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Crop Notes

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BOTRYTIS GRAY MOLD PROBLEMS ON LETTUCE

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Introduction. In the early part of 2009, the relatively cool spring weather and some late spring rains were associated with gray mold problems on lettuce grown in desert, inland, and coastal regions. Gray mold can be a commonly encountered fungus that usually is relatively minor in importance for lettuce. However, if environmental conditions are favorable for the pathogen, gray mold can cause significant crop losses and reduced quality in the field.

Pathogen. The causal agent of gray mold on lettuce is *Botrytis cinerea*. This fungus is a very commonly found organism that readily grows as a saprobe on dead, declining plant tissue and organic matter. The characteristic fuzzy, velvety, grayish brown growth of the fungus can often be readily seen on diseased areas of the lettuce, especially on lettuce crowns in contact with soil and that may be shielded from the sun by overlying leaves. Black sclerotia (hard fungal resting structures measuring from 1/8 to 1/4 inch in diameter) may form on these diseased tissues, although some isolates produce few or no sclerotia. Sclerotia are usually dome-shaped or rounded and may appear identical to sclerotia produced by the species of *Sclerotinia* (*S. sclerotiorum*) that produces large sized resting structures. The fungus grows best at 62-74 F and is inhibited at warm temperatures above 89-90 F. *Botrytis cinere*a of lettuce is the same pathogen that causes gray mold disease on grape, strawberry, tomato, ornamental plants, and many other crops.

Symptoms. There are several different gray mold problems on lettuce.

(1) Death of transplants: Usually involving spring planted romaine, gray mold can cause newly transplanted lettuce to wilt, dry up, and eventually die. The transplant crown tissue becomes brown and soft. The characteristic fuzzy gray sporulation of the pathogen is usually present on the affected crown tissue in contact with the soil. While still in trays and under greenhouse conditions, lettuce transplants can also become infected with gray mold; however, such infections are always associated with old, overgrown transplants in which the older leaves have begun to age and decline (senesce).

(2) Primary crown rot: On established lettuce plants, gray mold can cause a decay disease of the crown tissue that results in poor growth, wilting of older leaves, and eventual collapse and death of the plant. Infected crowns develop a soft, mushy rot that is orange-brown to light brown in color. When the crown is significantly affected or girdled, the entire plant will die. The characteristic fuzzy gray sporulation of the pathogen is usually present on the affected crown tissue.

(3) Secondary crown rot: In some situations, *Botrytis* will colonize and rot lettuce crowns as a secondary factor following other problems. For example, if lettuce drop (*Sclerotinia minor*) or Phoma basal rot (*P. exigua*) diseases are affecting the lettuce, *B. cinerea* can subsequently colonize these previously damaged tissues and contribute further to crown decay and plant death. Symptoms and signs of this secondary gray mold are identical to those of primary gray mold.

(4) Foliar blight: *Botrytis* can also cause lettuce to develop a soft, brown rot of leaves, particularly on the leaf margins and on young leaves deep down within the heads of romaine and leaf lettuce types. Almost without exception, *Botrytis* infections of lettuce foliage follow damage caused by physical injury, frost damage, or tipburn disorder.

Diagnosing gray mold will require careful examination (see table). Overall plant wilting and collapsing symptoms caused by gray mold may look similar to such symptoms caused by *Sclerotinia* and

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perhaps *Phoma*. Also, the visible presence of *B. cinerea* on damaged lettuce tissues does not necessarily mean gray mold is the main concern; because *B. cinerea* grows so well on injured plant tissues, *Botrytis* may be a secondary agent following other diseases or damage. Accurate diagnoses, therefore, require careful examination of the crown and perhaps lab testing.

Disease cycle. *Botrytis cinerea* survives in and around fields as a saprophyte on crop debris, as a pathogen on numerous crops and weed plants, and as sclerotia in the soil. Conidia develop from these sources and become windborne. When conidia land on senescent or damaged lettuce tissue, they will germinate if free moisture is available and rapidly colonize this food base. Once established, the pathogen will grow into adjacent healthy stems and leaves, resulting in disease symptoms and the production of additional conidia. Cool temperatures, free moisture, and high humidity favor the development of the disease.

