Large scale irrigation and nitrogen fertilizer management trials in lettuce

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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 quick nitrate test (QNT) to customize the fertilizer rates to match 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 (grower advantage in nitrogen) practice

Procedures Trials were designed to compare the BMP and standard grower practices on large replicated strips in commercial fields located in the Salinas Valley near South Salinas and in South County (Table 1). The management strips were 160 feet in width and 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. Soil moisture data and plant biomass was compared weekly between management treatments. Leachate during irrigation events was sampled using a suction lysimeter. Yields of cored product were measured in small plots (2, 100 feet × 13.3 ft plots) located within the management strips and using commercial equipment to harvest the center 12 beds of the management strips. Samples of the cored product were determined for quality by Fresh Express.

Summary of Results Water and nitrogen fertilizer was significantly reduced in the BMP treatment (Tables 3 and 4), 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 was at the South County 1 trial (reduction of 7.5 inches), and the greatest reduction in nitrogen fertilizer was at the South County 2 trial (reduction of 140 lbs of N/acre). The South Salinas site had the least reduction in water and fertilizer because the grower standard practice was similar to the BMP treatment.

Estimated water and fertilizer savings (Tables 3 and 5) were highest at the S. County 1 site ($135/acre) and least at the South Salinas site ($18/acre). Average savings in water and fertilizer for the 3 trials was $70/acre. Although average water savings were less than fertilizer savings ($14/acre for water and $57/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 when too much water was applied, significant amounts of nitrate nitrogen leached below the 2 foot depth. 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. On average, twice as much nitrate-nitrogen leached under the grower standard compared to the BMP management treatment.

The soil nitrate levels during the season provided further evidence to indicate that nitrate leaching was minimized under the BMP treatment. Although an additional average of 65 lb of N fertilizer per acre

were applied in the Grower standard treatment compared to the BMP treatment, average soil nitrate levels remained highest in the BMP treatment.

Yields estimated from small plots were comparable between the BMP and Grower standard treatments at the S. County site but were about 13% less than the grower treatment at the South Salinas and S. County 2 sites (Table 8). However, different varieties planted at the South Salinas site confounded yield measurements, and uneven plant populations increased variability in yield measurements at the S. County 2 site. Yields measured using commercial equipment only found yield differences at the S. County 2 site.

Conclusions

These trials demonstrated that careful water management and nitrogen fertilizer management can minimize nitrate leaching, resulting in significant fertilizer and water cost savings. 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 deep percolation. In addition the quick nitrate test can provide guidance for management fertilizer nitrate.

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

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

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

Trial Site	Irrigation method	Soil type
S. County 1	sprinkler	Rincon clay loam
S. Salinas	sprinkler/drip	Chualar sandy loam
S. County 2	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.

Trial Site	Grower Total Applied Water (inches)	BMP 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
S. County 1	17.7	14.7	10.1	13.4	17	15.5	--[3]/59
S. Salinas	9.9	8.7	7.6	8.9	12	7.6	48/76
S. County 2	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 S. County 1 and 2, and 150 feet for S. Salinas

[3.] only sprinklers were used at this site.

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

Trial Site	Grower Total Applied Water	BMP Total Applied Water	Grower Germination Water	BMP Germination Water	Grower Post Germ. Water	BMP Post Germ. Water
S. County 1	17.7	14.7	5.6	4.5	12.1	10.2
S. Salinas	9.9	8.7	3.5	2.4	6.4	6.3
S. County 2	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 and fertilzer cost savings at trial sites.

Trial Site	Grower Total Applied Nitrogen (lbs N/acre)	BMP Total Applied Nitrogen (lbs N/acre)	BMP Nitrogen Reduction (lbs N/acre)	Grower Mean Soil Nitrate (over season) (ppm NO3-N)	BMP Mean Soil Nitrate (over season) (ppm NO3-N)	Grower N uptake at harvest (lb N/ac)	BMP N uptake at harvest (lb N/ac)	Fertilizer Cost Reduction ($/acre)[1]
S. County 1	248.3	109.7	138.6	33.3	47.0	133.8	141.5	119.20
S. Salinas	76.9	64.7	12.2	18.3	19.5	138.2	122.8	10.49
S. County 2	199.7	153.6	46.1	19.5	20.4	86.4	93.38	39.65
Average	175.0	109.3	65.6	23.7	29.0	119.5	119.2	56.44

[1] based on $0.86/lb of nitrogen (AN20) - quote from Wilbur Ellis

Table 6. Estimated nitrate leaching losses for BMP and Grower treatments at the South County 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
	---------- inches ----------				ppm	lb/acre
BMP	0.8	0.6	0.0	0.3	173.9	11.2
Grower	1.4	0.6	-0.1	0.9	178.4	37.3

[1] July 25 - July 29, 2008

Table 7. Estimated nitrate leaching losses for BMP and Grower treatments at the South Salinas trial during germination using sprinklers.

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

[1] July 10 - July 24, 2008

Table 8. Yield and biomass in BMP and grower standard treatments.

	Grower	BMP	Grower	BMP	Grower	BMP	Grower	BMP	BMP Percent
	Total Yield		(untrimmed)		Mean Head (CFR)[1]		Total CFR Yield		Difference
Trial Site	(lbs/acre)		(lbs/head)		(lbs/head)		(lbs/acre)		from Grower Standard
S. County 1	86591	85701	2.36	2.33	1.78	1.77	54649	55506	101.6
S. Salinas	74037	69525	1.81	1.68	1.29	1.11	52903	45911	86.8
S. County 2	56869	53880	1.87	1.76	1.19	1.02	24290	21045	86.6
Average	72499	69702	2.01	1.92	1.42	1.30	43947	40821	91.7

[1.] CFR = cored for region