Cooperative Extension • Monterey County

Crop Notes

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In This Issue:

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IMPROVING NITROGEN USE IN STRAWBERRY PRODUCTION

Tim Hartz and Tom Bottoms, UC Davis
Michael Cahn and Barry Farrara, UC Cooperative Extension

Strawberry growers are well aware of the increasing regulatory pressure on agriculture to reduce nitrate-nitrogen (NO_3-N) leaching to groundwater. For the first time, the Regional Water Quality Control Board has proposed a numerical target for seasonal N fertilization for strawberry production; that target is 120% of total crop N uptake. Over the 2009-10 and 2010-11 production seasons we conducted extensive monitoring in several dozen strawberry fields in the Watsonville-Salinas area to develop an understanding of the nitrogen dynamics of current production practices, and to identify ways in which nitrogen use efficiency might be improved.

All fields were planted either with 'Albion' or a common proprietary day-neutral variety. Root zone (top 12 inch) soil sampling for NO_3-N concentration was done on a monthly basis from April through September; in 8 fields we also conducted soil NO_3-N sampling at the time of planting in the fall. Cooperating growers provided detailed records of their fertilizer management. In seven fields crop N uptake was documented by collecting 8-12 whole plants per field on a monthly basis from March to September. Fruits were removed, and the vegetative portion (leaves and crowns) were oven-dried, ground and analyzed for N content. At each sampling date ripe fruit were also analyzed, and the amount of N contained in fruit was estimated by multiplying the fruit N concentration by the marketable yield during each sampling period.
In three fields we also evaluated the efficiency of current preplant controlled release fertilizer (CRF) use. Sites 1 and 2 were fields near Salinas and Watsonville, respectively, and were planted with 'Albion'; soil texture at both sites was a loam. Site 3 was a field of clay loam soil near Castroville, and was planted with a proprietary day-neutral cultivar. At sites 1 and 2 the growers' standard CRF application (18-8-13, 7-9 month release rating, 108 lb N/acre) was compared to a half rate application; at site 3 both a half rate and no CRF were compared to the grower's standard application (18-8-13, 7-9 month release rating, 77 lb N/acre). Each trial utilized a randomized block experimental design, with 4 replicate plots per CRF rate. At all sites marketable yield data were collected by experienced commercial harvest personnel from April to October. To document the pattern of N release from the CRF, polyester mesh bags containing 4 g of the 18-8-13 CRF were buried in soil beds on November 4 at site 1 and November 23 at site 2. On approximately monthly intervals, 3 replicate bags of each CRF were recovered, and the amount of N remaining in the CRF granules was determined.

Results
Crop N uptake showed a characteristic pattern in all fields (Fig. 1). From crown planting through March, crop N uptake was slow, averaging less than 25 lb N/acre by the first of April. From that point forward crop N increased at a steady rate of approximately 1 lb/acre/day through August; vigorous fields were slightly above that rate, with less vigorous fields somewhat below. By the end of August seasonal N uptake in these fields averaged about 170 lb/acre. This estimate was based only on above-ground vegetation and marketable fruit; adding the N content of roots and cull fruit would add approximately 30 lb/acre, meaning that total crop N uptake would average about 200 lb N/acre/season. Crops that continued to be harvested through the fall would obviously continue to take up N, although at a slower rate as the weather cooled and growth rate declined.

Complete fertilizer records were obtained for 15 of the monitored fields. Growers had widely varying fertilization programs, ranging from a seasonal total of 126-433 lb N/acre (Fig. 2). All but one grower applied preplant CRF, with an average application rate of about 90 lb N/acre. Neither preplant CRF rate, nor total seasonal N application rate, was correlated with the marketable yield obtained.

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There was a trend toward declining root zone soil NO_3-N as the season progressed (Fig. 3). Averaged across fields, soil NO_3-N at planting was typically high; most strawberry plantings in this region follow vegetable crops, and therefore often begin the strawberry season with high residual soil NO_3-N. By June the average soil NO_3-N had fallen below 10 PPM, where it remained for the rest of the season. There were individual fields in which summer soil NO_3-N was maintained above 20 PPM by high levels of fertigation, but as a group they were no more productive than fields with lower soil NO_3-N levels.

The pattern of N release from the 18-8-13 CRF, averaged over the two field sites, is shown in Fig. 4. Approximately 75% of the initial N content had been released by the end of March. This rate of N release was much faster than the rate of strawberry N uptake over the winter; a 90 lb N/acre preplant application would release more than 60 lb N by the end of March, while plant sampling showed that crop N uptake by that time was typically less than 25 lb/acre.

The results of the CRF rate comparison trials reinforced the conclusion that current CRF use patterns are not efficient. At the end of April crop N uptake averaged only 31 lb N/acre across sites, with CRF rate having minimal effect on crop N uptake (Fig. 5). Reducing preplant CRF (site 1) or eliminating it altogether (site 3) did not affect marketable fruit yield (Fig. 6). However, reducing the CRF rate at site 2 resulted in a statistically significant 9% yield reduction. Fruit yield improvement with the full CRF rate at site 2 may have been related to greater NO_3-N leaching at that site resulting from high rainfall (22 inches by April 1 vs. 14 and 13 inches at sites 1 and 3, respectively), as well as heavy irrigation applied by the grower in April and May. Rather than routinely using high preplant CRF rates to protect against such unusually high winter rainfall or inefficient irrigation, a program of more accurate irrigation scheduling, soil NO_3-N testing in the spring, and earlier fertigation (where appropriate) would be a more nitrogen-efficient practice.