For *Botrytis* to penetrate and invade lettuce, plant tissues generally need to be damaged, senescent, or otherwise compromised; lettuce tissues are therefore predisposed to infection by frost or heat damage, physiological problems such as tipburn, or the activity of other pathogens. Injured tissues that are wet and in contact with the soil are especially susceptible. While all lettuce types can develop gray mold, romaine cultivars appear to be especially susceptible. In addition, some circumstantial evidence indicates that the 80-inch bed system of growing lettuce may result in increased gray mold problems during the cool, wet early spring season. This wider bed system results in denser plant stands, increased retention of moisture in the lower plant canopy, reduced wind penetration, and earlier senescence of old leaves. Such conditions favor the development of gray mold. However, the link between 80-inch beds and increased gray mold would need to be confirmed with field trials.

Control. Because *B. cinerea* initiates infection on damaged tissues, minimize damage to lettuce that is caused by cultural practices, environmental extremes, or other pathogens and pests. Use transplants that are not too large and overly mature; older transplants are subject to additional leaf breakage and damage during planting, and hence are more susceptible to gray mold infection. Minimize damage to lettuce transplants during the planting process, though it is not possible to prevent all injury. In the field, reduce leaf wetness by avoiding or reducing sprinkler irrigation. Schedule crop residue incorporation and soil preparation so that excessive plant residues are minimal at planting.

In some areas where weather trends are cool and moist, it may be helpful to apply fungicides to protect plants from gray mold. However, *B. cinerea* strains resistant to some fungicides are already widespread in some geographic areas. Use diverse fungicide products with different modes of action to reduce the risk of pathogen insensitivity. Before using any fungicide for the control of *B. cinerea* on lettuce, check with your local Agricultural Commissioner's Office for label restrictions and use information.

Botrytis Problems on Lettuce: A Summary

	Symptoms and Signs	Predisposing Factors
1. Transplant death	wilting and drying of leaves	1. Damage to transplants from
	poor growth of transplants	normal handling during planting.
	crown tissue soft and brown	
	eventual death of transplants	2. Wet soil conditions.
	gray sporulation usually present	
2. Crown rot	occurs on established plants	1. Senescent or damaged tissue
(primary)	outer leaves wilt	at base of crown.
	plants may be stunted	
	crown tissue soft, orange to brown	2. Wet, humid conditions at
	crown eventually is girdled	base of crown.
	eventual collapse of plant	
	gray sporulation usually present	
3. Crown rot	occurs on established plants	1. Senescent or damaged tissue
(secondary)	outer leaves wilt	at base of crown.
	plants may be stunted	2. Can follow Sclerotinia, Phoma.
	crown tissue soft, orange to brown	3. Wet, humid conditions at
	crown eventually is girdled	base of crown.
	eventual collapse of plant	
	gray sporulation usually present	
4. Foliar blight	sections of leaf have soft, brown rot	1. Injured leaf tissue from
	leaf margins are often affected	physical damage, frost damage,
	inner leaves of romaine/leaf lettuce	or tipburn.
	are often affected	
	gray sporulation may be present	

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Botrytis is commonly found growing on organic matter and a number of crops.

On lettuce, there are several different gray mold problems.

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Botrytis growth is favored by cool temperatures, free moisture, and high humidity.

The fuzzy gray growth of Botrytis cinerea is often readily seen on diseased crowns.

Gray mold is best managed by minimizing damage to the lettuce plant.

Romaine transplants can be very susceptible to gray mold disease.

