Vegetable BMP Research - 2004-2005 Season: Introduction

With more than 20,000 acres planted each year in Collier and Hendry counties, Southwest Florida is an important production area for winter fresh-market tomato (*Lycopersicon esculentum Mill.*). Depending on market conditions, Southwest Florida tomato production is estimated between $150 and $300 million. While polyethylene mulch, raised beds, stakes and transplants are always used, tomatoes are grown at various dates, plant densities, and irrigation methods. Planting dates range from late August to mid-February which results in 15 to 21 week-long growing seasons, as compared to 13 week-long-growing seasons for spring plantings in North Florida. Within-row spacing ranges from 18 to 24 inches, and beds are spaced 5 to 6 ft apart. When tomatoes are grown on soils that have a shallow impermeable layer (3 to 6 ft deep), seepage irrigation may be used. Seepage irrigation consists of maintaining and managing a water table perched on an impermeable layer found between 18 and 24 inches from the top of the bed. Seepage irrigation is also used for frost protection by raising the water table to the soil surface. When the impermeable layer is absent or interrupted, seepage irrigation is replaced by drip irrigation. In some cases, “hybrid systems” are used where seepage irrigation is used to supply crop water needs, and a drip tape is placed under the bed to supply fertilizers.

Current UF-IFAS recommendations for N fertilization in tomato production in Florida are based on 6-ft center-to-center bed spacing, 7,260 linear beds foot/planted acre, and consists of a base and a supplemental rate. The stet-wide base rate is 200 lb/acre for N (1A = 7,260 linear bed feet) and soil-test-based rate for P, K and micronutrients. Supplemental fertilizer applications are recommended in addition to the base rate under the following conditions: (1) after a leaching rain (defined as 3 inches in 3 days or 4 inches in 7 days), (2) under extended harvest season (when the crop is grown and harvested for more than 13 weeks), or (3) when plant nutrient levels (leaf or petiole) fall below the sufficiency range while a UF-IFAS recommended irrigation method is followed. Supplemental applications are recommended once a situation develops, not on a preventive basis.

Fertilization practices used in tomato production in Southwest Florida are linked to irrigation practices. For tomato grown with seep irrigation, approximately 25% of the fertilizer is broadcasted in the bed (bottom or cold mix). The rest of the fertilizer is applied in one or two bands on the shoulders of the bed (hot mix). Water rising by capillarity slowly dissolves the fertilizer band, which supplies nutrients to the crop. All the fertilizer is applied pre-plant and is expected to adequately supply plant nutritional needs throughout the season. Additional fertilizer applications are sometimes made through the plastic using a fertilizer wheel. With drip irrigation, typical fertilization practices consist of applying 25% of the total N and K_2O rates broadcast on the bed area, while 100% of P_2O_5 and micronutrients are applied pre-plant. The remaining 75% of both N and K_2O are injected through the drip tape. With both irrigation systems, fertilizer rates used for tomato production in Southwest Florida are typically higher than those recommended because growers believe that recommended rates are too low and current recommendations do not provide enough flexibility to reflect the different growing conditions found throughout Florida.

The ‘Water Quality/Quantity Best Management Practices for Florida Vegetables and Agronomic Crop” manual was developed in 2001-2004 jointly by the Florida Department of Agriculture and

Consumer Services and UF-IFAS to reduce the environmental impact of off-site movement of fertilizers (www.floridaagwaterpolicy.com). BMPs are cultural practices that aim at maintaining productivity while reducing the environmental impact of production. The BMP manual for vegetables should be adopted by rule (5M-6) and by reference in 2005. While the BMP manual recognizes several strategies for nutrient management (including fertilizer rates that exceed current recommendations), the long-term success of this voluntary program is based on the improvement of water quality. Although N runoff has not been identified as a widespread problem in south Florida, the environmental concern remains that the combination of over-fertilization and excessive irrigation may contribute to elevated nutrient concentrations in ground and surface waters.

