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Trickle Irrigation: One Answer To Site-Specific Nutrient Management

Practice is combined with tissue nitrate testing used to avoid N deficiencies as well as unneeded N inputs.

Summary: *Trickle irrigation in combination with feedback from in-season nitrogen (N) tissue tests offers almost unlimited flexibility in developing site-specific nutrient management plans. Field experiments were conducted during 1994-95 in southern Arizona to evaluate the agronomic, economic, and environmental response of broccoli and cauliflower to a factorial arrangement of water and N rates, both ranging from deficient to supraoptimal. Concurrent evaluation of crop response surfaces for marketable yield, net economic return, and unaccounted for nitrogen fertilizer determined that profitable yields of broccoli and cauliflower could be produced with minimal impact on the environment.*

California and Arizona are the first and second leading producers of broccoli and cauliflower in the United States. These two crops are harvested from 162,000 acres each year and have a total value of over \$457 million. Much of the production in these two states is accomplished on arid and semiarid soils, and represents about 92 percent of the broccoli and cauliflower harvested annually in the United States.

Broccoli and cauliflower are highly dependent on inputs of irrigation water and nitrogen (N) fertilizer to achieve optimum production. Growers realize that these inputs must be carefully managed to ensure optimum yields and profits, and minimal environmental impact.

Increasingly, growers are adopting

production practices that allow them to significantly improve N and water-use efficiency. Two such practices are: 1) conversion to drip irrigation systems, and 2) the use of in-season tissue nitrate tests to monitor the N status of the crop. Used together, these technologies offer almost unlimited flexibility in developing site-specific nutrient management plans. The ability to inject multiple “split” applications of fluid N fertilizers directly through the drip system offers this flexibility in N management. The use of tissue nitrate testing provides the information growers need to avoid N deficiencies as well as unneeded N inputs.

Existing plant tissue N testing guidelines for broccoli and cauliflower, however, have two deficiencies. Either they are not calibrated to recommend the amounts of N fertilizer needed, or they contain guidelines for only the latter portions of the growing season when it is too late for remediation. Studies, therefore, were initiated to: 1) develop and calibrate N tissue tests to monitor crop N status as well as predict optimum timing and rates of fluid N fertilizer applications throughout the growing season, and 2) determine the response of trickle-irrigated broccoli and cauliflower to varying levels of N and water inputs to clearly identify best management practices (BMP).

N is key

Yield/return. Pronounced N x water treatment differences were visually

apparent beginning at the 6- to 8-leaf stages for both crops, and persisted and intensified as the season progressed. In general, N deficiency had a much greater negative effect on marketable yield and net return than did excessive water (“Wet”) for both crops as shown in Figures 1 and 2. A severe N deficiency (89 lbs/A of N) decreased these two yield parameters an average of 50 and 85 percent for broccoli and cauliflower, respectively. In contrast, excessive water application decreased average marketable yield and net return by only 14 and 32 percent for broccoli and cauliflower, respectively. Due to moderately high rainfall during the growth periods, no yield reductions were measured in the “Dry” water treatments for either crop.

N loss. In general, unaccounted for N fertilizer values were moderately low for both crops. Only when excessive water and a supraoptimal level of N (267 lbs/A) were applied did unaccounted for N fertilizer amounts exceed 100 lbs/A. It is estimated that the amounts of unaccounted for N below 36 lbs/A per crop would result in NO₃-N concentrations <10 ppm in the drainage water passing below the root zone of these crops. Concurrent analysis of crop response surfaces for marketable yield, net return, and unaccounted for N fertilizer revealed that profitable yields for both broccoli and cauliflower can be produced with minimal impact on groundwater.

Quality. Broccoli and cauliflower harvest quality and earliness were significantly decreased by a nitrogen deficiency. In contrast, irrigation water treatments (Wet, Optimum, Dry) had no significant effects on these quality parameters.