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SPINACH AS A HOST OF IMPATIENS NECROTIC SPOT VIRUS

Steven T. Koike, University of California Cooperative Extension
Hsing-Yeh Liu and Beiquan Mou, USDA-ARS in Salinas

In the fall of 2008, researchers (Hsing-Yeh Liu and Beiquan Mou, USDA-ARS) documented the occurrence of the Impatiens necrotic spot virus (INSV) on spinach in the Salinas Valley; this is the first report of this virus on spinach in California. This finding is important in light of the recent damaging outbreaks of INSV on lettuce in the Salinas Valley. Symptoms on spinach consisted of stunted plants, interveinal yellowing, a general chlorosis, and a thickening and distortion of the spinach leaves. Some leaves may also develop areas that turn brown and die (necrosis). Confirmation of INSV in spinach required serological and molecular (reverse transcription-PCR) tests.

A number of new INSV hosts have recently been reported.

INSV is a plant-infecting virus placed in the tospovirus group. INSV is vectored from plant-to-plant only by the thrips insect. Most research, including our lettuce INSV studies conducted in the Salinas Valley, indicates that INSV is vectored only by the western flower thrips (*Frankliniella occidentalis*). However, other work indicates that some other species (*F. fusca, F. intonsa*) could also vector INSV. Only thrips in their larval stage are able to acquire the virus via feeding on infected plants; they then can carry and transmit the virus for the remainder of their lives. There is presently no evidence that INSV is seedborne in spinach or other crops.

Historically, INSV is known to be more of a disease concern on flowering ornamental plants and greenhouse crops; the INSV occurrences on lettuce and now spinach, therefore, are apparent departures from this pattern. Elsewhere there are new reports of INSV on pepper, potato, and peanut, so the host range of this virus is expanding. Researchers (Koike and Gilbertson) are presently investigating the occurrence of INSV in fields of faba bean and radicchio grown in the Salinas Valley.

On spinach, the other common thrips-vectored virus, Tomato spotted wilt virus (TSWV), has been found previously in coastal plantings. TSWV in spinach caused yellow spots, chlorotic blotches, brown necrotic spots, and some leaf distortion. Disease incidence was low and the virus did not result in significant economic losses. It is important to remember that INSV, TSWV, and other plant viruses may cause similar symptoms in spinach and that positive diagnosis is not possible without the use of appropriate tests.

It is not known whether INSV will be an important problem on spinach, or if infected spinach could serve as a source of vectoring thrips for lettuce; however, growers, PCAs, and field personnel should be aware of this new report and inform us if virus-like symptoms are observed on spinach.

It is not clear if INSV will be a significant problem for spinach production.

INSV causes yellowing and poor growth of spinach (Photo by B. Mou).

OPTIMIZING OVERHEAD SPRINKLERS: PRESSURE EFFECTS ON APPLICATION RATE, DISTRIBUTION OF WATER, AND PUMPING COSTS.

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Overhead sprinklers have an important role in the production of many cool season vegetable crops. Because sprinklers can be used to uniformly moisten the soil surface, they are used for germinating shallowly planted vegetable seed and for establishing transplanted vegetable crops. Sprinklers also provide a practical method to irrigate crops such as baby lettuce and baby spinach which may reach maturity in less than 30 days and have too many plant rows on a bed to be practically configured for surface drip. Other vegetable commodities such as broccoli are not sufficiently valuable to incur the extra costs associated with the use of drip irrigation.

Irrigation run-off often occurs on soil types when the infiltration rate decreases to less then the application rate of the sprinklers. In an unsaturated state, most soils have high infiltration rates, but as soils are irrigated and the pores become saturated, water infiltrates slower into the soil. Additionally, some soil types are susceptible to crusting due to the impact of water droplets from sprinklers. The soil crust impedes infiltration of water into the soil, thereby increasing run-off.