Conclusions:

Our results contain some good news and some bad news. The good news is that the proposed seasonal N fertilization target of 120% of crop N uptake is currently being met by a number of growers; assuming a seasonal crop uptake of 200 lb N/acre, more than half of the monitored fields for which we obtained fertilization records met the target. The bad news is that some growers are substantially above that target. For those growers, our data suggests two ways to reduce N fertilization rates with minimal risk to crop productivity. First, reconsider current CRF practices. Reducing CRF rates, at least in field situations in which winter N availability is likely to be adequate (medium- to heavy-textured soils being rotated out of vegetable crops), and/or switching to a CRF with a slower N release pattern that more closely matches crop N uptake, will likely reduce the amount of CRF N that is lost from the field. Second, use a fertigation program that supplies N at a rate similar to crop N uptake. Fertigation far in excess of crop N demand (about 1 lb N per acre per day) is likely to lead to NO_3-N leaching, not improved growth.

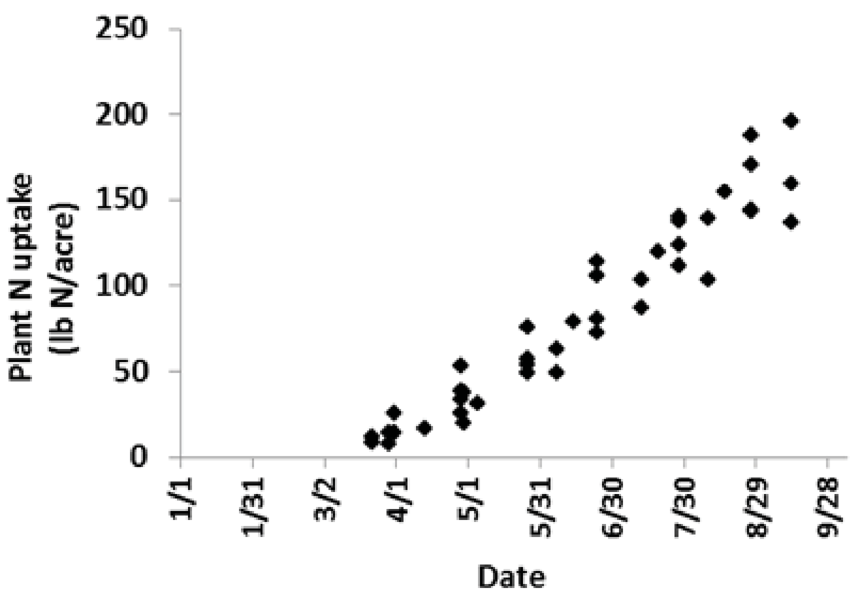

Fig. 1. Pattern of strawberry N uptake over the season; data from 7 commercial fields.

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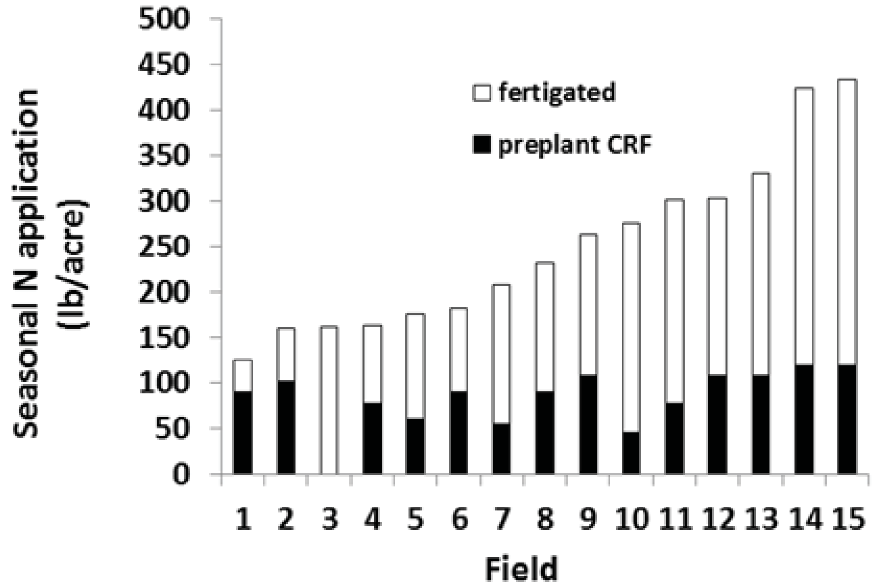

Fig. 2. Seasonal N application in 15 of the monitored fields.

