Soil Testing to Optimize Nitrogen Management for Processing Tomatoes

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Introduction:

In recent years, California has produced upwards of 90% of the nation's processing tomato crop. Over 300,000 acres of processing tomatoes are currently harvested annually in California, making this crop the most widely grown vegetable in the State. Major production areas are the San Joaquin and Sacramento Valleys. Because of the generally high economic value processing tomatoes provide to common rotations in these regions, production practices typically rely on relatively large inputs of nitrogen fertilizers. Recently, there is mounting evidence suggesting that "insurance" may be built into fertilizer recommendation systems for processing tomatoes in the form of excessive nitrogen rates so as to guard against deficiencies. Though the economic and environmental consequences of applying too much N fertilizer in these production areas are largely unknown, the need to develop better methods for estimating fertilizer N application rates is critical due to past (and possible future) N fertilizer price increases as well as widespread concerns with NO_3^- contamination of surface and groundwater that may occur through leaching losses.

Over the last decade, a number of nitrogen fertilizer application rate experiments have been conducted at the University of California's West Side Research and Extension Center (WSREC) in Five Points, CA. This Center is in the heart of the San Joaquin Valley's (SJV) processing tomato production region, with over 170,000 acres grown annually within a 75 mile radius of the Center. Repeated trials indicate that maximum yield responses result from application of 100 to 150 lbs of nitrogen per acre, depending on residual soil N levels. These studies have been conducted where either a cereal and/or corn crop were grown without added nitrogen and harvested by green chopping and removing all aboveground plant parts the season before the tomato fertilizer trials. Few, if any, growers plant tomatoes in soils with such low N levels, yet 200 to 300 lbs of nitrogen per acre are still routinely applied to most tomato acreage. Evaluations of late season water run N applications have also been conducted at the Center and have shown no increase in yield over routine *conventional* fertilization programs. Many growers however, still make one or two water runs of CAN 17 as an additional application of 20 to 40 lbs of nitrogen per acre. Though few data are available on the efficiencies of N fertilizer use and possible links between crop management and NO_3^- leaching losses in the row cropping systems of this region, NO_3^--N levels of waters collected in tile drains in many parts of the Central SJV frequently exceed 55 ppm, suggesting the possibility of nutrient use inefficiencies and eventual groundwater contamination.

Development of better systems for making N fertilizer recommendations has been identified as a major goal in reducing NO_3^--N pollution of groundwater and in sustaining profitability in agricultural production regions. Soil tests for N availability may be a means for economically and environmentally optimizing nitrogen fertilization rates. The quest for practical soil tests for nitrogen however, has been both long and difficult. Simple and reliable soil testing protocols for optimizing nitrogen management of corn however, have been developed and are now widely used in the northeast and in the midwest. These testing systems are based on the correlation between NO_3^--N determinations of the surface foot of soil when corn plants are about 6 - 12 inches tall (measured from the ground surface to the center of the whorl and the probability of obtaining a yield increase to sidedress N fertilizer application. On-farm evaluations in the early 1990's in Iowa have shown that this late-spring soil testing procedure has enabled many corn growers to reduce inputs of N fertilizer by one-third with negligible reductions in yields. Recent work in California's coastal cole crop production regions has relied on similar early season soil testing and may enable many broccoli and cauliflower growers to reduce N applications by 50 - 100 lbs/acre with per acre savings of $20 to $40. Similar work has not been done for processing tomatoes in California.

Objectives

This project is developing a protocol for recommending fertilizer application rates based primarily on early-season soil testing. This testing system is based on the correlation between NO_3^- -N of the surface foot of soil and other N pools in the surface two feet of soil at early plant growth stages. Similar protocols have been successfully developed for corn in the northeast and midwest, and recently have been successful in broccoli and cauliflower production in California's coastal cole crop production regions.