Reducing the application rate of overhead sprinklers may be one method to reduce run-off. For example, if water is infiltrating at an average rate of 0.15 inches per hour and the sprinkler system is applying water at 0.25 inches per hour (0.1 in/hr greater than the infiltration rate), reducing the application rate of the sprinkler to 0.2 inches per hour (0.05 in/hr greater than the infiltration rate) could reduce run-off by 50%.
The challenge is to reduce the application rate without reducing the uniformity of the sprinklers. We have noted that some farming operations pressurize overhead impact sprinklers to pressures greater than pressures recommended by the manufactures of the sprinkler heads. For example, we have measured nozzle pressures for the ½ inch brass impact heads, (Rainbird 20JH) between 60 psi and 70 psi. Reducing the system pressurized from 60 psi to 40 psi, could reduce the application rate by 18% for nozzles with a 7/64" diameter orifice (Table 1).

Reducing the system pressurized from 60 psi to 40 psi, could reduce the application rate by 18% for nozzles with a 7/64" diameter orifice (Table 1).

The question remains whether lower pressured would reduce the uniformity of the sprinklers. We conducted tests to determine the effect of nozzle pressure on the distribution profile of water from new Rainbird 20JH sprinkler heads using nozzles with a 7/64" diameter orifice. We placed the heads on a test stand and operated them under normal wind conditions and collected water in buckets radiating in 8 directions from the sprinkler head, spaced at 2 foot increments. We also used Sprinkler Profile and Coverage Evaluation (SPACE) software from the Center for Irrigation Technology, Cal State University Fresno to estimate distribution uniformities under different lateral pipe spacings and pressure scenarios.

Results:
The average flow rate with a 7/64" nozzle was 2.31 gal/min at 40 psi and 2.84 gal/min at 60 psi. These flow rates were slightly higher than reported by Rainbird (Table 1), but the relative differences were similar. Lowering the pressure from 60 to 40 psi reduced the flow rate from the sprinkler heads by 18%.
Applied water collected at varying distances from the sprinkler head were expressed as a percentage of total applied water in Figures 1 and 2. We measured no significant differences in the relative amounts of water applied at pressures of 40 psi and 60 psi at wind speeds of 4.5 mph (Figure 1) and between 6 and 7 mph (Figure 2). With a higher wind speed, a greater portion of water was applied within 15 feet of the sprinkler head (Figure 2) compared to a slightly lower wind speed (Figure 1). These results should be a reminder that wind speed has much more effect on the distribution of water from a impact sprinkler head than nozzle pressure.
Using the SPACE overlap program and the distribution profiles from Figure 1, we evaluated the uniformity of overhead sprinklers operated at pressures of 40 and 60 psi. Spacing between heads along the sprinkler pipe was assumed to be 30 feet. Table 2 presents estimated distribution uniformity and scheduling coefficient for sprinklers operating at pressures of 60 and 40 psi for various distances between lateral pipes. Predicted distribution uniformities were 83% or greater for all pipe configurations at wind speeds of less than 5 mph.

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These results should be a reminder that wind speed has much more effect on the distribution of water from a impact sprinkler head than nozzle pressure.

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The predicted distribution uniformities for 60 and 40 psi were similar at 30 and 33 foot distances between lateral pipes. The SPACE program predicted a small reduction in uniformity at distances between pipes of more than 33 feet (Table 2). Using the data from Figure 2 (wind speeds between 6 and 7 mph), the SPACE program also predicted similar distribution uniformities for nozzle pressures of 40 psi and 60 psi for distances between lateral pipes ranging from 30 to 40 feet (results not shown).

Energy costs to pump water increased as nozzle pressure increased by 20 psi. For an electrically driven pump, the difference in energy costs between 40 and 60 psi may range from $7 to $12 per acre-ft of water pumped depending on the price of electricity (Table 3). Similarly for diesel driven pumps, an increase of pressure of 20 psi could increase pumping costs from $16 to $26 per acre-ft of water pumped (Table 4).

Summary

Our tests demonstrated that for typical spacings used for solid-set sprinkler pipe on cool season vegetables of 30 feet^2 30 feet or 30 feet^2 33 feet, increasing nozzle pressure from 40 psi to 60 psi did not improve distribution uniformity. However, energy costs for pumping at higher pressures were increased by $7 to $26 per acre-foot of water depending on the energy source (electric vs diesel) and price of energy. Also, the amount of water applied per hour increased by about 18% by raising the pressure from 40 to 60 psi. On soils where water tends to infiltrates slowly, the higher application rate of water could also increase tail water run-off.