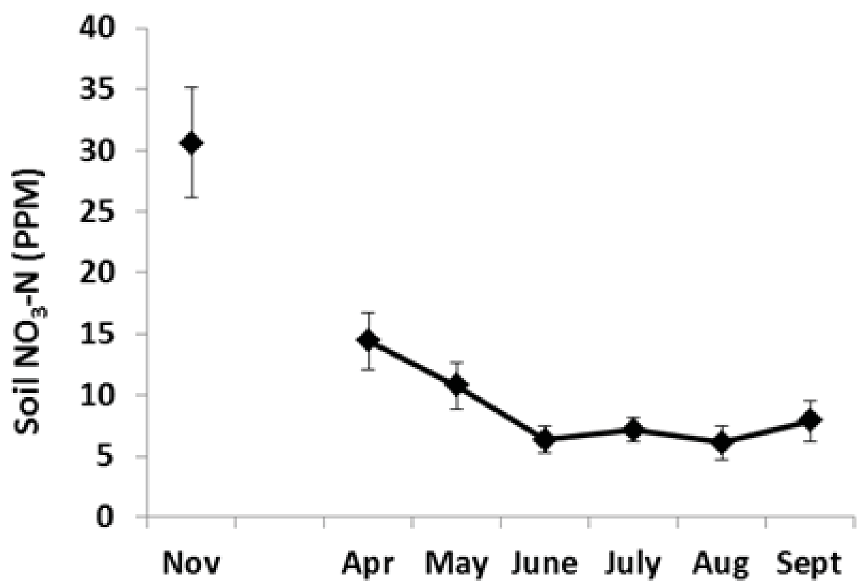

Fig. 3. Pattern of root zone (top 12 inch) soil NO3-N over the production season.

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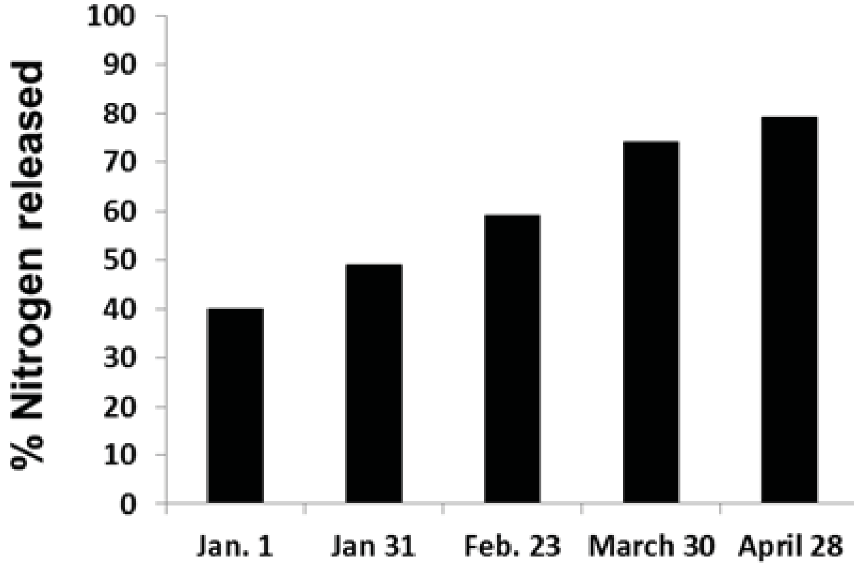

Fig. 4. Pattern of nitrogen release from 18-8-13 controlled release fertilizer (CRF).

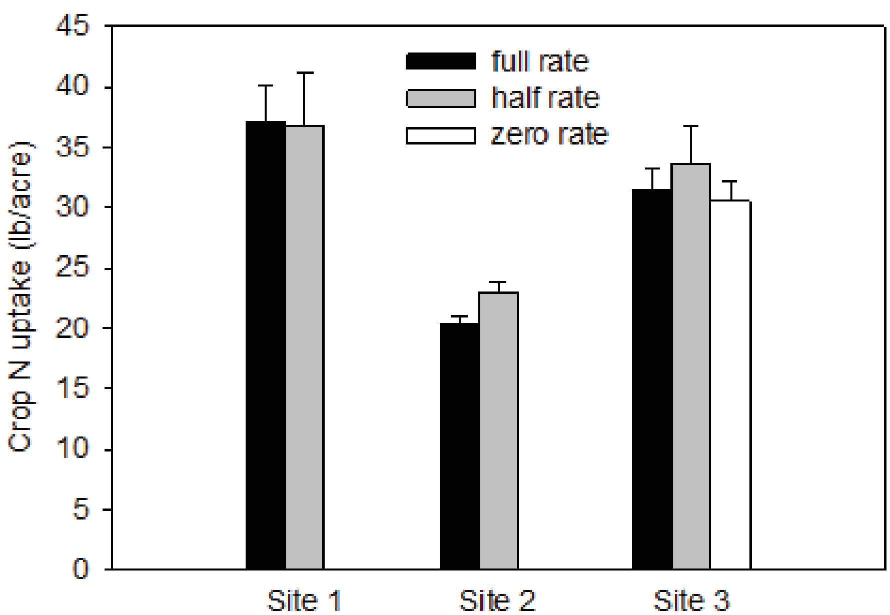

Fig. 5. Effect of preplant controlled release fertilizer rate (CRF) on crop nitrogen uptake by the end of April; bars indicate the standard error of measurement.

