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FOLIAR ANALYSIS AS A DIAGNOSTIC TOOL AND BASIS FOR RECOMMENDING FERTILIZERS ON ANNUAL CROPS[1]

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Yesterday afternoon, Moore (6) discussed the basis for agronomists using plant analysis to diagnose plant nutrition problems and predict when plants might respond to applications of fertilizer. He emphasized that there are a number of factors that affect the nutrient content of a plant, but that when sampling procedures are standardized and are followed on all samples taken, meaningful relationships have been established between the nutrient content of a specific plant part taken at a specified stage of growth and response from fertilizer for many crops.

Following Moore's discussion, Lombard (5) outlined specific examples of how plant analyses have been used to predict response from application of fertilizers on tree fruits in western Oregon. Lombard and Stebbins emphasized the use of a plant analysis with tree fruits where perennial plants grow in the same area for a number of years. Plant analysis, under these conditions, can be used to adjust the next year's fertilizer applications.

Most of the field crops, normally called agronomic crops, and vegetable crops are annuals. By the time the crop has developed enough for a sample with a specified stage of maturity to be collected and analyzed, it is often too late to apply fertilizer for the crop that year. This is especially true for phosphorus where the phosphorus must be applied at or before planting for efficient use by most crops.

The conditions under which plant analysis can be made on annual crops limit the of this information to diagnosis and identification of soil fertility problems that are found in the field for most situations. This information is also used to evaluate the adequacy of the fertilizer program that year and to suggest changes that should be made on the fertilizer program the next year, if that crop or a crop with a very similar fertilizer requirement is going to be grown on that field.

One of the most outstanding exceptions is the work that Dr. Ulrich (12) started in California, where nitrate nitrogen content of sugar beet petioles has been used to monitor the nitrogen nutrition status of sugar beets and predict when nitrogen should be added during the growing season. The length of the growing season is an important factor in determining the level of nitrogen that should be maintained in sugar beets. We would anticipate that the amount of nitrogen that should be applied for the production of sugar beets would be different in central California valleys when compared with central Washington areas or the higher elevation areas in the Snake River Valley (for example, Twin Falls) where sugar beets are grown. This means that the optimum level of nitrogen fertilization and, in turn, the optimum level of nitrate nitrogen that should be present in the sugar beet petiole at a specified stage of growth or number of days after planting would be different for these different areas.

The Vegetable Crops Department in California (11) has defined the optimum content of N, P, and K for potatoes under their growing conditions. Potatoes are

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another example where the length of the growing season and an early versus late season crop will need to be evaluated before the nitrate nitrogen levels can be used in the Pacific Northwest. This morning, Kunkel (4) emphasized the importance t̶ t planting date and time of harvest (and thus the length of the growing season) h. s on the optimum rate of nitrogen fertilizer that should be applied for production of potatoes. This means that we would expect different optimum levels of nitrate nitrogen in potato petioles when the following potato producing areas of the Pacific Northwest are compared: Prosser, Washington; Othello, Washington; Madras, Oregon; Redmond, Oregon; Klamath Falls, Oregon; Ontario, Oregon; Boise, Idaho; Twin Falls, Idaho; and Idaho Falls, Idaho. These locations represent four distinct climatic areas where potatoes are grown. The central Washington areas probably have the longest growing season with the highest temperatures. These would be followed by the southern Idaho area around Boise and Ontario, Oregon. The Snake River Valley increases in elevation so that areas around Idaho Falls and Pocatello have about the same length of growing season that the areas around Redmond, Oregon and Klamath Falls, Oregon have. This wide range in the length of the growing season, as well as the temperatures during the growing season, means that the optimum yield of potatoes that should be anticipated will vary tremendously from the long growing season to the short growing season areas. This also means that the optimum level of nitrate nitrogen to be maintained in the petiole of a particular potato plant at a specified stage of growth will vary throughout this area. Potatoes that are planted the middle of May in areas with a cooler growing season and that are frequently killed by frost the first week of September will have a much lower nitrogen requirement than potatoes that are planted the first week of April and are frosted down or that have the vines killed the middle of October.

This research work on sugar beets and potatoes from California has given us a place to start in evaluating the nutritional requirements for these crops in the P(fic Northwest and certainly reduced the amount of work that we will need to do to obtain a satisfactory calibration for the optimum nitrogen content of these crops in this area.

Presumably, the optimum levels of phosphorus and potassium nutrition do not vary as markedly with length of growing season, so that it takes considerably less work to confirm the critical levels for these nutrients that have been established in other areas.

As we examine the literature, we find that there is an abundant amount of information available on suggested critical levels of nutrients for many plants. The largest collection of this information is in the University of California publication, "Diagnostic Criteria for Plants and Soils," that has been edited by Dr. Chapman (1). Each chapter in this book was prepared by a different author and reviews the information that is available on critical nutrient levels by nutrients. Symposia on diagnostic techniques for both soil and plant analyses were held at the 1964 and 1965 meetings of the American Society of Agronomy. The information from these symposia was published as Special Publication #2 from the American Society of Agronomy with Part 1 on soil testing and Part 2 on foliar analysis. These publications make an excellent place for any researcher or Extension agronomist to start in evaluating optimum levels of nutrients that should be maintained in the crops that are grown in a specific area. With this amount of information available, I do not think it would be worthwhile for me to list another set of critical values for the Pacific Northwest. In the remaining portion of this discussion, I shall try and point out those crops from the Pacific Northwest where we do have fairly good i(rmation where response from application of fertilizer has been related to the level of a nutrient in a plant.