Our tests demonstrated that for typical spacings used for solid-set sprinkler pipe on cool season vegetables of 30 feet^2 30 feet or 30 feet^2 33 feet, increasing nozzle pressure from 40 psi to 60 psi did not improve distribution uniformity.

Table 1. Flow rates for varying pressures and nozzle sizes on 20JH sprinkler heads. Values determined by Rainbird, Inc.

	---------------- nozzle size ----------------			
Nozzle pressure	7/64"	1/8"	9/64"	5/32"
psi	-------------- gpm -----------------			
35	2.05	2.68	3.39	4.19
40	2.19	2.86	3.62	4.47
45	2.32	3.03	3.84	4.73
50	2.45	3.20	4.05	5.00
55	2.57	3.35	4.24	5.23
60	2.68	3.50	4.43	5.47

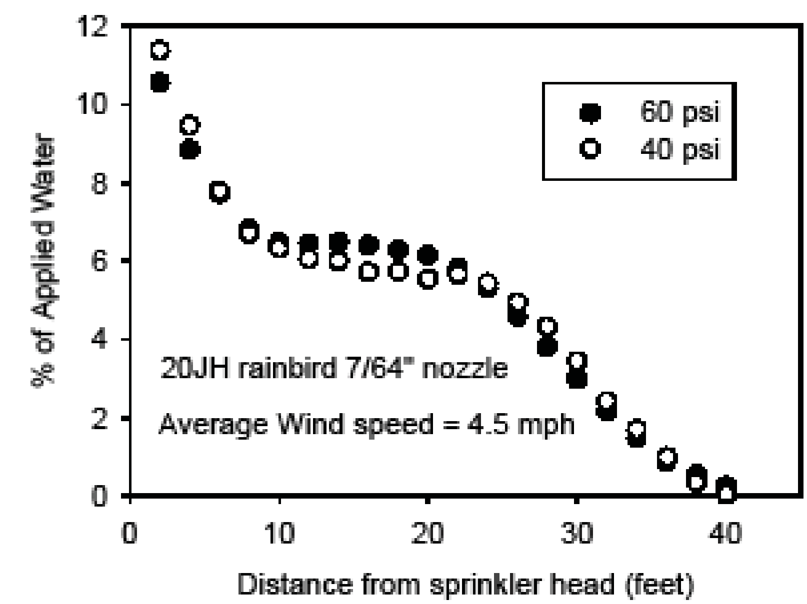

Figure 1. Average distribution of water from a rainbird 20JH sprinkler head with a 7/64 inch diameter nozzle at pressures of 60 and 40 psi and average wind speeds of 4.5 mph

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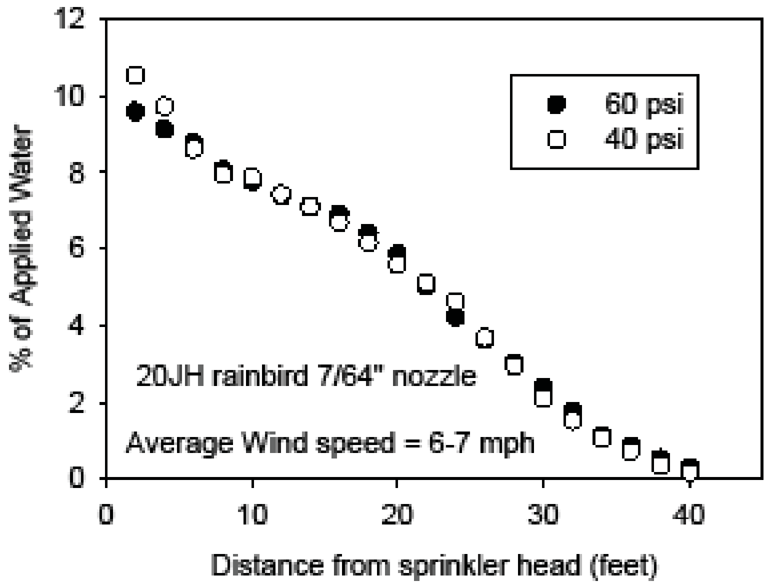

Figure 2. Average distribution of water from a rainbird 20JH sprinkler head with a 7/64 inch diameter nozzle at pressures of 60 and 40 psi and average wind speeds of 6 to 7 mph.