Calibration. The results obtained using the preliminary midrib tissue NO₃ test calibration for both crops were quite successful. Cumulative applications of 219 lbs/A of N with broccoli and 260 lbs/A of N with cauliflower were recommended by our preliminary guidelines. For both crops, the yield

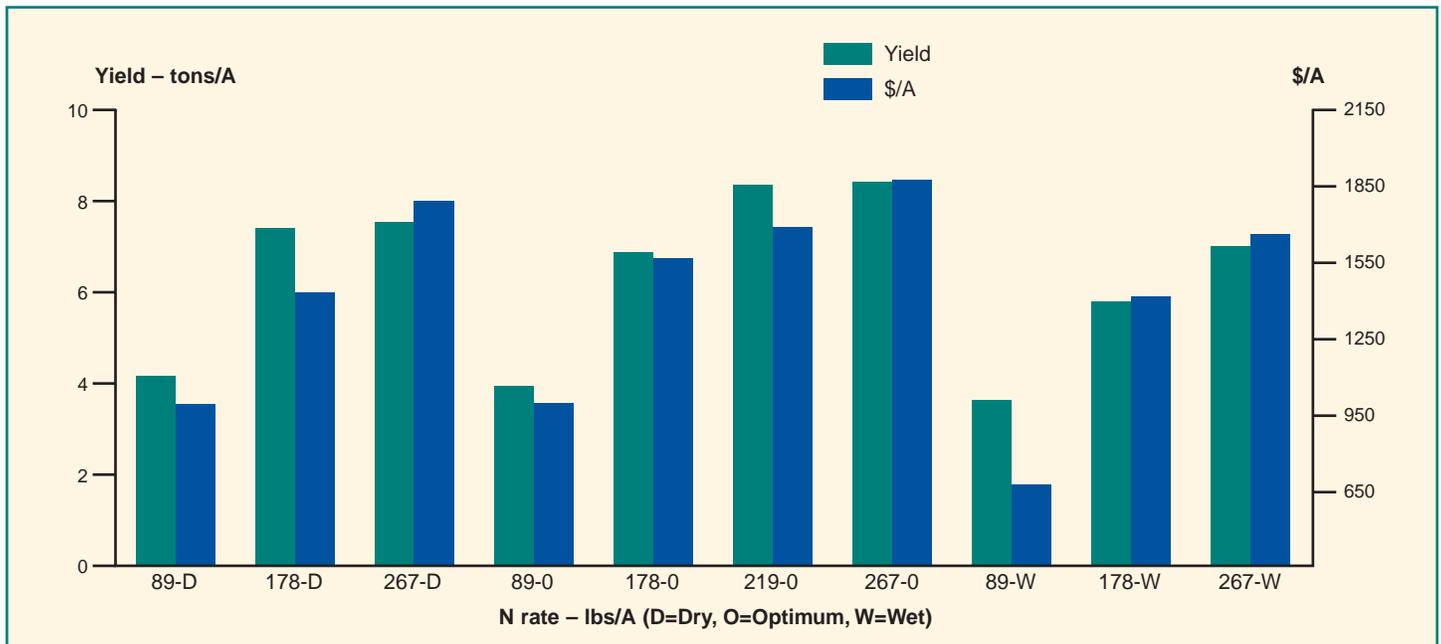


Figure 1. Marketable yield and net return for broccoli in response to N x water treatments, Doerge, et al., University of Arizona, 1994-95.

and quality parameters measured were statistically no different from the top yielding N x water treatment. The seasonal midrib NO₃ patterns obtained in these BMP treatments also tracked reasonably near the optimum patterns recorded (Figures 3 and 4).

Methodology

Site. Experiments were conducted on the irrigation research facility at the

Maricopa Agricultural Center, University of Arizona.

Water. Three rates of water and three rates of N were applied in two randomized complete block factorial experiments—one for broccoli and one for cauliflower. There were four replications. A tenth water x N treatment was also included. The BMP treatment received the optimum water treatment and N fertilizer applications were based

solely on preliminary midrib analysis calibrations for both crops.

Delivery system. Water and N were delivered through a subsurface drip irrigation system using one line of tubing injected 6 to 8 inches deep along the centerline of raised soil beds spaced every 40 inches. Nitrogen was supplied in five to six split applications injected into the drip irrigation system. Water was applied daily using an automated system

