Fertilizing Trellised Tomatoes Under Drip Irrigation

By Bill Yarborough

Introduction

Fertilization of tomatoes in Western North Carolina (WNC) has traditionally been based on research conducted in the 1950's that assumed little or no irrigation and tomato varieties requiring high rates of nitrogen. That fertilization strategy is not optimal for the trellised, drip-irrigated tomatoes commonly grown today. New recommendations for this crop have been developed based on recent field studies and research in North Carolina and from other states emphasizing the use of plant analysis to monitor and adjust applied materials. Nitrogen, potassium, and boron appear to be the key elements in producing quality tomato fruit.

History of Tomato Production and Fertility Research in Western North Carolina

Tomatoes were introduced into WNC in the 1950's by cooperation of growers, USDA-Agricultural Extension Service, WNC Development Association, and NCDA-Marketing Division to provide farm income improvement. The first tomatoes were staked with large posts and wire. The varieties selected were of the indeterminate type with season-long ripening and heavy yield potential. There was little to no irrigation on these early plantings. The staked system had high labor and material costs.

Early research on tomato fertility evaluated nitrogen. Rates of nitrogen for indeterminate varieties of tomatoes such as manapals were established in the 200-250 lb range. These varieties grew throughout the season and ripened fruit as such. It was considered important that adequate nitrogen was available to allow for season-long vegetative growth. These nitrogen recommendations remained for close to 30 years.

Another issue addressed with early research was the physiological disorder known as blossom end rot. Research on blossom end rot started as a plant pathological investigation. No primary pathogen was isolated, and a physiological disorder was suspected. Work with plant nutrient amendments began. Phosphorus was one of the first nutrients investigated since soils in the area were known to have no natural source of phosphorus. Studies showed increasing rates of phosphorus decreased the incidence of blossom end rot. A soil index equation for phosphate was developed by the NCDA soils lab; for a soil index of 0, an amendment of 1000 lbs/acre actual phosphate was recommended.

Continued research determined that the addition of calcium carbonate (limestone), and the subsequent raising of pH, also decreased the incidence of blossom end rot. Closer studies linked calcium deficiency directly to the blossom end rot disorder. It should be noted that normal superphosphate was the supplier of phosphorus in the early work. This material also contains calcium. The reduction of blossom end rot with the addition of high rates of phosphorus derived from normal superphosphate was most likely incorrectly credited to the addition of phosphorus rather than to the addition of calcium supplied from normal superphosphate. The phosphorus soil index equation was reevaluated by the NCDA soils lab; the maximum recommended rate was reduced by nearly one half, where it remains today.

Trellised tomatoes using small stakes similar to tobacco sticks replaced the staked tomatoes in the 1960's. Shorter varieties were selected with determinate varieties becoming more popular. This trellised system reduced significantly the high labor and material costs involved with the staked system. This system allowed for greater acreage to be farmed. Fertility recommendations for the trellised system changed little from the staked system.

The tomato industry improved significantly with the addition of Dr. Randy Gardner, NCSU plant breeder. His work produced determinant varieties uniquely suited to WNC that were compact, expressed

---

Bill Yarborough, Regional Agronomist, North Carolina Department of Agriculture and Consumer Services

Published in Soil Science Society of North Carolina Proceedings, Vol. XLIV (2001)

shortened season ripening, were of excellent shipping quality, and had high yields. These new determinate varieties, which dominate the varieties planted today, were found to respond negatively to excess nitrogen. It was noted early on that these varieties required careful nitrogen management. Excess nitrogen early in the season produced heavy vegetative growth, possible flower abortion, and possible decrease in fruit quality. Nitrogen recommendations were adjusted over time. The recommended rate of nitrogen was reduced nearly in half to 120 lbs\acre. This is the amount of nitrogen recommended to date.

Other nutrients were evaluated and suggested recommendations developed throughout the last 40 years. All the nutrients recommended assumed the tomatoes were field planted. Soil science research from most of the other major field crops was directly applied to the production of trellised tomatoes. This works well until another variable is added to the equation…**drip irrigation**. The ability to add water when necessary and to provide nutrients on demand adds another degree of management as well as opportunities or challenges to the tomato producer and to their advisors providing information.

Drip irrigation was introduced into Western North Carolina in the early to mid 1980's and quickly became adopted by most growers. Most of the interest was as a water supplement. Work by the NCDA with several growers in the late 1980's showed promise with drip irrigation as a superior method of fertilization. Nitrogen could be managed through the use of plant analysis. The use of plant analysis for fertilizer recommendations proved to be worthy for monitoring other important nutrients as well, notably calcium, potassium, and boron. The purpose of this paper is to discuss some of the findings of this work, suggest recommendations, and discuss the need for research into this growing science of drip irrigation as an important part of prescription farming.