Vegetable BMP Research - 2004-2005 Season: Objectives

1. Establish partnerships with selected tomato growers to evaluate the effects of N nutrient applications under commercial growing conditions;
2. Evaluate the effect of selected N application rates on plant growth, nutritional status, yield, disease and pest incidences, and crop market value;
3. Determine the optimal N rate for tomato production and evaluate the cost effectiveness of selected N application rates.

Vegetable BMP Research - 2004-2005 Season: Field Trial

Locations (Map) and treatments (See Table 1) consisted of N fertilizer rates ranging from 200 to 418 lb N/acre in two adjacent blocks , with each trial including the UF-IFAS rate and the grower's rate. In some trials, intermediate rates were also included. The UF-IFAS rates were created by changing the rate or composition of the hot mix. Custom-made blends were used in each trial to keep constant the rates of P, K and micronutrients. The trials represented the diversity of growing conditions in Southwest Florida and included different varieties (mostly 'Florida 47', 'Sebring' and BHN), plant densities (in-row spacing of 18 to 26 inch between plants; 5 or 6 foot bed centers), soil types, and farm sizes (700 to 5,000 acres). All the tomato crops were grown using polyethylene mulch (white/black), except for one on silver, stakes and methyl bromide was applied at different rates as a soil fumigant. Cooperators prepared the beds, applied the bottom and hot mix, fumigated the soil, and applied the polyethylene mulch, transplanted, pruned, staked, irrigated (seepage and drip irrigation) and provided pest and disease control.

Table 1. Experiment number, irrigation type, N rates evaluated, plot size, planting date, number of harvest in the 2004-2005 N management trials in Southwest Florida.

Trial Number	Farm	Season	Irrigation type	N rate (lb/acre)[z]	Plot size (acres)	Planting date	Number of harvest

[z] based on 6-ft spacing or 7,260 linear bed feet per acre.

[y] BS = biosolids.

Table 1. Experiment number, irrigation type, N rates evaluated, plot size, planting date, number of harvest in the 2004-2005 N management trials in Southwest Florida.

Trial Number	Farm	Season	Irrigation type	N rate (lb/acre)[z]	Plot size (acres)	Planting date	Number of harvest
1	1	Fall, 2004	Seepage	200, 240, 260, 260+BS[Y]	0.33	28 Sept	3
2	2	Fall, 2004	Seepage	195 and 255	0.83	5 Oct.	3
3	3	Fall, 2004	Seepage	200 and 300	0.83	5 Oct.	2
4	4	Fall, 2004	Drip/seepage	250 and 418	0.10	11 Oct.	3
5	5	Spring, 2005	Drip	260 and 300	25	22 Nov.	3
6	2	Spring, 2005	Seepage	195 and 255	0.83	3 Dec.	3
7	2	Spring, 2005	Seepage	195 and 255	0.83	28 Jan.	3

Pre-season soil samples were collected from each field, oven-dried, passed through a 20-mesh screen, and sent to the ARL/USTL laboratory in Gainesville for routine analysis using the Mehlich-1 extraction. Soil pH was determined in a 1:2 dilution (v/v) with distilled water. In seepage-irrigated fields, shallow monitoring wells were installed in each treatment to measure the depth of the water table depth. Monitoring wells were constructed from a 4-ft long, 4-inch diameter PVC pipe screened at the bottom 8 inch. A float was attached to one end of a 0.75-inch PVC pipe to serve as the water level indicator. The float-0.75 inch PVC pipe assembly floated freely inside the 4-inch well. Permanent marks were made at every 1 inch to indicate the water table depth below the plastic mulch bed. Weekly observations of the ground water table depth were taken throughout the growing season. On 30 and 60 days after transplanting (DAT), the shoots of three tomato plants (fruits removed) selected randomly in each treatment were collected and oven dried at 65°C until constant weight to determine dry matter accumulation. Beginning at first flower buds and continuing until third harvest, fresh petiole sap NO_3-N and K concentrations were measured weekly using ion-specific meters (Cardy, Spectrum Technologies, Inc., Plainfield, IL). The number of plants showing symptoms of Fusarium crown rot (caused by *Fusarium oxysporum f.sp. radicis-lycopersici*) in each harvest plot was counted weekly in trial 1 between 12 Jan. and 2 Feb. Weekly counts of all adult whiteflies (*Bemisia argentifolii*) were made on 10 top fully expanded leaves from 10 randomly selected plants in 3 locations in each plot at four trials (replicates). Analysis of the mean number of whiteflies counted in each plot over each 7-day interval was accumulated to give an estimated value of whiteflies x days for each plot. An analysis of variance (ANOVA) over all replicates (farms) was conducted by considering only the highest and lowest N rate treatments (designated “high” and “low”) for those farms where more than 2 rates were tested.