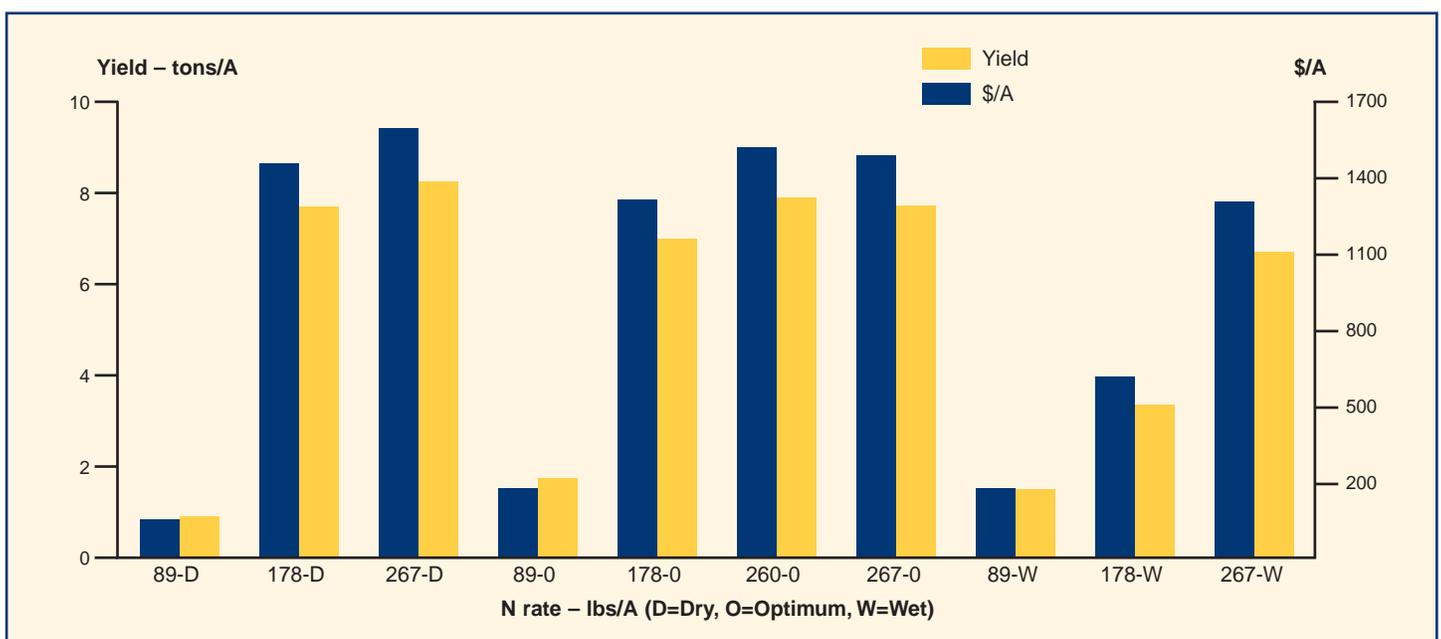


Figure 2. Marketable yield and net return for cauliflower in response to N x water treatments, Doerge, et al., University of Arizona, 1994-95.

to maintain average soil moisture tensions at the target levels. Daily readings of tensiometers placed at 12 and 24 inches were used to assist in irrigation scheduling.

Plots. Individual plots were 40 feet by 13.33 feet.

Tracking. ^{15}N labeled $(\text{NH}_4)_2\text{SO}_4$ was applied in two-meter-long microplots to investigate the effects of water level (Dry, Optimum, and Wet) and time of ^{15}N application (4- to 6-leaf and early heading) on N-use efficiency. This experiment was conducted in the broccoli experiment only.

Data collected. The following determinations were made in evaluating our '94-'95 field experiments:

1. Total aerial dry matter and biomass N content at final harvest
2. Midrib nitrate concentrations at 4- to 6-leaf, 10- to 12- leaf, head initiation, head development, and final harvest stages
3. Marketable yield and quality
4. Dry matter and total nitrogen content in unfertilized comparison plots to measure apparent nitrogen-use efficiency
5. ^{15}N content (water x N timing) in 18 broccoli microplots
6. Soil nitrate content to a depth of three feet in one-foot increments in all main plots, plus ^{15}N in the 18 microplots in samples taken immediately postharvest.

Nitrogen budgets were calculated for all of the main plots by the difference method. For each of the ^{15}N microplots, they were calculated using the isotopic dilution method.

Planting. Experiments were established on September 16 by direct seeding with a Stanley precision planter.

Irrigation. All plots were irrigated uniformly for 28 days until stands reached the 1- to 2-leaf stage. At this time, daily irrigation was scheduled to maintain the targeted soil water tensions. Total amounts of irrigation water applied (Dry, Optimum, Wet)

following stand establishment were 2.8, 3.2, and 14.7 inches for broccoli and 1.4, 2.6, and 17.4 inches for cauliflower.

Rainfall. A total of 5.0 and 5.2 inches of rainfall occurred during the broccoli and cauliflower experiments.