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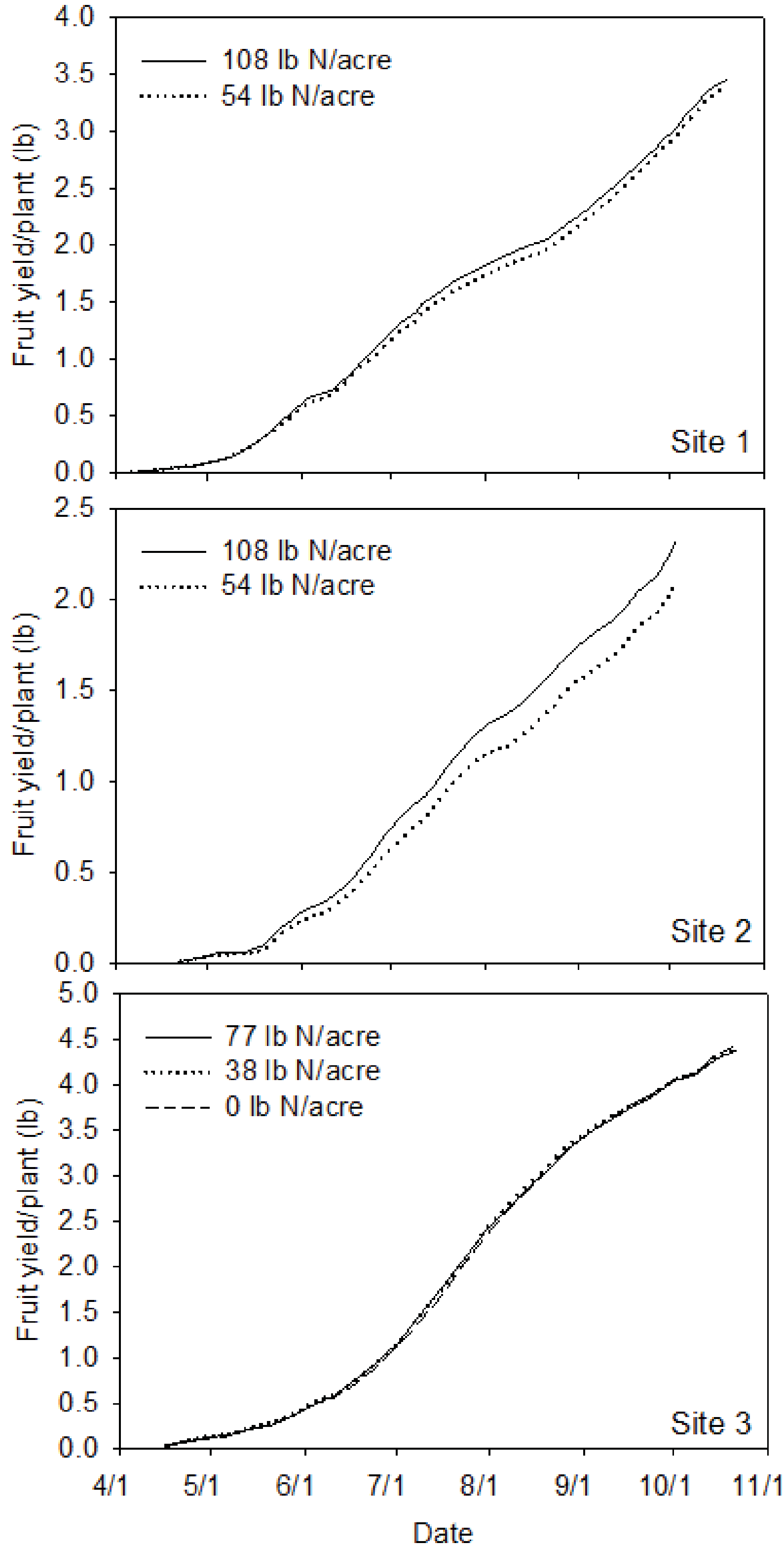

Fig. 6. Effect of preplant controlled release fertilizer (CRF) rate on marketable fruit yield.

WATER USE OF STRAWBERRIES ON THE CENTRAL COAST

Michael Cahn and Barry Farrara, UC Cooperative Extension, Monterey
Tom Bottoms and Tim Hartz, UC Davis

As acreage of strawberries has steadily increased in central coast valleys, concerns about the impacts of production on water supplies have been raised. Since most of the central coast is reliant on ground water, a major commodity such as strawberries can affect regional water supplies. In the Pajaro Basin, where ground water is currently in over-draft, conservation by agriculture is considered one of several paths to restoring parity between pumping and ground water recharge. To determine if conservation is possible without reducing economic returns, it is important to examine the present water-use patterns of as strawberries. Many of the practices that growers currently use such as drip irrigation and soil moisture monitoring, would suggest that strawberry producers are already efficient users of water. We conducted a 2- year study measuring water use in commercial strawberry fields in Monterey and Santa Cruz counties. Our objective was to determine the amount of water currently used to grow strawberries and to identify strategies that could help growers improve water management of their crops and potentially conserve water. The following describes the 2nd year of the study and compares the results with the first year.

Procedures

Flow meters were installed in approximately 0.5 to 1-acre sections of 35 commercial strawberry fields located in the Salinas-Watsonville production region during January and February of 2011. Fields with a proprietary day-neutral variety and UC Albion were included in the study. Planting configurations ranged from 48-inch and 52-inch wide beds with 2 plant rows, and 64-inch wide beds with 4 plant rows. Drip tape discharge rates in fields ranged from low flow (0.34 gpm/100 ft) to high flow (0.67 gpm/100 ft) and drip systems varied between either 1 or 2 drip lines per bed. Soil texture among sites varied from clay to loamy sand and the salinity of the irrigation water ranged from 0.3 to 0.9 dS/m.