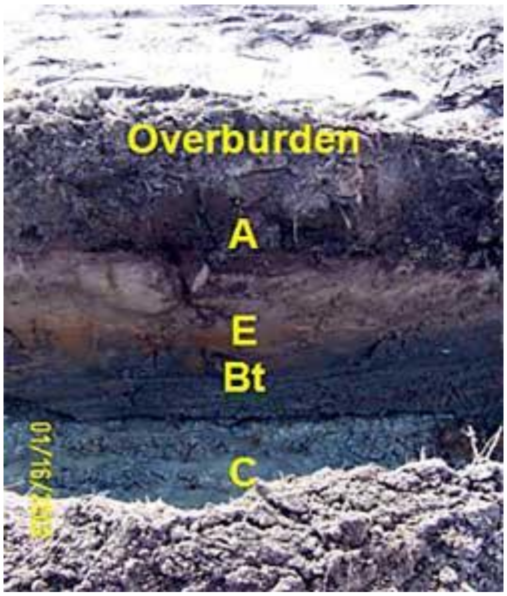
Harvest was done by the project’s crew on at least six plots in each treatment following commercial practices. Harvest plots contained 10 plants each, and were 15 to 22 ft long, and were clearly marked to prevent unscheduled harvests by commercial crews. Marketable tomatoes were graded in the field according to USDA specifications of number and weight of extra-large (5x6), large (6x6), and medium (6x7) fruit. The number of plots harvested in experiment five was twelve. There were no true replications, but within each field the within-plot variability of yield components was compared to the across-plot variability using ANOVA and mean separation using the Duncan’s Multiple Range Test at the 5% level.

The economic section of this paper calculates a monetary value for each fertilizer treatment for each farm site. The values compare projected total revenues gained by fertilizer treatment utilizing yield data and market prices reported at the date of each harvest. The purpose of the economic calculations was not to document actual losses or gains, but to illustrate some of the economic issues associated with N fertilization decisions.

Southwest Florida tomato growers harvest mature-green tomatoes in two market windows - fall/winter and early spring. It is important to realize that grower prices for the fresh tomato are set on a daily basis and are sensitive to total market supplies. Tomatoes imported from Mexico, Europe and Canada, compete with those from Southwest Florida for the same market windows.

Vegetable BMP Research - 2004-2005 Season: Soil Types

The soils in the area (Immokalee and Riviera soil series) are characterized with a surface horizon (A) almost always of sandy texture and a leaching zone (E) is often found (Immokalee soil series). Located beneath this leaching zone, some soils have a distinct brown or black horizon, called the spodic horizon (Bh). This horizon is composed of organic matter that is leached down the profile and by both physical and chemical means has been deposited in the lower part of the soil profile. Often high in aluminum and iron and usually with a low pH, the horizon is almost always sandy in texture. This horizon impedes water flowing vertically through the soil and causes water to accumulate above this horizon. This water accumulation is referred to as a perched water table and is often quite beneficial for maintaining a constant water table for vegetable production.



