. Nitrate estimates using the Nitrachek Test for precise N-fertilization during growth and after harvest, for quality testing potato tubers.

O'Sullivan, M. and M. Flynn. 1974. A simple method of identifying manganese deficiency in the field. Irish J Agr Res. 13:234-240.

Prasad, M. and T. Spiers. 2003. A rapid nitrate sap test for outdoor tomatoes. Scientia Horticulturae. 25:211-215.

Yang, Z., J. You, M. Xu, and Z. Yang. 2009. Interaction between aluminum toxicity and manganese toxity in soybean (Glycine max). Plant Soil. 319:277-289.