Traditional Tools and New Technology Play Key Roles in Site-Specific Management

By A.E. Ludwick

The goal of any diagnostic program should be to evaluate and correct potential deficiencies before they actually occur and cause yield losses. The photos on pages 8 through 15 present symptoms expressed by crops when they are seriously deficient. Since significant production losses can occur even when plants express little or no obvious visual symptoms, growers should hope to never see these symptoms in their fields.

In-season diagnosis offers the opportunity to fine-tune fertilizer recommendations, adjusting rates according to changes in yield potential and in environmental conditions as the season progresses. It has been most widely used over the years for nitrogen (N) fertilization where multiple applications are made in an attempt to enhance plant uptake efficiency and to minimize nitrate loss below the root zone. In-season diagnosis is also used for a spectrum of other nutrients, especially in irrigated and high cash value systems.

The pre-sidedressing soil nitrate test (PSNT) is proving to be a valuable research tool and holds promise for on-farm production systems as diverse as field corn in the Midwest and vegetables in the Salinas Valley of California. "Quick tests" make PSNT useful by eliminating costly time delays in obtaining and implementing the results. Samples may be run in the field or collected and run at the end of the day back at a central location. Quantitative procedures utilizing the portable nitrate specific ion electrode are enhancing the utility of this test.

Soil testing and plant analysis are traditional diagnostic tools that continue to be important in site-specific nutrient management. Both are being refined to better plan fertilizer programs. New tools such as portable specific ion electrodes hold promise in speeding diagnosis and implementing corrective actions. All these and other tools that are being developed and perfected will contribute to higher, more efficient crop yields and improved environmental conditions.

Diagnostic procedures for plant tissue analysis and interpretation of the results are traditional tools that support site-specific management. Plant samples taken early can assist with in-season fertilizer decisions, and those taken later can guide plans for next season. The desire for greater production efficiency has led researchers to evaluate nutrient demand of crops on a per day basis throughout the growing season. These nutrient uptake patterns provide valuable information as to critical periods when nutrients are most in demand. Such information is essential to planning effective in-season fertilization.

Once limited to N, fertigation and foliar applications of various nutrients are proving beneficial in many cropping systems. Again, portable specific ion electrodes are being utilized for quantitative

analysis via extraction of plant sap in the field. The nitrate specific ion electrode is most widely used. The K specific ion electrode is reliable up to about 2,000 ppm, the approximate critical level for some crops. This can be useful for diagnosing deficiency, but not for monitoring uptake over typically encountered ranges of K. Values from fresh plant sap must be correlated to those of dried tissue or new calibration data (critical values) obtained.

Improving Accuracy and Precision

Much has been written over the years about collecting reliable soil samples from the field. Traditionally, recommendations call for something on the order of 20 to 25 individual cores (subsamples) to be taken from each "uniform" area and composited into a single sample for analysis.

Site-specific management requires very accurate information. Soil sample intensity could be a seriously limiting factor. Sampling fields on a grid pattern offers some interesting questions. How many cores per grid point are sufficient...are practical? And what about a grid size of 1 acre...2.5 acres...5 acres? A fairly common recommendation seems to be five cores per grid point in fields of 2.5-acre grids. If the variability of nutrients is spatially independent across fields, then five cores would be a very small number to identify true variability.

Accurate sampling of plant tissue is also important to support the goals of site specific management. A recent refinement in plant tissue sampling and fertilizer management involves boron (B). Boron is generally considered to be an immobile or only slightly mobile nutrient. As such, growing tips should exhibit deficiency first since B would not be re-translocated in the phloem from more mature tissue.

Recent research at the University of California shows the mobility of B is species dependent. Those plant species in which sorbitol is a major sugar readily translocate B (e.g., almond, apple, nectarines, cherry, pear, and peach). Sorbitol-poor species that do not readily translocate B include walnut, fig and pistachio. Translocation is apparently accomplished through the formation of mobile B-sorbitol complexes. Nutrient mobility is an important factor in selecting which plant part to sample and in timing foliar sprays for greatest effectiveness.

Precision and accuracy of analyses are also issues in the laboratory. Past studies have demonstrated surprising variability in some cases. There are programs available to assist laboratories with a wide range of analyses for a nominal fee. One such program is the Western States Proficiency Testing Program which has been directed cooperatively by researchers at the University of California and Utah State University. In 1996, 104 laboratories from 26 states, Canadian provinces and foreign countries participated in this program. Based on the past three years, the program has demonstrated an overall improvement in both the precision of individual analyses and the number of laboratories providing acceptable values within prescribed limits.

Looking to the Future

Chloride (Cl) was declared an essential plant nutrient in the mid-1950s. However, it was believed at the time that this was primarily of academic interest and that actual deficiencies of Cl in the field would rarely, if ever, occur. During the next few decades researchers in the Great Plains observed many responses by wheat to K, applied as potassium chloride (KCl), on soils testing high in available K.

Initially it was thought that the K soil test was unreliable. However, it was ultimately determined that many of these soils did, in fact, contain adequate K for

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rates are adjusted according to yield goal. Changes under consideration for K on potatoes include increasing the K sufficiency level from 150 to 175 ppm and more than doubling recommended K_2O rates for comparable soil test values.

Researchers at Utah State University are presently re-evaluating calibration data for P and K for irrigated alfalfa production. Initial results suggest that current recommendations are too low. Soil test sufficiency levels and corresponding rates of P fertilizer should be raised. Also, recommended rates of K fertilization may be too low and should be increased. These observations are based on only one year of research. Calibration will continue for at least another three years to build a sufficiently reliable database.

A 10-year P calibration study by Montana State University researchers completed in 1995 for spring wheat indicated that the previously established sufficiency level of 16 ppm $NaHCO_3$-extractable P is still valid. However, recommendations for rates of P fertilizer should be increased and a starter P application should be applied regardless of soil test. Researchers cite advances in spring wheat varieties and production technology for prompting this study and the resultant new recommendations.

These are just a few examples to illustrate the value of calibration research. Soil testing continues to be widely recognized as a diagnostic tool, but the point to be made is that soil testing programs based on outdated calibration data (or no data at all) can be counter productive. In each of the examples cited above, new research produced higher recommendations. Previous recommendations were obviously too low for optimum production. Site-specific management will best be served by current calibration information that accurately reflects the nutrient needs of today's production systems. BC

MID-SEASON K deficiency is shown in this cotton field in the San Joaquin Valley.

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optimum wheat production and that the responses were to the Cl component of the KCl fertilizer. Chloride deficiencies have since been documented in many of the Plains states and in several provinces of Canada. Both available soil test and tissue analysis procedures are calibrated for wheat, the crop most affected by Cl deficiency in North America.

There is ample opportunity to expand our understanding of fundamental agronomy and to improve the utilization of diagnostic tools. It is important that this knowledge base continues to grow in support of all new innovations, including site-specific management. BC

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