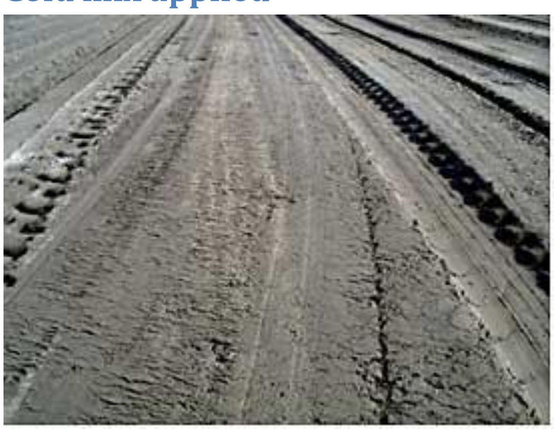
In some soils (Riviera soil series), another diagnostic horizon may be found below the leaching zone (Bt) created by the deposition of clay particles. This diagnostic horizon may be sandy or sandy loam in texture and may allow the formation of a perched water table. Below these diagnostic horizons, substratum (C) may be present. Other type of soils in these area are the soils originally formed in sloughs and other low-lying areas, then graded through land-leveling and bedding techniques, may be quite difficult to manage for commercial vegetable production. Land leveling can create problems especially when large amounts of soil must be moved exposing sub soils. Often, soils formed in low areas (sloughs) have been stripped of organic matter and clay that coat sand grains in other soils. These naturally formed uncoated sands are difficult to wet and difficult to drain and often drip irrigation or a combination of seepage and drip irrigation is used.

Vegetable BMP Research - 2004-2005 Season: Bed and Fertilizer Preparation

Field preparation

Cold mix application

Cold mix applied



Broadcasting the cold mix

Pre-bedding

Fumigation

Hot mix application

Hot mix applied on the two shoulders

Polyethylene plastic application

Plastic polyethylene applied

Transplantation

Staked

Vegetable BMP Research - 2004-2005 Season: Economic Analysis

Many tomato growers in Southwest Florida believe that they would incur significant financial losses if they limited N fertilization rates to 200 lb N/acre. They believe that a 50 percent increase in the N-rate would support higher production levels and allow them to fully take advantage of favorable market prices. In other words, they view higher N-rates as a form of insurance. Most prices presented in the price history of US#1 tomatoes corresponding to all the harvest dates during the 2004-05 N trials (See Table 1) were higher for the larger sizes (5x6s). Under high price market conditions, the price difference between 5x6s and 6x7s increased. When the market prices fell to low levels, there was no price difference between extra large and medium sized tomatoes. Most of the fall trials were harvested during January 2005, a time when the market was at historic low prices. Between the end of December and mid-March, tomato prices were below an estimated break-even price of $9.50 per 25-lb box. More importantly, a price of $4 per 25-lb box or below does not even cover harvest, packing, and marketing costs. Consequently, many fields were picked once for the 5x6 size and then abandoned. For the purpose of data collection, grower-cooperators allowed field trials to be picked three times regardless of the commercial market conditions. By the latter part of March, prices rebounded and the market for southwest growers remained strong for the rest of the spring season. Abandoning fields for economical reasons may result in increased residual fertilizer levels left in the field at the end of the season. This may not be an environmental concern for N as it may be denitrified during the summer flooding of the fields.

Table 1. Price history for US#1 ($ per 25-lb box) during the harvest window (27 Dec. 2004 and 2 June 2005) of Southwest Florida tomato industry. (Source USDA Agr. Mark. Serv., Fruit & Vegetable Market Rept.)

Harvest Date	**Grade class**		
	5x6 ($/box)	6x6 ($/box)	6x7 ($/box)
27 Dec	9.20	7.20	7.20
3 Jan	7.20	5.20	4.20
10 Jan	5.20	4.20	3.20
18-19 Jan	4.20	3.20	3.20
27 Jan	6.20	6.20	6.20
8/10 Feb	7.20	7.20	7.20
15 Mar	9.20	9.20	9.20
22 Mar	13.20	12.20	10.20
29 Mar	13.20	11.20	9.20
5 Apr	13.20	10.20	8.20

Table 1. Price history for US#1 ($ per 25-lb box) during the harvest window (27 Dec. 2004 and 2 June 2005) of Southwest Florida tomato industry. (Source USDA Agr. Mark. Serv., Fruit & Vegetable Market Rept.)