Forage Legumes

We probably have more information on optimum levels of phosphorus, potassium, and sulfur for forage legumes in the Pacific Northwest than for any other group of crops. Most people have sampled the top half of the alfalfa plant or the leaves and petioles of clover at the first blossom. Research work at Oregon State University has shown that 0.25% P and 1.5% K at this stage of growth have generally been adequate levels of P and K. As literature is reviewed (1, 10), it is apparent that these have been fairly common values for these nutrients from a fairly wide range of conditions, for both alfalfa and clover.

The work of Pumphrey and Moore (8) has shown that 0.22% sulfur for the entire top of the alfalfa plant at early bloom has been an adequate level of sulfur for optimum yield of alfalfa in northeastern Oregon. This work emphasized the importance of the change in both sulfur and nitrogen (7,8) content of alfalfa from early in its stage of growth through the bloom period. It was evident that both the nitrogen and the sulfur contents of the alfalfa plant decrease as the plant approaches bloom and goes on to maturity. This work does suggest that the possibility of using a nitrogen-sulfur ratio should be investigated as a basis for predicting optimum sulfur nutrition of this crop and that this value might be used over a wider range of maturity than the critical level for S suggested. As critical levels of sulfur for legumes are reviewed, it might be logical to suggest a content of about 0.25% S when the top half of a legume plant is sampled at early blossom time,to allow some margin of safety. The work of James et al (2) at Oregon State University suggests that the critical level of molybdenum for alfalfa (the top one-half of the plant at early bloom) is between 0.3 and 0.5 ppm of molybdenum. This is in good agreement with the optimum level of molybdenum suggested for alfalfa by the work that Reisenauer did in eastern Washington (9).

With all of our forage legumes, we have an example of a situation where the crop generally occupies the same field for a number of years. This means that if we are growing the crop under irrigation, we have the possibility of adding fertilizers during the middle of the growing season that could result in an increased yield that year and we can use foliar analysis as a basis for adjusting the fertilizer program that will be applied the following year for the production of the crop.

Vegetable Crops

The Western Fertilizer Handbook (10) has a list of critical levels that is suggested from work in the Pacific Northwest for a number of crops. The most recently matured trifoliate leaf of the bean plant, at the time when the third or fourth set of trifoliate leaves has developed, has been used to evaluate the phosphorus status of the plant with a critical level of 0.35% P suggested. The critical phosphorus level of sweet corn plants, when leaf samples are taken at about 18 inches of height, would be about this same value.

Potassium deficiency symptoms on snap beans have generally been evident at early blossom time and samples of the most recently matured trifoliate leaves at this stage of growth have shown adequate K values with 1.5% K or above. The index leaf of the corn plant (the leaf opposite the first ear) at tasseling time has been used to indicate the K status of corn plants. Critical values of 1.5% K have been suggested.

Some work has been completed in attempting to define the critical level for zinc for corn plants in the Pacific Northwest. This value is probably higher for sweet corn, where uniformity of maturity for mechanical harvest is very important, than it would be for field corn. Zinc values of 15 to 20 ppm of zinc on the index leaf of a corn plant taken at tasseling time have been suggested for sweet corn.

Work from the Western Washington Experiment Station (10) has suggested .20% phosphate phosphorus and above 1.2% K from a recently matured leaf taken from canning peas at the 6 to 8 node stage of growth.

Work in the Willamette Valley has provided some basis for suggesting critical levels for potassium, calcium and magnesium on broccoli. This work should be confirmed under a wider range of soil fertility conditions before widespread use is made of these values in adjusting fertilizer programs.

Cereal Grains

Critical levels for phosphorus, potassium, and sulfur have not been established for vegetative plants samples taken during the growing season for cereal grains (wheat, barley and oats) or for grass seed crops in the Pacific Northwest.

Summary

I believe that it is apparent that there are a number of situations where we can make use of plant analysis values from properly taken plant samples to diagnose the soil fertility problems and adjust fertilizer application programs in the Pacific Northwest. In a number of cases, critical values for several nutrients have been evaluated under Pacific Northwest conditions. There are many situations where critical levels for a number of plant nutrients have been suggested in publications such as "Diagnostic Criteria for Plants and Soils" (1). This information could be used as a basis for starting to define critical levels under Pacific Northwest conditions and it could probably be used to help diagnose nutritional status of plants when paired samples from reasonably close healthy and "deficient" fields are compared. I think everyone concerned with these probelms would agree that these critical levels need to be confirmed under Pacific Northwest conditions before widespread use is made of them to adjust fertilizer application programs.

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