Additional correlations are being sought as part of this project between fresh petiole sap testing, dry plant tissue testing, and N fertilizer management practices. Specific objectives of the project are as follows:

1. To develop and extend information on pre-sidedress soil testing as a means for optimizing nitrogen management for processing tomatoes

2. To evaluate the effectiveness and utility of fresh petiole sap testing using the Cardy Meter for decision making in tomato nitrogen management

3. To investigate relationships between fresh sap nitrogen testing, dry tissue testing and current sufficiency levels being used by commercial testing labs for nitrogen fertilizer recommendations

4. To evaluate and present the potential of a quick soil nitrogen test as a means for establishing soil nitrogen levels during the season in conjunction with fresh sap testing

Tasks Completed in 1998:

During the 1998 growing season, the project was carried out on six on-farm sites in the West Side region of the San Joaquin Valley and at the WSREC in Five Points, CA. Five mid-season and one late-season fields were utilized at the on-farm sites. Each site received N fertilizer sidedress applications of between 0 to 250 lbs /acre of urea in increments of 50 lbs / acre, with six replications per site.

Soil samples were collected at 0 - 1 and 1 - 2 ft depths form each plot prior to N sidedress applications. The samples were tested for total N (Total Kjeldahl Nitrogen, TKN), potentially mineralizable nitrogen (PMN), NO_3^--N and NH_4^+-N. Leaf petiole samples were collected at three plant growth stages: first blooom, fruit set and fruit color / bulking. Petiole samples were used to determine fresh sap nitrate using the Cardy Meter. Testing for dry petiole nitrate levels was conducted simultaneously at the UC DANR Lab at UC Davis. In-field plot yields and quality determinations of tomatoes were done by machine harvesting each strip plot. Electronic scales mounted to gondola weigh wagons were used to determine in-field plot yields. Five-gallon samples of unsorted fruit were collected on the harvester from each plot for in-field determinations of fruit maturity and percent defects. Before weighing of these samples, 50-count red fruit subsamples were retrieved and sent to State Grading Stations for determinations of soluble solids and color.

Results

Data from the six on-farm sites in 1998 did not show a correlation between the amount of urea applied at sidedress and total yield. In almost all cases, yields were essentially the same regardless of the amount of fertilizer N added at sidedress. Possible explanations for this lack of correlation include the relatively large amount (57 lb / acre) of non-sidedress N fertilizer applied through water runs, foliar sprays and pre-plant treatments, and the initial high soil residual N content from previous crops.

Evidence for these explanations can be found in data collected from the experimental plots at the WSREC, which did show a high degree of correlation between amount of urea applied and total yield. Prior to the experiment, a crop of barley and Sudan grass was grown on the WSREC field without any N added, and all foliage was cut and removed to deplete soil residual N levels. Initial soil N levels at the WSREC field were generally lower at 0-1 ft. depth and significantly lower at 1-2 ft. depth than those of the on-farm sites. Furthermore, the WSREC field did not receive additional, non-sidedress N applications. Yield response to applied sidedress N was thus observed in the WSREC experiment.

It could, therefore, be suggested that all six on-farm sites were above the threshold level of soil NO_3^--N for a yield response to additional fertilizer, while the WSREC site was below the threshold. However, there is certainly not enough evidence yet to conclusively make this statement. Future trials are needed not only increase the number of data to be used in determining the sidedress fertilizer response threshold, but also to get a wider range of initial soil NO_3^--N levels at early plant growth stage.

Plant petiole testing at the three plant growth stages (first bloom, fruit set, first fruit color) showed a relationship between the dry matter method, which was sent to DANR Lab for analysis, and the wet sap method, which was conducted using the hand-held Cardy Meter. Nitrate readings from both methods tended to decline at successive later plant growth stages, with those from the dry petioles dropping more rapidly than those of the fresh petioles. Dry petiole nitrate levels were generally higher than wet sap (or fresh petiole) levels at the first bloom stage, approximately equal at the fruit set stage, and somewhat lower at the first fruit color stage. It should be noted that the DANR Lab tests for NO_3^--N in dry petioles, while the Cardy Meter measures for NO_3^- in wet sap.