Applied water was monitored with flow meters until the end of the crop in October 2011. In 14 of the 35 fields, flow meters were connected to dataloggers to record the irrigation scheduling pattern and granular matrix blocks (irrometer watermark) were installed to monitor soil moisture tension at 6 and 12 inch depths. Infra-red photos of the canopy were taken at each of the 14 field sites at monthly intervals, and used to estimate crop coefficients of strawberry and to determine crop evapotranspiration (ETc) from reference evapotranspiration data available from the California Irrigation Management and Information System (CIMIS). Samples of irrigation water were collected for analysis of nitrate and salinity content. Undisturbed cores of soil were collected for determining the water retention pattern for each soil type. Collected data was analyzed to determine if water-use was consistent with the water requirements of the crops. In addition to the fields monitored during the 2011 production season, flow meters were installed at 3 additional sites in October 2011 so that the volume of water used for transplant establishment could be determined.

Results

Average water applied to strawberries between January and October 2011 for the 35 sites ranged from 12 to 42 inches of water and averaged 24.8 inches (Fig. 1). Average seasonal volume applied for the 14 intensively monitored fields was 25.5 inches and ranged from 13 to 40 inches (Fig 2.). Although the average applied water for the 2011 season was greater than the average volume (21 inches) applied during the 2010 season, less rainfall occurred between January – mid February in 2011, which required supplemental irrigation to maintain adequate moisture around the root balls of the young transplants. Applied water during the period between January and May 2011 averaged 8 inches, 32% of the total applied water for the season. Rainfall averaged 11.7 inches between January and May 2011. Although some rainfall likely satisfied the water needs of the crops, 90% of the precipitation occurred between January and end of March when crop water needs were minimal due to low evapotranspirational demand. Much of the rainfall would have likely contributed to drainage and run-off during the winter months.

Crop ET estimates for the sites, developed from measures of canopy cover and spatial CIMIS reference ET data, averaged 17.5 inches and ranged from 11.4 to 22.9 inches. Growers applied an average of

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146% of crop ET from January – October, with a range of 116% to 186% of crop ET (Fig. 3). From June – October, applied water averaged 123% of Crop ET (Fig. 4), indicating that most of the application of water above ET occurred during the winter months when evapotranspiration demand of the crop was low. Applied water during the winter and early spring (January – April) averaged 276% of crop ET and ranged from 112% to 576% of crop ET. In addition, rain contributed significantly to the applied water to the crop.

Soil moisture data recorded with watermark sensors provided a cross-check of flow meter and ET data. Average monthly soil moisture tensions were low (< 15 cbars) during January – March when applied water and rainfall exceeded crop ET (Table 1). Soil tensions increased during the production season when crop ET increased. Sites 1 and 6, where more than 150% of crop ET was applied during June through October (Fig. 4), had soil water tensions averaging less than 15 cbars at the 6 and 12 inch depths (Table 1). In contrast, sites 3, 7, 10 and 11, where less than 100% of crop ET was applied during June through October (Table 1) had soil water tensions averaging greater than 15 cbars at the 6 and/or 12 inch depths. Across all sites, soil moisture tension was related to applied water, expressed as a percentage of crop ET. Figure 5 shows that average monthly soil moisture tension was often greater than 30 cbars, indicating depleted soil moisture, when the average volume of applied water was less than 125% of crop ET.

The volume of water applied per irrigation event during the production season (June – October) was usually less than the water holding capacity of the soil; and therefore would presumably not cause excessive drainage. The average volume of water applied per irrigation for all 14 sites was 0.27 inches (Table 2), and the average water holding capacity of the soil between 5 and 30 cbars of tension was 0.35 inches per foot of depth for the top soil layer (Table 3).

The volume of water applied for crop establishment was evaluated in 3 fields between November 2011 and March 2012 (Table 4). An average of 6.2 inches was applied to establish transplants during November and December 2011. In 2010, the amount of water applied to establish transplants averaged 4 inches for 6 monitored fields. The lower amount of water used in 2010 was presumably due to early rain events that supplemented crop water demands during November and December. In addition to the establishment water in November and December, an average of 5.6 inches was applied between January and March 2012 (Table 4). In 2010, an average of 2.4 inches of water was applied during the same months. Rainfall ranged from 5.1 to 8 inches for these 3 sites between November 2011 and March 2012.

Conclusions

The results of the 2011 season are consistent with results reported for the 2010 season demonstrating that many growers under-irrigated during the production season. Because only 2 fields (14% of total) were irrigated with more than 150% of crop ET during the production season, the potential to conserve water may be limited during this period. In addition, nitrate leaching may not be a significant issue during the production season. The volume of water applied per irrigation was generally small (averaging 0.27 inches), and would be unlikely to exceed the water holding capacity of the soil. Our previous study has shown that soil nitrate levels are often less than 10 ppm nitrate-N between May and October. The combination of minimal drainage and low soil nitrate levels during the production season would suggest that a majority of growers were unlikely to leach significant amounts of nitrate beyond the root zone.