Harvest Date	**Grade class**		
	5x6 ($/box)	6x6 ($/box)	6x7 ($/box)
12 Apr	13.20	10.20	8.20
19 Apr	19.20	17.20	13.20
2 May	17.20	15.20	13.20
19 May	13.20	13.20	13.20
2 June	13.20	13.20	13.20

Table 2 (below) summarizes for each trial the impact of N rate differences within a trial on 5x6 yields and total revenue. In trial one, four N rates were evaluated. On the remaining farm sites, only two N rates were considered, the “grower-standard” and an IFAS rate of 200 lb N/acre. For example, the “grower-standard” on trial three was 300 lb N/acres, or a difference of 100 lb N/acres between “grower-standard” and UF-IFAS rate. A monetary value of yield differences was calculated on the basis of the projected yield differences between N rate treatments and prices listed in Table 4 that corresponded to the actual harvest dates of a given trial.

Table 2. Differences between higher and lower nitrogen rate (lb/acre), 5x6 yield (25 lb box/acre), and revenue ($/acre) in seven N fertilization trials conducted in 2004-2005 in Southwest Florida.

Trial		**Difference Lower - higher N rate**		
	N rate (lb/acre)	36	60	60+BS
1 Seepage/Fall 3-harvests	5x6 Yield (boxes/acre)	415	348	98
	Revenue ($/acre)	$2,848	$1,191	$773
	N rate (lb/acre)		60	
2 Seepage/Fall 3-harvests	5x6 Yield (boxes/acre)		171	
	Revenue ($/acre)		$1,042	
3 Seepage/Fall 2-harvests	N rate (lb/acre)		100	
	5x6 Yield (boxes/acre)		17	

Table 2. Differences between higher and lower nitrogen rate (lb/acre), 5x6 yield (25 lb box/acre), and revenue ($/acre) in seven N fertilization trials conducted in 2004-2005 in Southwest Florida.

Trial		**Difference Lower - higher N rate**
	Revenue ($/acre)	$1,064
4 Drip/Fall 3-harvests	N rate (lb/acre)	168
	5x6 Yield (boxes/acre)	388
	Revenue ($/acre)	$3,104
5 Drip/Spring 3-harvests	N rate (lb/acre)	60
	5x6 Yield (boxes/acre)	187
	Revenue ($/acre)	$3,567
6 Seep/Spring 3-harvests	N rate (lb/acre)	60
	5x6 Yield (boxes/acre)	84
	Revenue ($/acre)	$422
7 Seep/Spring 3-harvests	N rate (lb/acre)	60
	5x6 Yield (boxes/acre)	134
	Revenue ($/acre)	$2,604

Yield and financial impacts varied across trials. In all trials except trial six, total production of extra larges (5x6) boxes was greater under the higher grower fertilization rate. Total revenue was greater on all experiment sites, even in trial six. Since treatment plots were harvested regardless of market prices, it must be noted that revenue differences for the fall trials were overstated. When prices fall below $5 per box, growers will often choose either to abandon the crop, or direct harvesting crews to pick only the extra large sizes (5x6s). Trial six illustrated an important lesson of market timing. While the UF-IFAS rate on trial six produced more total cartons of 5x6s, 5x6 yields from the grower standard plots were greater during the third harvest date – April 19 when the market price exceeded $19 per box.

Vegetable BMP Research - 2004-2005 Season: Results

Weather data in the 2004-2005 growing season from the FAWN station in Immokalee showed monthly minimum-maximum temperature and rainfall in September, 2004 to May 2005 (Table 1). During that period, minimum daily temperatures below 38° F occurred on 13 Dec. (37.8° F), 15 Dec. (35.1° F), 20 Dec. (35.4° F), 24 Jan. (32.3° F), 12 Feb. (31.4° F), and 13-16 Feb. Rainfall events greater than 0.80 inch occurred on 25 Feb. (1.1 inch), 27 Feb. (0.97 inch), 3 Mar. (0.85 inch), 9 Mar. (2.12 inch), 17 Mar. (2.46 inch), and 2 Apr. (0.85 inch). None of those rainfall events met either of the leaching rain criteria. Because most trials were located south of the FAWN station located in Immokalee and up to 70 miles away from it, these weather data should be used only to describe the general weather conditions in the area and not to precisely assess the local conditions in each trial. Overall throughout Southwest Florida, the 2004-2005 seasons was cool and dry.

