Observations from Five Seasons of Monitoring Fertilization and Irrigation of Peppers

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INTRODUCTION

Bell peppers are among the most heavily fertilized crops grown in California. Nitrogen (N) fertilization rates can be very high, and, in the past, growers in some regions have used more than 300 pounds per acre seasonally. Currently, contamination of groundwater and surface water sub-basins by nitrate-nitrogen (nitrate-N) are documented and to varying degrees are due to past and current crop production practices. Current water quality initiatives in the region, including the future Total Maximum Daily Load Allocations for nutrients and salinity (TMDLs) in the Pajaro River Watershed, will require that growers maximize fertilization and irrigation efficiencies.

Since 2000, we have conducted a variety of on-farm soil and crop monitoring studies in Santa Clara and San Benito County pepper fields as part of public and private contracts. The objectives of this work has been two-fold: (1) to provide growers with data and observations that can increase fertilization and irrigation efficiency (thus reduced input costs) and; (2) to reduce further nitrate movement to ground- and surface waters. From 2000 to 2004, we have monitored all types of pepper production systems, including bell peppers for fresh and process markets and chili-type varieties, grown with drip and sprinkler-drip hybrid irrigation practices. As one would expect, grower irrigation and fertilization practices vary significantly.

METHODS

The basic monitoring approach has included routine sampling and analysis of plant petiole nitrate and potassium, occasional soil nitrate-nitrogen (nitrate-N) and whole leaf sampling, as well as, analysis of irrigation waters. The bulk of the data accumulated during this time has come from either weekly or bi-weekly fresh-sap analysis of petioles. Soil samples are typically collected from the top foot of soil and occasionally, in selected fields, we have collected soil samples from the 0-1, 1-2, and 2-3 foot depth intervals prior to and following cropping. In all cases petiole, leaf, and soil samples are collected from up to 15 fixed locations in a field, depending on field size and configuration. Well water samples have been collected for full agricultural suitability analysis, including nitrate-N. In 2000-2003, tensiometers were occasionally employed to monitor soil water potential at various depths and compare grower irrigation scheduling to Eto estimates from the appropriate CIMIS location.

Beyond the collection and interpretation of soil, crop, and water data, we have made many qualitative observations based on walking fields, simple field trials, and a large amount of time spent in discussion with growers and ranch managers about their approaches, successes, and mistakes

OBSERVATIONS

Work by Dr. Tim Hartz and others have suggested that 180 to 240 pounds per acre of N will generally produce maximum marketable yields of green bell peppers under drip fertigation. However, there is no rigorous research data concerning optimal N fertilization for the many minor chili-type peppers. During the five seasons of field monitoring, we have noted good production in bell pepper fields with as little as 160 lbs N and less than optimal production in Jalapeno fields receiving up to 380 lbs N. Generally, we have also observed that irrigation scheduling in many fields could be improved by closer monitoring, either by ‘feel’, in-field moisture measurement devices, and/or computer-based scheduling tools.

A common observation in these years has been a tendency for growers to apply excessive quantities of N early in the crop season. These applications are typically made because the grower

desires to increase early plant vigor (as visually determined by early color) and pre-bloom foliage cover, which is expected to increase fruit size, yield and decrease sunburn damage to pepper fruit. While some researchers have concluded that sunburn damage is not a concern, our observations (particularly in 2004) suggest that in this region, sunburn damage can occasionally be a problem, leading to significant yield loss.

A second common observation is a tendency for excessive irrigation in the early season, particularly during cool, foggy, or windy conditions. This was also widespread in the 2004 season, as poor climatic conditions in May and June did not favor rapid growth and development. Growers often attempt to overcome this with additional water and N based on visual observations that, ultimately reduces crop use efficiency and increases production costs.

In general surface and buried drip systems are well designed and maintained and generally irrigation uniformity is good to excellent for these. There have been exceptions, but overall, the installation and maintenance of these systems is no longer a challenge or problem for most growers. However, fertigation scheduling and injection practices vary widely, are often inconsistent, and are the most common area for improvement. We have often noted decreased N fertilizer efficiency in fields where, a single weekly injection of N is followed by up to two irrigations (water only). The negative effect is the leaching of a portion of each weeks fertilizer (as nitrate) that leads to 'peaks and valleys' in N availability and uptake by crops. Conversely, a few growers who inject smaller quantities of N more regularly or irrigate with clear water more frequently, appear to have more effective crop N use and use less total fertilizer than others.

Many growers now use commercial services that provide weekly petiole sampling and analysis for N and potassium (K) status. We have found this to be very useful tool for diagnosing crop status and indicating problems in fertilization and irrigation. However, one of the challenges (and source of confusion/frustration) for growers is due to the existence and reference to different interpretive values (ppm in fresh sap) for N and K adequacy levels. This is particularly true given the growth habits and nutrient needs of bell peppers in comparison to the many chili-type varieties grown in the region. Further, these data do not substitute for occasional soil testing. Our review of data from 5 seasons, suggests that many growers may be over- or under-applying K fertilizers due to lack of annual soil test records. In this region, there are some soil types that have a much more readily available supply of K, than others. In 2003 we were able to collect a representative set of whole leaf samples at the second pick of a number of fields that demonstrates this variation.

In many cases, crop use efficiency of applied fertilizer may be less than ideal. Soil nitrate-N levels during the crop season may fluctuate greatly, even during a single week. In-season leaching may often occur on coarse- and fine-textured soils with high gravel content, and it appears that some growers 'over-correct' with increased fertilization. Additionally, some of the well waters tested contain high levels of nitrate-N that may supply agronomically significant quantities of available N. In 2003 we were able to collect a number of post-crop soil samples for residual nitrate-N. These data indicate that both in- and post-season (winter rains) leaching of nitrate-N may still be a source of nitrate in ground- and surface waters in the Pajaro River Watershed.

CONCLUSIONS

Pepper production in the region is now largely based on drip fertigation with N fertilizers (commonly AN-20 and CAN-17) applied in weekly or more frequent intervals. Drip systems can provide enormous 'fine-tune' control of water and N delivery to peppers. However, not all growers are optimizing their use of this technology with irrigation and fertigation schedules that match the water and nutrient needs of different pepper types at the different growth stages of these crops. These are the critical factors affecting soil nitrate dynamics and the potential amount of in- and post-season losses of nitrate-N to the off-site environment, as well as production costs, marketable yield, and quality.

In the words of one grower, "… we should know better by now, no pepper crop is going to grow faster just because you give it more water and N, we should pay more attention to the weather, soil moisture, and growth stage of our crops".