Table 2. Estimated distribution uniformity and scheduling coefficients for 20JH Rainbird sprinkler heads with a 7/64 inch diameter nozzle at pressures of 40 and 60 psi and varying lateral spacings. Spacing between heads on lateral lines is 30 feet and riser height is 18 inches.

Spacing between lateral lines	Distribution Uniformity (lowest quarter)	Scheduling Coefficient (5%)
feet	%	
-------------Nozzle pressure = 60 psi --------------		
30.0	94	1.1
33.3	90	1.1
36.7	87	1.2
40.0	88	1.2
-------------Nozzle pressure = 40 psi --------------		
30.0	94	1.1
33.3	88	1.2
36.7	83	1.3
40.0	83	1.3

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Table 3. Estimated electrical energy costs for pumping water and pressuring overhead sprinklers to 40 and 60 psi.

	Pumping Costs for Sprinklers[1]		
	Pressure at nozzle		
Energy Cost Rate	40 psi	60 psi	Difference
$/kWhr	------- $/acre-ft ----------		
0.10	33.5	40.8	7.3
0.12	40.2	48.9	8.7
0.14	46.9	57.1	10.2
0.16	53.6	65.2	11.6

1. 120 ft operating depth for well, 90% efficiency motor, 72% efficiency pump

Table 4. Estimated diesel energy costs for pumping water and pressuring overhead sprinklers to 40 and 60 psi.

	Pumping Costs for Sprinklers[1]		
	Pressure at nozzle		
Energy Cost Rate	40 psi	60 psi	Difference
$/gal	------- $/acre-ft ----------		
2.50	73.7	89.7	16.0
3.00	88.4	107.6	19.2
3.50	103.1	125.5	22.4
4.00	117.9	143.4	25.5

1. 120 ft operating depth for well, 25% efficiency engine, 72% efficiency pump

LARGE SCALE IRRIGATION AND NITROGEN FERTILIZER MANAGEMENT TRIALS IN LETTUCE

Micheal Cahn & Richard Smith, University of California Cooperative Extension

Commercial field –size trials were conducted to demonstrate practices to improve irrigation and nitrogen fertilizer management in romaine and iceberg lettuce in the Salinas Valley during 2008. Managements included 1). Scheduling irrigations based on weather and soil based information, and 2). Using the nitrate quick test (NQT) to match fertilizer rates with the nitrogen uptake pattern of the crop. Together, these practices may prevent excessive use of water and fertilizer and provide tools for optimizing yield and quality of lettuce. The combined nitrogen and water management practices were referred to as the BMP (best management practices).

Procedures Trials were designed to compare the BMP and standard grower practices on large replicated strips in commercial fields located in the northern and southern parts of the Salinas Valley (Table 1). The management strips were 160 feet wide by the length of the field. Trials ranged from 15 to 27 acres in size. Soil textures ranged from silty clay to sandy loam at the trial sites (Table 2). The iceberg crop was irrigated with overhead sprinklers only and the romaine crops were irrigated with sprinklers for approximately the first 30 days of the crop followed by surface placed drip tape until harvest. Irrigations were scheduled from estimated consumptive water use for lettuce which was based on CIMIS evapotranspiration data and the water holding capacity of the soil. Applied water of the different management treatments was monitored using flow meters. Nitrogen fertilizer recommendations were based on weekly determinations of soil nitrate in the top foot of soil using the nitrate quick test. Soil moisture data and plant biomass was

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compared weekly between management treatments. Leachate during irrigation events was sampled using a suction lysimeter. Yields evaluations of trials 1&2 were made of cored lettuce using commercial equipment to harvest the center 12 beds of the management strips and trial 3 yield evaluation was made in small plots (2, 100 feet ^{2} 13.3 ft plots) located within the management strips.

