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REPORT

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Irrigation and disease management of vegetables

Goals

Wise use of irrigation may help farmers to reduce fungicide applications on vegetable crops. Such a reduction is potentially significant when one considers that irrigation, fertilizer, and pesticide use account for more than 50 percent of the energy expended in fresh vegetable production.

Researchers demonstrated the most efficient irrigation system by comparing overhead with trickle irrigation, bare ground with black plastic mulch, and traditional disease management with computer-modeled approaches. They particularly emphasized water and energy savings as well as which system minimized chemical inputs into the environment. They also wanted to test whether trickle irrigation, which does not wet the leaves, results in less fungi growth and thus reduced fungicide use.

Part of this two-year project tested a weather-based model predictor system to eliminate preventive spraying that uses up to 100 gallons of diesel fuel per acre in the manufacture and application of chemicals. Fewer sprays conserve energy directly because less fuel and fungicide are used.

Approach

The site—the Muscatine Island Field Station on Iowa's eastern border—offers sandy soils that serve the highest concentration of vegetable growers in the state. The experimental design used treatments applied randomly and replicated three times. The whole plot was irrigated, either by overhead or trickle means. Subplots of either bare ground or black plastic mulch were treated with fungicide sprays.

Tomato transplants were set in place May 24 of 1988 and 1989. Each plot consisted of three double rows 16 to 18 inches (in.) wide, 20 feet (ft) long, and 6 ft center to center. Plants were set 9 to 12 in. apart.

Irrigation equipment: A sand point well and an existing 1.5-horsepower pump supplied water for both the overhead and the trickle systems. In the overhead irrigation system, aluminum pipes with risers set on 20-ft centers ran the length of each row. They delivered 1.57 gallons per minute, at 35 pounds per square inch, with a wetting diameter of 59 ft. Tensiometers, which measured the relative availability of the soil water for plant use, ensured that irrigation remained uniform. A new pump in 1989 provided a more uniform wetting pattern.

The 1988 trickle irrigation system used 1-in. polyvinyl chloride (PVC) main line; laterals were drip-in tubing with tiny emitter outlets every 12 in. Because tomato roots grew into these outlets, T-tape, turbulent-flow, trickle tubing with 8-in. openings was used in 1989.

Computer disease model: The FAST computer model (*Forecasting Alternaria solani on tomato*), an extensively field-tested system developed by Penn State researchers in 1976, uses temperature, relative humidity, rainfall, and leaf wetness data to determine the risk of an outbreak of early blight caused by *A. solani*. Widely used by growers of fresh-market tomatoes in Pennsylvania as well as in the tomato-growing regions of Ontario, *FAST* was central to this project because it can also predict the risk of outbreaks of *Septoria leaf spot* and *anthracnose*, two other serious tomato diseases.

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Budget

\$25,256 for year one
\$10,197 for year two

Environmental data processing and collection: Electronic sensors, including four leaf wetness sensors, four temperature sensors, and one relative humidity sensor, were placed within the plant canopy on both the overhead-irrigated plot and a nearby trickle plot to gather information during both growing seasons. A weather station adjacent to the plots connected these sensors to a data logger that recorded sensor signals every minute to get daily averages. This system allowed researchers to decide on a daily basis whether environmental conditions called for a foliar fungicide.

Findings

Irrigation program: Because of the severe 1988 drought, the pump ran up to 14 hours daily to provide both overhead and trickle irrigation. Overhead irrigation, which used about as much water as commercial growers do, worked well. But because tomato roots plugged the trickle system's emitter holes by mid July, the pump ran more frequently, and it was destroyed by the season's end. Thus, adequate water rates were difficult to determine. The T-tape tubing designed to eliminate rootlet plugging worked satisfactorily in 1989, another drought year.

Surprisingly, the black plastic mulch did not conserve water with either of the two irrigation systems. Water moved laterally only about six inches in the coarse, loamy sand soil. The plastic may have prevented *overhead* irrigation water from reaching plant roots early in the season, but the trickle tubing was placed between the 16-in. double rows *under* the plastic; thus, irrigation water could enter the soil profile. Researchers concluded that for the trickle system to be effective, it must include a lateral line for each row rather than one per double row. But this modification would prohibitively raise the annual material cost.

Harvest: In 1988, the initial fruit was harvested on Aug. 8; a total once-over harvest occurred on Aug. 23 (see Table 1).

Table 1. Effect of irrigation system and ground mulch on processing tomato yield, 1988.

Treatment	Yield, tons/acre			
	Marketable	Green	Rots	Total
<i>Overhead;</i>				
bare ground	13	8	0.3	21
<i>Overhead;</i>				
black plastic	13	7	1.1	20
<i>Trickle;</i>				
bare ground	12	6	1.0	18
<i>Trickle;</i>				
black plastic	18	14	0.9	32

Irrigation/ground cover interaction affected marketable yield significantly. Essentially, trickle irrigation with black plastic mulch was superior to the same irrigation without ground cover because much more green fruit was produced. Because the dry conditions allowed no significant disease to develop, disease was not factored into harvest figures.

In 1989, initial fruit harvest on Aug. 9 and a total "once-over" on Aug. 25 showed no significant interactions (see Table 2). Overhead irrigation on bare ground worked much better than trickle irrigation or the black plastic mulch; however, the trickle system used in this project reduced the grower's income compared with overhead irrigation.

Table 2. Effect of irrigation system, ground mulch, and fungicide program on processing tomato yield, 1989.

Treatment	Yield, tons/acre				
	Marketable	Green	Rots	Total	Late*
Irrigation					
-overhead	31	3	3	37	19
-trickle	24	3	2	29	17
Ground cover					
-bare	31	3	2	36	19
-black plastic	24	4	3	31	17
Fungicide					
-none	26	3	3	32	16
-conventional	30	3	2	35	20
-model-based	27	3	3	33	18

* Late = that portion of marketable yield that simulated machine harvest or once-over harvest on Aug. 25.

No fungal diseases developed on tomato foliage or fruit during either growing season, even in unsprayed control plots. But bacterial canker appeared in some plots by mid July in both years.

FAST model performance: During the 1988 monitoring period, the FAST model recommended four fungicide applications for the overhead-irrigated treatment and one application for the trickle-irrigated treatment. Weather station data suggested a single-spray application. Under a commercial tomato-processor's recommended spray program, fungicides would have been applied weekly during this

period. But the FAST model eliminated two sprays for the overhead-irrigated plots and five sprays for trickle-irrigated plots during the six-week period.

The heat and drought of the 1989 growing season nearly duplicated that of 1988. *Fungicide spraying during the second year was reduced by 56 percent and 75 percent respectively for the overhead and trickle treatments as compared with the conventional spray schedule.* As in 1988, use of the FAST system reduced fungicide spraying substantially without sacrificing fruit yield or quality.

Implications

Fewer fungicide spray trips over a field mean reduced fungicide costs and smaller amounts of synthetic chemicals released into the environment.

In this project, trickle rather than overhead irrigation resulted in even greater fungicide savings. Researchers also learned that using black plastic mulch offers no advantage; it neither conserved water nor improved marketable yields during either year of the study on these very sandy soils.

The FAST model shows potential for improving profitability of Iowa tomato growers as well as enhancing environmental quality. The absence of the major foliar fungal diseases such as early blight, Septoria leaf spot, and anthracnose on plots during both years of the study means that FAST needs further testing under Iowa conditions.

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