The greatest opportunity to conserve water appeared to be during the winter months, when applied water amounts greatly exceeded crop ET. Approximately one third of the irrigation water was applied during the winter and early spring when evapotranspirational demand of the crop was minimal. In 12 of the 14 monitored fields an average of 300% of crop ET was applied during this period. Although ET is low during the winter, growers may be challenged to reduce water applications because of concerns with maintaining sufficient soil moisture to establish young transplants and leach salts. They may also need to irrigate for the purpose of fertigating, and to maintain sufficient moisture in beds to protect the crop from frost damage. However the combination of monitoring soil moisture status and following the crop ET demand would be useful ways to determine if applied water could be reduced. Finally, because soil nitrate levels are generally higher during the fall and winter than during the summer, and applied water and rainfall greatly exceed crop water demand, the greatest potential for nitrate leaching would be during the winter.

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Table 1. Average monthly soil moisture tension at the 6- and 12-inch depths for 11 commercial strawberry fields during the 2011 season.

	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9		Site 10		Site 11		AVG		Max		Min	
Month	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"
	soil moisture tension (cbars)																											
Jan	7	4	2	2	17	10	10	7	6	4	--	--	--	--	--	--	--	--	7	7	--	--	8	6	17	10	2	2
Feb	5	4	6	1	16	9	13	8	12	13	5	4	1	5	10	2	--	--	7	12	14	2	9	6	16	13	1	1
Mar	8	4	12	1	25	14	16	16	13	16	9	7	6	8	14	8	13	4	9	19	13	5	12	9	25	19	6	1
Apr	14	1	9	0	15	9	8	8	30	12	4	8	0	1	10	7	16	13	6	14	6	0	11	7	30	14	0	0
May	13	1	9	0	17	10	17	10	30	14	9	6	5	1	11	4	15	7	19	19	16	2	15	7	30	19	5	0
Jun	8	1	2	0	20	11	14	7	23	17	12	7	9	1	10	3	16	8	52	29	9	3	16	8	52	29	2	0
Jul	4	0	0	0	23	9	14	6	13	5	6	3	18	0	10	2	18	7	85	25	17	13	19	6	85	25	0	0
Aug	3	0	0	0	23	9	5	4	10	4	4	1	16	2	10	1	18	6	80	43	10	18	16	8	80	43	0	0
Sep	2	0	0	0	23	14	10	5	10	3	5	1	15	1	11	1	28	4	90	115	6	17	18	15	90	115	0	0
Oct	8	2	0	1	21	14	41	14	18	4	21	3	17	2	20	7	30	6	55	51	43	41	25	13	55	51	0	1

Table 2. Volume of water applied per irrigation in commercial strawberry fields between June and October 2011.

Site Number	Irrigation Volume Average	Maximum	Minimum
	inches		
1	0.37	1.14	0.06
2	0.25	0.67	0.06
3	0.46	0.83	0.19
4	0.20	0.33	0.11
5	0.51	1.26	0.09
6	0.33	0.67	0.15
7	0.36	0.54	0.14
8	0.30	0.43	0.16
9	0.18	0.37	0.07
10	0.10	0.18	0.06
11	0.15	0.34	0.07
12	0.14	0.33	0.05
13	0.27	0.46	0.07
14	0.20	0.34	0.11
AVG	0.27	0.56	0.10

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Table 3. Available soil moisture at 2011 monitoring sites.

Site	Soil	Available soil water (5 to 30 cbars) 0-1 foot	1-2 feet
		inches of moisture per foot of depth	
2	loam	0.34	0.18
4	clay	0.20	0.13
7	sandy loam	0.49	0.19
8	loam	0.33	0.27
9	fine sandy loam	0.30	0.23
10	sandy loam	0.42	0.32
AVG		0.35	0.22

Table 4. Water used for establishment and post-establishment of strawberries.

Location	Transplant Establishment Method	volume	Post Establishment method	volume	Applied Water by Month Nov	Dec	Jan	Feb	Mar
		inches		inches	------------inches-------------				
Watsonville	sprinkler/drip	5.6	sprinkler/drip	9.9	0.0	5.6	3.5	3.5	2.9
Castroville	sprinkler/drip	6.1	drip	2.5	1.2	4.9	1.0	0.0	1.4
Salinas	sprinkler/drip	7.0	sprinkler/drip	4.3	3.8	3.2	0.4	1.4	2.5
Average		6.2		5.6	1.7	4.6	1.7	1.6	2.3

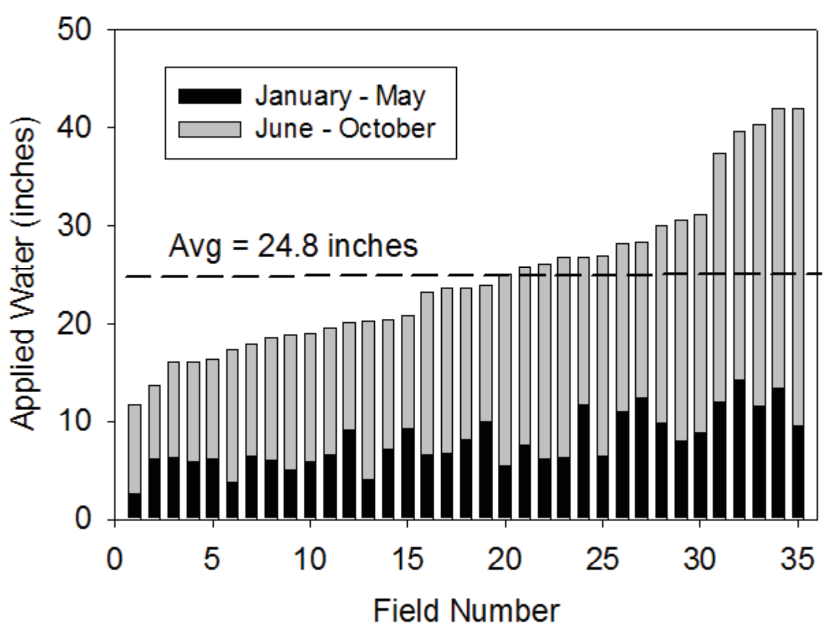

Figure 1. Seasonal volumes of irrigation water applied to 35 commercial strawberry fields (January – October 2011).