N content. Water applications contained between 0.6 and 7.9 lbs/A of nitrogen.

Refinement

The preliminary guidelines used for the 1994-95 crops will be refined as

needed and tested again in the 1995-96 season. Planting of both crops went as scheduled on October 2, 1995. All equipment and data-gathering installations are in place and functioning properly. As of mid-December, the experiments were in excellent condition and harvesting began in February of this year.

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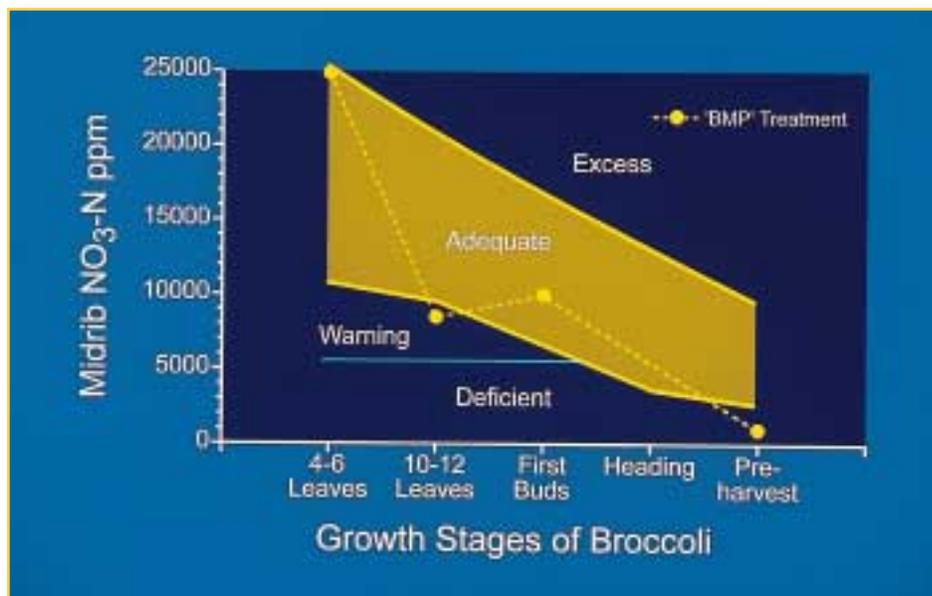


Figure 3. Interpretation of seasonal petiole nitrate levels in the BMP nitrogen treatment for broccoli, Doerge, et al., University of Arizona, 1994-95.

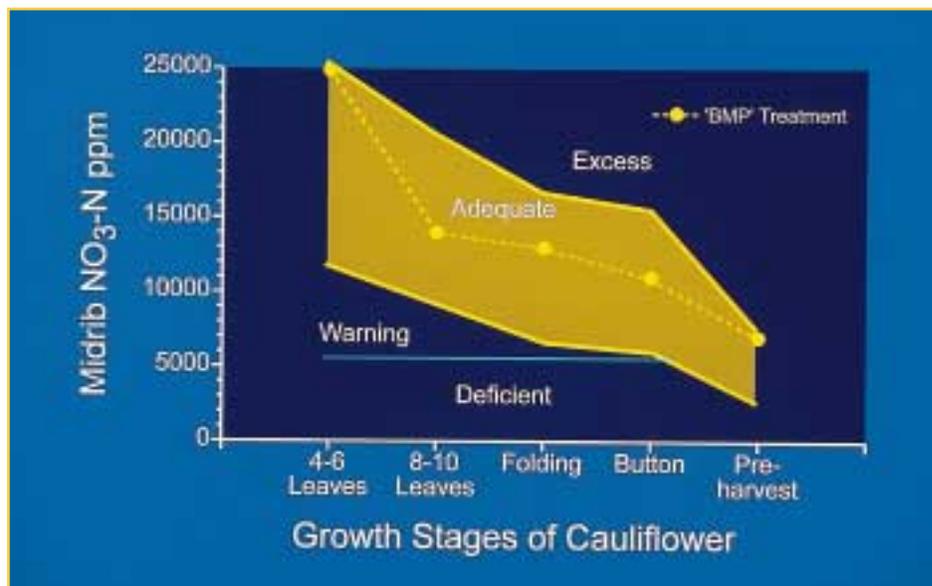


Figure 4. Interpretation of seasonal petiole nitrate levels in the BMP nitrogen treatment for cauliflower, Doerge, et al., University of Arizona, 1994-95.