Summary of Results Water and nitrogen fertilizer application was significantly reduced in the BMP treatment (Tables 3, 4 and 5), averaging 109 lbs of N/acre and 11.8 inches of water for the BMP treatment and 175 lbs of N/acre and 15.7 inches of water in the grower standard treatment for all trial sites. The greatest reductions in water and nitrogen fertilizer were in Trial 3 and Trial 1, 7.5 inches and 139 lbs of N/acre, respectively. Trial 2 had the least reduction in water and fertilizer because the grower standard practice was similar to the BMP treatment.

Monetary savings for applied water and fertilizer (Tables 3 and 5) were highest in Trial 1 site ($98/acre) and least for Trial 2 ($14/acre). Average savings in water and fertilizer for the 3 trials was $53/acre. Although average water savings were less than fertilizer savings ($14/acre for water and $39/acre for nitrogen fertilizer), careful water management is needed to prevent nitrogen fertilizer losses through leaching.

Monitoring of water use, soil moisture and nitrate concentration of leachate demonstrated that nitrate nitrogen leached below the 2 foot depth in both treatments. Nitrate-nitrogen concentrations in leachate sampled with a suction lysimeter ranged from 105 to 178 ppm (Tables 6 and 7). The higher amounts of water applied in the grower standard treatments resulted in more percolation of nitrate nitrogen during 4- day (Table 6) and 14-day (Table 7) periods compared to the BMP irrigation treatment. Applying water rates closer to consumptive water use in the BMP treatment minimized nitrate leaching and reduced the economic loss of applied nitrogen to the crop.

Soil nitrate levels were higher in the BMP treatment over the course of the growing season in spite of the lower total nitrogen application. This observation indicates that by applying irrigation water at rates close to consumptive use of the crop, nitrate can be effectively maintained in the root zone and leaching losses can be minimized. This can save growers money (see Tables 6&7) and help to safeguard water quality.

Yields in Trials 1 and 2 were comparable between the BMP and Grower standard treatments (Table 8). Yield of the BMP treatment was 13.4% less than the grower standard in Trial 3; however, uneven plant populations in this trial increased variability in yield measurementsl.

Conclusions

These trials demonstrated that careful water management and nitrogen fertilizer management can result in equivalent yields, save money and provide water quality benefits. In addition, reducing nitrate leaching could minimize nitrogen loading to our regional aquifer. The main tool for improving irrigation scheduling for lettuce is using CIMIS evapotranspiration data and soil water holding properties to estimate a reasonable irrigation schedule that will maintain yields and minimize percolation of nitrate. The nitrate quick test can provide guidance for management of fertilizer nitrogen. Taken together these techniques can provide growers with tools to help make decisions to improve the efficiency of lettuce production.

Table 1. Planting date, lettuce type and varieties at trial sites.

Trial Site	planting date	Days to harvest	lettuce type	variety
Trial 1	6/28/2008	68	iceberg	Gabilan
Trial 2	7/14/2008	65	romaine	Sun valley/Platinum
Trial 3	8/23/2008	70	romaine	Altura

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Table 2. Irrigation method and soil types at trial sites.

Trial Site	Irrigation method	Soil type
Trial 1	sprinkler	Rincon clay loam
Trial 2	sprinkler/drip	Chualar sandy loam
Trial 3	sprinkler/drip	Cropley silty clay /Salinas Clay loam

Table 3. Applied water in BMP and grower standard treatments, and estimated crop water use and energy savings at trial sites.