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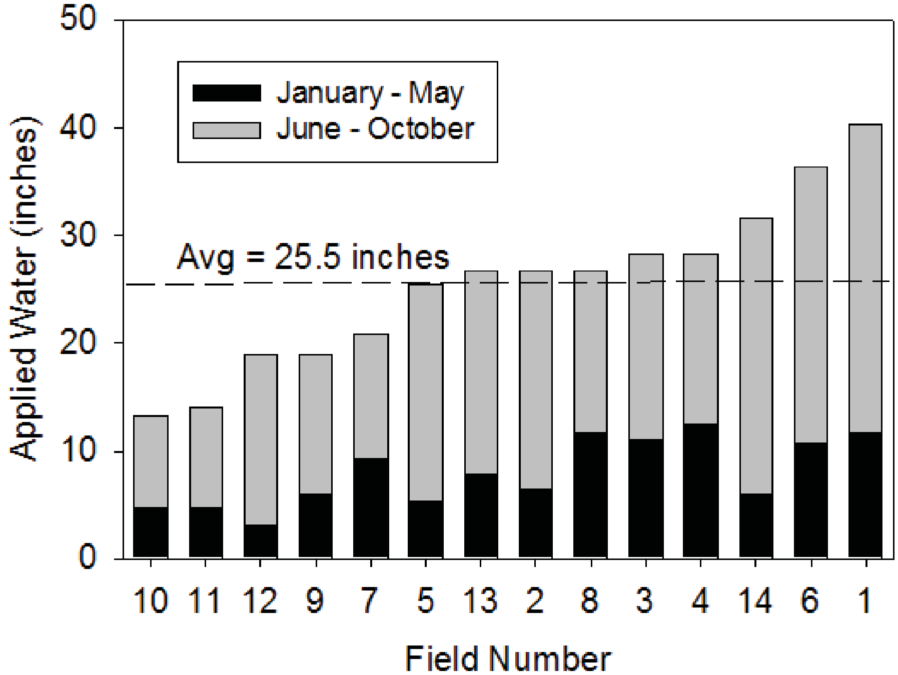

Figure 2. Seasonal applied water to 14 strawberry fields intensively monitored (January – October 2011).

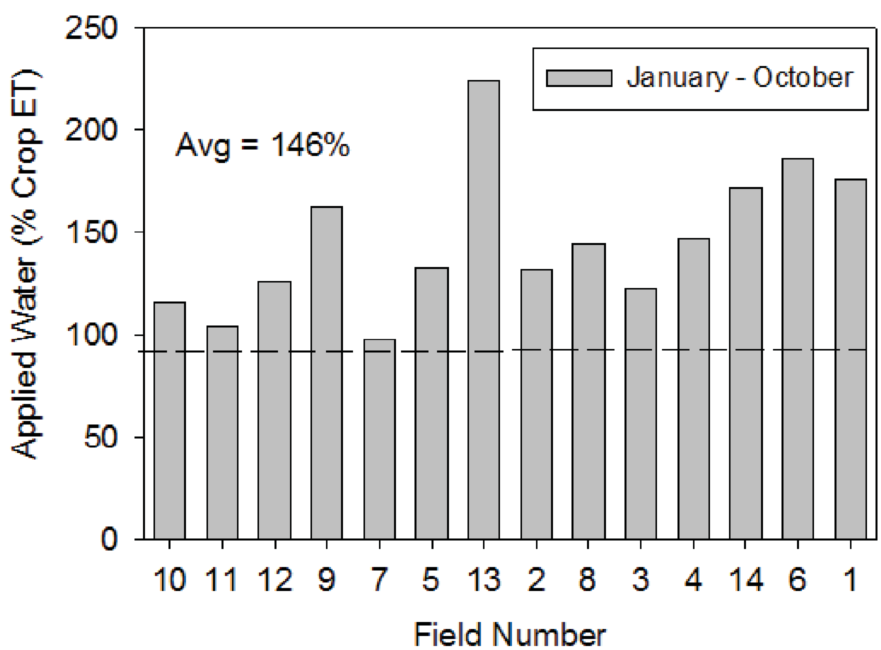

Figure 3. Seasonal applied water as a percentage of crop ET for 14 strawberry fields (January – October 2011).