Table 1. monthly minimum-maximum temperature and rainfall in September 2004 to May 2005, respectively

Date	Monthly temperatures (min. & max. F)	Rainfall (inches)
Sept 04	65.2 - 91.8	6.46
Oct 04	51.2 - 89.1	0.39
Nov 04	48.6 - 87.9	0.48
Dec 04	35.1 - 85.2	0.77
Jan 05	32.3 - 83.3	0.58
Feb 05	missing value - 83.0	2.31
Mar 05	44.6 - 89.8	5.81
Apr 05	43.4 - 88.2	1.82
May 05	55.4 - 93.4	1.55

The water table depth for the seepage-irrigated trials (one, two, three, six, seven) ranged from approximately 10 to 25 inches in trial 1. Some fluctuations in the ground water table were observed due to changes in irrigation volume or rainfall. Wells in trial 2, 6, and 7 showed the least fluctuations in the water table depths. Previous research trials using seepage irrigation have shown that tomato yields were not reduced when the water table depth was maintained near the 20-inch depth. While keeping a lower water table resulted in reduced water use in that trial, water table depth fluctuations are likely to occur in large fields as observed in trial 1. Trial four was the only site where the water table reached to the surface between the row middles. Such fluctuations can cause N flushing from the bed. However, the risk of nutrient leaching was reduced in trial four with the use of drip irrigation for fertigation. The fluctuations in water table among the drip-irrigated experiments (trials four and five) were highest in trial four where the water table depth varied from 32 to 11 inches. The low water table depth (10 inches) between 24 Dec. and 7 Jan. was attributed to a 0.6-inch rainfall event on 25 Dec. (trial 4). Such occasional low water table conditions are mostly unavoidable and are to be expected in Southwest Florida. The risk of nutrient leaching caused by temporarily high water tables due to rainfall or frost protection may only be reduced by using drip irrigation tubing (mixed system) or a controlled-release fertilizer. The amount of fertilizer leached by changes in water table depth was not quantified in this study.

The differences in plant dry weight 30 and 60 DAP for all trials (one, two, three, four, five, six, seven) and seasons were not significant, except in trial 4 on 60 DAP. In trial four on 60 DAP; the higher N rate produced significantly higher tomato plant dry weight (187 g/plant) than the 250 lb N /acre rate (114 g/plant). Overall, N rates had little effect on tomato biomass 30 and 60 DAP. It was also observed that differences in shoot weight when plants are small may be due to differences in pruning. Although plant size is not necessarily a good predictor of marketable yield, large and actively growing tomato plants are often associated with increased earliness and increased nutrient reserves. Vegetable growers often report an association between increasing number of yellowing or senescent older leaves with increasing incidence of diseases on the lower part of the plants. Data that support this observation are currently not available.

Petiole sap NO_3-N and K concentrations tended to be above the UF-IFAS sufficiency threshold in all trials (NO_3-N: one, two, three, four, five, six, seven | K: one, two, three, four, five, six, seven), N treatments and throughout the season. Changes in petiole sap NO_3-N concentrations were different with seepage and drip irrigation (Fig. 2a, b). The different phases of petiole sap concentration changes in seepage irrigated trials showed (1) a period of low petiole response to fertilize rate (corresponding to the time needed for root establishment and the solubilization of nutrients in the hot band), (2) a period of increase well above the sufficiency range, followed by (3) a period of decrease. Dry weather conditions in 2004-2005 did not result in petiole sap nutrient concentration during period (3) to fall below the sufficiency range. Although tomato sap NO_3-N concentrations were higher in the higher N rates than in lower N rates, the N nutrition of plants receiving either N rate would be "sufficient". These plant-based data suggest that tomato plants maintained adequate levels of N (and K) even at the low N rates when cool and dry weather conditions prevailed.