	Grower	BMP					
Trial Site	Total Applied Water (inches)		Estimated Crop ETc (inches)	Estimated Consumptive Water Use [1] (inches)	Water use reduction (%)	Energy Savings ($/acre)	Estimated pumping costs (drip/sprinkler)[2] $/acre-foot
Trial 1	17.7	14.7	10.1	13.4	17	15.5	--[3]/59
Trial 2	9.9	8.7	7.6	8.9	12	7.6	48/76
Trial 3	19.4	11.9	6.7	8.7	39	18.1	29/59
Average	15.7	11.8	8.1	10.3	23	14	39/65

1. consumptive water use = ETc/DU; DU = distribution uniformity of the irrigation system

2. assumes energy costs of $0.15/kWhr, operating well depths of 75 feet for Trials 1 and 3, and 150 feet for Trial 2

3. only sprinklers were used at this site.

Table 4. Applied water in BMP and grower standard treatments during germination and post germination.

	Grower	BMP	Grower	BMP	Grower	BMP
Trial Site	Total Applied Water		Germination Water		Post Germ. Water	
Trial 1	17.7	14.7	5.6	4.5	12.1	10.2
Trial 2	9.9	8.7	3.5	2.4	6.4	6.3
Trial 3	19.4	11.9	6.0	5.8	13.4	6.1
Average	15.7	11.8	5.0	4.2	10.6	7.5

Table 5. Applied nitrogen fertilizer and soil nitrate levels in BMP and grower standard treatments, and fertilzer cost savings at trial sites.

	Grower	BMP	BMP Nitrogen Reduction	Grower	BMP	Grower	BMP	Fertilizer Cost Reduction
Trial Site	Total Applied Nitrogen (lbs N/acre)		(lbs N/acre)	Mean Soil Nitrate (over season) (ppm NO3-N)		N uptake at harvest (lb N/ac)		($/acre)[1]
Trial 1	248.3	109.7	138.6	33.3	47.0	133.8	141.5	83.16
Trial 2	76.9	64.7	12.2	18.3	19.5	138.2	122.8	7.32
Trial 3	199.7	153.6	46.1	19.5	20.4	86.4	93.38	27.66
Average	175.0	109.3	65.6	23.7	29.0	119.5	119.2	39.38

[1] based on $0.60/lb of nitrogen (AN20) as of May 2009

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Table 6. Estimated nitrate leaching losses for BMP and Grower treatments at Trial 1 during a single sprinkler irrigation.

Management Treatment	Applied Water[1]	Crop ET	Soil Moisture Storage	Percolation	NO3-N concentration in leachate	Nitrogen loss by leaching	Fertilizer N costs due to leaching[2]
	----------------	inches	----------------		ppm	lb/acre	$/acre
BMP	0.8	0.6	0.0	0.3	173.9	11.2	6.74
Grower	1.4	0.6	-0.1	0.9	178.4	37.3	22.40

[1] July 25 - July 29, 2008

[2] N fertilizer price = $0.60/lb (May 2009)

Table 7. Estimated nitrate leaching losses for BMP and Grower treatments at Trial 2 during germination using sprinklers.

Management Treatment	Applied Water[1]	Crop ET	Soil Moisture Storage	Percolation	NO3-N concentration in leachate	Nitrogen loss by leaching	Fertilizer N costs due to leaching[2]
	----------------	inches	----------------		ppm	lb/acre	$/acre
BMP	2.4	1.2	0.0	1.2	116.4	31.4	18.85
Grower	3.5	1.2	0.3	2.1	104.9	49.5	29.67

[1] July 10 - July 24, 2008

[2] N fertilizer price = $0.60/lb (May 2009)

Table 8. Commerical yields of BMP and grower standard treatments.

Trial Site	Grower	BMP	BMP Percent Difference from Grower Standard
	Total CFR Yield[1] (lbs/acre)		
Trial 1	43233	42828	99.1
Trial 2	27857	27938	100.3
Trial 3[2]	24290	21045	86.6
Average	31793	30604	95.3

1. CFR = cored for region

2. yield data was estimated from small plots

WE ARE GOING GREEN!

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