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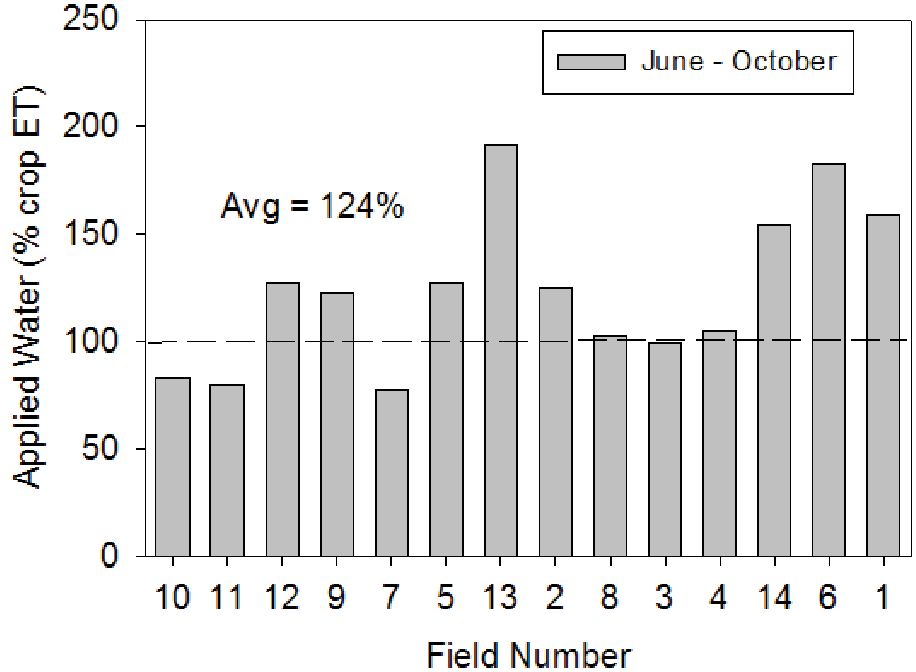

Figure 4. Seasonal applied water as a percentage of crop ET for 14 strawberry fields (June – October 2011).

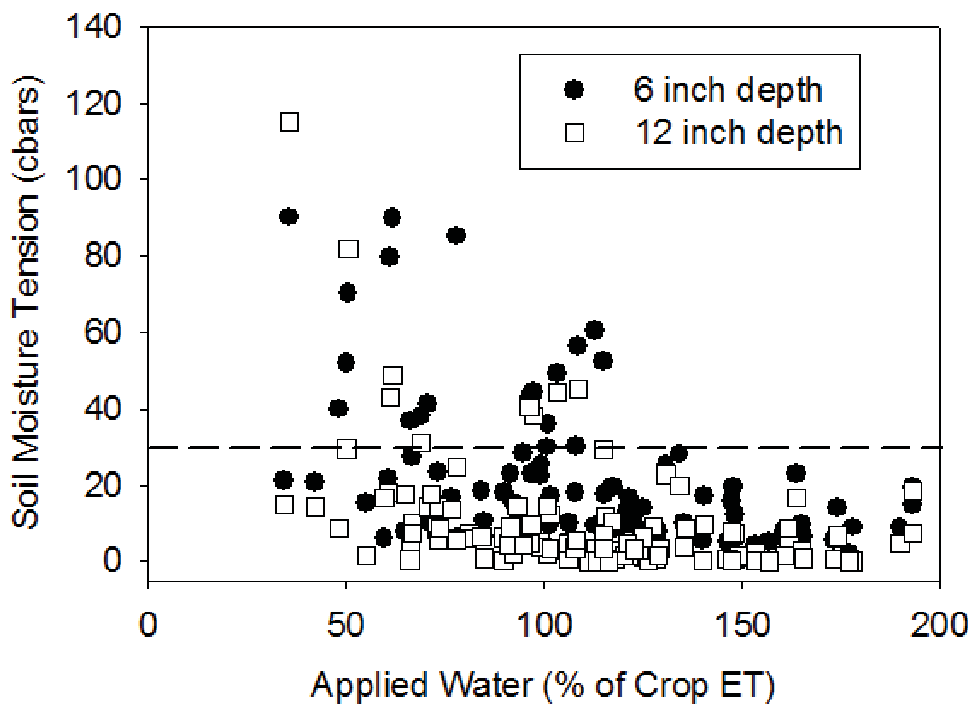

Figure 5. Average monthly soil moisture tension vs average monthly applied water expressed as a percentage of crop ET (May – October 2011).

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CropManage Workshop
Monterey County Agricultural Center Conference Room
1432 Abbott St, Salinas CA 93901
Wednesday, March 13th / Tuesday, April 2nd 2013
(9 am – 11 am)

We will offer two hands-on workshops to learn in depth about the features of CropManage, a new Web-tool that provides decision support on irrigation and N management of lettuce. Learn how to use CropManage for improving the efficiency of your farming operations or for adding value to your consulting services. Wi-Fi internet access is available at our conference room so you are welcomed to bring a laptop or tablet computer so that you can follow along as we tour through the features of the software. There should be sufficient time to answer questions as we cover the following topics:

1. Purpose and main features of software
2. Getting started with CropManage
   (login, setting up new ranches, adding new plantings, fertilizers).
3. Using CropManage for decision support and record keeping (soil nitrate quick test, recommendations on N fertilizer and irrigation schedules, maintaining fertilizer and irrigation records).
4. Additional features (advanced settings, exporting data, integrating flow meter data).
5. Discussion of new features or changes needed.

To keep the group size manageable so that we can provide individual help, we would like to limit each workshop to 20 participants. Please RSVP in advance by sending an email to larriaga@ucdavis.edu with the subject heading "CropManage workshop" and let us know which workshop (March 13 or April 2) you will be attending and the number of participants in your group. We will email you a confirmation

Hope to see you soon,

Michael Cahn