In trial one, the symptoms of Fusarium crown rot first appeared on 12 Jan. 05. The number of plants showing symptoms increased through 2 Feb 05. The plants in the plots with the lowest N rate of 200 lb N/acre had the highest amount of disease incidence with an average of 53% symptomatic plants. The other three treatments receiving 236, 260 or 260+ biosolids lb N/acre, had 10%, 27%, and 20% average disease incidence, respectively. These observations support growers' observations and suggest that plant nutritional status may influence the susceptibility of tomato to diseases such as Fusarium crown rot. These results support the need to include the incidence of diseases in the selection of practical fertilizer rates. However, N rate may need to be associated with factors in determining the incidence of Fusarium crown rot symptom because such an association was not observed in all the trials.

More adult-whitefly days were observed on plants receiving the highest N rate as compared to the lowest N rate (trials one, two, three and four). The trend was consistent among all four individual farms (replicates) and statistically significant over all farms $F = 30.6$, $df = 1, 19$, $P < 0.01$. Nitrogen in the form of amino acids is the limiting resource for *sternrrhynchous homoptera* including whiteflies. Amino acids are concentrated by these phloem feeders through excretion of water and sugars as honeydew. Whitefly adults are known to prefer leaves and plants with higher

N concentrations that correspond to higher amino acid titers in the phloem. Positive response of adult-whitefly day to N fertilization has also been observed on cotton (*Gossypium hirsutum*) in the field.

Significant yield differences in the first harvest were found in two (Trial 1: First, Second, Third, Total, Commercial Parkout First and Trial 4: First, Second, Third, Total) out of seven trials (Trial 2: First, Second, Third, Total | Trial 3: First, Second, Total | Trial 5: First, Second, Third, Total, Commercial Parkout First | Trial 6: First, Second, Third, Total | Trial 7: First, Second, Third, Total) ($P<0.05$), whereas differences in total yield were significant only in one trial. In one of these trials using seepage irrigation, increasing N rate from 200 to 236 lb N/acre resulted in a significant first-harvest yield increase of 149 boxes/acre ($P<0.05$) in the tomato size category of 5x6. Total marketable yield increased by 115 boxes/acre ($P>0.90$) in this trial. In the second trial using a hybrid seepage-drip irrigation system, increasing N rate from 250 to 418 lb N/acre resulted in a significant first-harvest yield increase of 297 boxes/acre in the size category 5x6. Total yield was also significantly increased by 552 boxes/acre. These results illustrate that fertilizer efficiency may increased in dry years and tomato yields may not always respond to high N rates in such years.

Vegetable BMP Research - 2004-2005 Season: Conclusions

In conclusion results from these first-year trials are encouraging and indicate that this project is on track to achieve its objectives:

1. On farm trials along with extensive one-on-one grower contact was an effective means to engage growers in the implementation and outcome of this research and demonstration project
2. Optimal N rate for tomato is not a simple “one size fits all”. Recommendations should consider irrigation method (seepage or drip irrigation) and growing season (early, mid or late plantings requiring from 15 to 20 weeks from plating to harvest), and position of the bed relative to irrigation (adjacent v-ditches or increasingly further away)
3. In-season tomato nutritional status monitoring provides a real-time tool for assessing plant fertilizer needs
4. For a relatively dry year like the 2004-2005 season, grower’s rate resulted in significantly greater early 5x6 yields in two out of seven trials (29% of the cases)
5. Increasing fertilizer rates increases the theoretical risk of environmental impact. This risk needs to be truly assessed, compared to the economical risk of profit, and possibly reduced through the use of targeted cost-share programs.
6. Increasing N rates may increase yield and decrease the incidence of diseases, but it may also increase the risk of whitefly infestation.