Nitrogen Recommendations

Nitrogen fertilization for tomatoes utilizing drip irrigation actually becomes easier from a management standpoint. Monitoring with regular plant analysis allows precision application of rates and timing. This was not possible before drip irrigation systems were readily available. Nitrogen had to be applied pre-plant with additional nitrogen applied post-plant (sidedressed) between the rows. Pre-plant application of excessive nitrogen can lead to heavy vegetative growth as well as fruit quality and shipping problems. The post-plant (sidedress) method was uncertain due to poor root development from compaction from heavy traffic, erosion potential during heavy rains, and unpredicted release during periods of low rainfall. Both pre-plant and post-plant application methods had unpredictable results. Fruit quality problems such as soft fruit led to many culls and shipping rejects.

Drip irrigation gives the manager many desirable options. Nitrogen can be applied at a low rate continuously over time. If additional nitrogen is shown through plant analysis to be necessary, it can be applied directly through the system. Results can be observed quickly.

Pre-plant nitrogen recommendations

Most work shows sufficient results with 40-60 lbs/acre nitrogen applied broadcast. It is advisable to evaluate each site to estimate residual soil nitrogen and reduce pre-plant *n* to the 40 lbs/acre rate if residual soil nitrogen is available. Soils with little estimated residual soil nitrogen (soils with little organic matter or very low CEC's) may need the higher 60 lbs/acre rate. Research from Florida seems to back up the lower rates of pre-plant nitrogen that NCDA&CS agronomists have recommended in WNC for many years.

Post-plant drip-injected nitrogen recommendations

Ideally, pre-plant nitrogen appears to run out in most years about the time the lower fruit has reached the size of a dime. It is advisable to begin plant tissue analysis at this time to monitor for nitrogen as well as other nutrients. A general rule of thumb for quality fruit is to apply 3-4 lbs/acre/week of actual nitrogen through the drip at this time.

Additional nitrogen will be necessary about 2 weeks from first harvest when the lower fruit is about the size of a dollar coin. Plant analysis should be continued on a weekly basis to monitor for all nutrients. The rate of nitrogen should be increased to 6-7 lbs/acre/week of actual nitrogen at this time. This should be continued throughout the peak picking season (weeks 1-6) with the nitrogen rate monitored with plant analysis. The rate of nitrogen can be reduced to 3-4 lbs/acre/week after the peak through the end of the season.

The total rate of nitrogen applied per season should be in the range of 90-120 lbs per acre depending on the site and should be monitored with plant analysis.

Phosphorus Recommendations

Adequate phosphorus is important to the tomato plant throughout early development. The role of phosphorus later in the season is not well documented. NCDA&CS soils lab recommendations

applied pre-plant appear adequate for tomato production based on plant analysis and yield data. No response from drip-applied phosphorus has been observed from NCDA&CS field studies. Phosphorus concentrations from plant analysis data during early growth are consistently sufficient. Phosphorus concentration from plant analysis during harvest fluctuates from adequate to low. These levels seem to follow a 10-14 day pattern. More work is needed to try and explain these concentration curves.

Potassium Recommendations

Potassium concentration in the tomato plant is important for fruit quality, size, and shipping. Drip irrigation has been shown to improve all of these characteristics as well as yield. Previously it has been hard to predict potassium concentration throughout the season with either pre-plant or post-plant (sidedress) application. Excess rainfall as well as excess nitrogen reduced the concentration of potassium, which decreased fruit quality. Post-plant (sidedress) applications were unpredictable for many of the same reasons as nitrogen application: compaction of the row middles, erosion potential during heavy rains, and insolubility during periods of low rainfall. Drip irrigation allows for precise, low-rate continuous feeding, especially during periods of heavy fruit load when potassium needs are greatest.

Most determinate varieties of tomatoes grown today produce harvestable fruit for a short peak. Most research has shown that over 60 percent of harvestable fruit is picked between harvest weeks 3-5. This heavy demand on the plant can reduce nutrient concentrations significantly. It can lead to lower yields at the end of the season due to stress on the plant.

Pre-plant potassium recommendations

Soil sample recommendations are important to determine index levels of potassium. Potassium recommendations based solely on soil samples have proven inadequate on many sites when drip irrigation is utilized. This has been discussed at length with many researchers. NCDA&CS agronomists have taken samples from within the row immediately after bedding and after harvest. Samples taken near the area with the drip orifice have little potassium remaining after the season. Samples taken in the bed away from the drip orifice have adequate levels of potassium. Plants dug from the beds with their roots carefully washed explain this difference. The feeder roots are heavily concentrated around the drip orifice area. Feeder roots away from the orifice have noticeably less mass. The plant responds to the water and nutrient supply just as would be expected. Feeder roots do not need to expand to other areas of the bed in search of either. Therefore, these roots strip the area of needed nutrients. These nutrients must be replaced continuously throughout the growing season.

Post-plant potassium recommendations

Plant analysis should begin when the lower fruit size is about the size of a dime and continued weekly through harvest. Potassium concentration early in the season ideally should be above 4.0 percent. If the concentration is low, application of potash should begin at the rate of 10-12 lbs/acre/week and continued until first harvest. Continue to monitor with plant analysis weekly.

If application has not begun by 2 weeks before first harvest, begin application of 10-12 lbs/acre/week of potash and continue until first harvest. Apply 20-25 lbs/acre/week after first harvest and continue throughout the peak (about harvest week 6). Potassium concentration during harvest should be held between 2.5-3.0 percent. Reduce the rate to 10-12 lbs/acre/week until final harvest.

The fertilizer potassium nitrate was one of the first materials evaluated by NCDA in field studies. Prilled materials were discouraged early on due to problems with getting the material in solution. Greenhouse grade or standard was selected. This material has proven worthy for tomato production in WNC. It supplies adequate ratios of nitrogen and potassium. A rate of potassium nitrate of 25 lbs/acre/week beginning when the lower fruit has reached the size of a dime until first harvest followed by 50 lbs/acre/week through the peak (harvest week 6) has proved a good program for WNC tomato production.

Boron Recommendations

Boron has been shown to be a necessary nutrient for tomato production. Application of boron has recently been shown to have promise in helping increase potassium concentration in the plant. NCDA&CS soils lab recommends 2 lbs/acre actual boron. Work provided by NCDA&CS agronomists when drip irrigation is utilized shows that this may not be enough boron for season-long production. This again is most likely due to application method. The feeder roots heavily massed around the drip orifice strip a limited area of the bed of available boron. Plant analysis should be used to monitor boron concentration and adjustments made from the results. Boron concentration should be in the range of 60-100 ppm throughout harvest. Boron materials can be supplied by drip or foliar. Care should be taken when

applying boron as it can be phytotoxic. A rate of up to 0.5 lb/acre of Solubor™ through the drip system or applied foliar with dilute sprays has worked well in WNC.

Calcium Recommendations

Calcium, as discussed earlier, is known to be necessary to prevent blossom end rot disorder. The NCDA&CS soils lab has a target pH for tomatoes of 6.5. It is the opinion of this author from many years of working with tomatoes and drip irrigation that calcium concentrations will be sufficient where agricultural limestone has been applied and the plant bed is adequately supplied with water. I have seen no advantage to applying materials other than limestone for supplying calcium when using the drip system. Results from plant tissue samples for over 10 years confirm this. It is suspected that application of calcium materials such as calcium nitrate may in fact reduce the ability of the plant to uptake potassium and lead to fruit quality problems. The NCDA&CS feels that the application of limestone to increase pH to the desired target coupled with careful water management will adequately supply calcium.

Fertility Recommendations Summary

· Soil test
· Pre-plant apply recommended amendments
· Pre-plant apply 40-60 lbs/acre actual nitrogen

Monitor with plant analysis

· Sample latest mature leaf hand
· Sample when lower fruit is the size of a dime
· Sample weekly

Begin fertilizer application

· Apply boron as needed for concentration of 60-100 ppm
· Begin drip application of fertilizer N and K when fruit is size of quarter (25 lbs/acre/week of 13-0-44)
· Increase 13-0-44 to 50 lbs/acre/week 2 weeks before harvest
· Continue application until after peak harvest is reached and reduce rate to 25 lbs/acre/week

The Agronomic Division is presently reviewing needed changes in crop codes, fertilizer rates, and plant tissue sufficiency ranges based on the data revealed under close monitoring conditions in Western North Carolina. This author feels there is a need for developing a graduated curve for sufficient plant nutrient concentrations throughout the season. The NCDA&CS Agronomic Division has agreed to begin evaluating this idea. Other drip-irrigated crops could use this concept as well. The Division would welcome researchers from both the Soil Science Department and the Horticulture Department from NCSU to help provide these sufficiency curves. It is felt that crops produced with drip irrigation demand a marriage of known soil science concepts for field grown crops and known horticulture concepts for greenhouse crops. Neither alone can address all the questions needing answers.