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Agriculture and Natural Resources | California Institute for Water Resources

Online Irrigation and Nitrogen Management Tool for Vegetables

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Project Summary

Summary:

The main objective of this project was to increase the capacity of CropManage (CM), an online resource that uses weather, soil, and crop data to assist growers in using water and nitrogen fertilizer efficiently for producing cool season vegetables. Specifically, we expanded CM to include additional vegetables such as broccoli and cauliflower, thereby providing a tool to growers that comprehensively addresses the cool season vegetable production system. We also interfaced CM with the UC Davis SoilWeb so that growers can easily import soil data into their ranch data base. Finally, we automated the capability to import and display soil moisture data from sensors in the field. Potentially this project will increase efficient use of water and nitrogen fertilizer, increase grower compliance with water quality regulations, and enhance safety of drinking water supplies.

Rationale:

Cool season vegetable production requires significant inputs of water and nitrogen (N) fertilizer to maximize yield and quality. Proposed changes in water quality regulations on the Central Coast and higher fertilizer prices in recent years have prompted grower interest in increasing efficiency of nitrogen fertilizer use in lettuce and other cool season vegetables. By improving water management and matching nitrogen applications to the uptake pattern of the crop, growers could potentially reduce fertilizer use and address water quality concerns.

Two tools available, the quick soil nitrate test and weather-based irrigation scheduling, have been shown to help lettuce producers better manage water and fertilizer nitrogen. Trials we conducted in commercial fields have demonstrated that soil nitrate concentrations greater than 20 ppm NO_3-N, are sufficient to maximize crop production. In addition, we have shown that evapotranspiration data available from the California Irrigation Management and Information system (CIMIS), can be used to accurately estimate the appropriate volume of water to apply to meet crop needs and minimize potential leaching losses of nitrate-N.

Both the quick nitrate soil test and weather based irrigation scheduling require increase management time for growers to implement these practices in their farming operations. The quick nitrate soil test entails collecting a representative soil sample in the field, extracting the sample, and calculations to estimate the concentration of soil nitrate. Weather based irrigation scheduling requires calculating crop evapotranspiration (ET) from CIMIS reference ET data and a crop coefficient corresponding to the developmental stage of the lettuce crop. In addition, information on the soil type and irrigation system is needed to determine the optimal irrigation interval and run-time. With multiple fields and ranches to track throughout the season, customizing water and fertilizer for individual fields could become a significant cost for growers.

CropManage, (ucanr.org/cropmanage) an online database-driven tool, was developed by UC Cooperative Extension to assist growers and farm managers in determining water and nitrogen fertilizer applications on a field-by-field basis. The software automates steps required to calculate crop water needs from CIMIS ET data, and estimates fertilizer N needs for lettuce using quick N test data and models of crop N uptake. The web application also helps growers track irrigation schedules and nitrogen fertilizer applications on multiple fields and allows users from the same farming operations to view and share data.

Tasks completed:

1. Analyze data from commercial fields and develop algorithms for crop growth rate, rooting pattern, and total nitrogen uptake for broccoli, cauliflower and cabbage.

Canopy cover, N uptake, and root depth data for broccoli, cauliflower and cabbage, collected from commercial fields during the past 2 years, was analyzed to develop algorithms for the CropManage online decision support tool. Canopy cover data shown in Fig. 1 were fit to a developmental model proposed by Gallardo et. al. (1996):

$$\text{Canopy cover (\%)} = \text{Gmax}/(1 + \exp[A + B\times\text{day}/(\text{Maxday}*\text{Fmax})] \qquad (1)$$

where Gmax is the maximum canopy cover, *A* and *B* are fitted parameters, day is the number of days after planting or transplanting, *Maxday* is the total days between planting and the end of the crop (last harvest), and *Fmax* is the fraction of the crop cycle when the maximum canopy size is achieved. Parameters for this model were determined for broccoli, cabbage, and cauliflower grown under various planting configurations and shown in Table 1 for broccoli.
N uptake data determined from whole plant biomass and tissue N content data were fit to models to describe crop N uptake patterns. Rooting depth was found to follow a linear pattern to a 48 inch depth for broccoli, cauliflower, and cabbage.

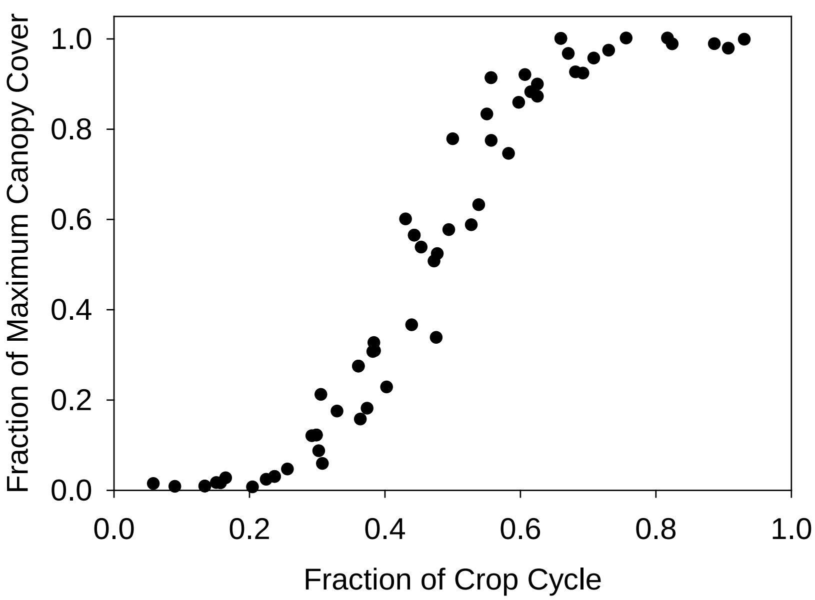


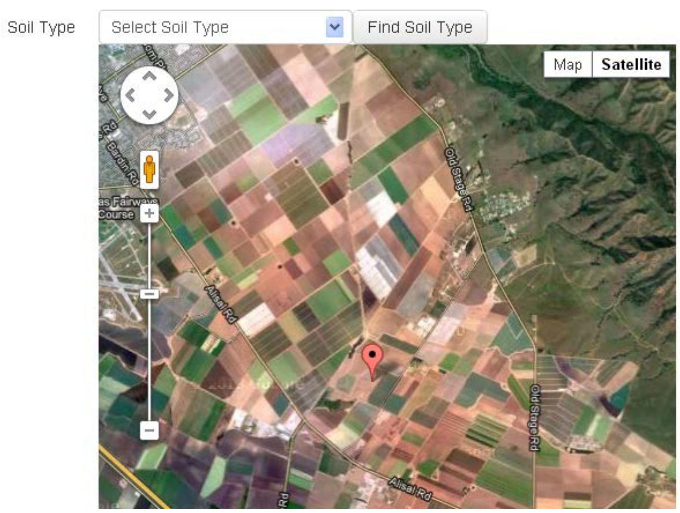
Figure 1. Canopy development of summer planted broccoli expressed as a fraction of maximum cover.

Table 1. Canopy cover model parameters for broccoli.

Crop description	number of sites	bed width	seedlines	Crop Cycle	Model Parameters A	B	Gmax	Fmax	Model fit R^2
	#	inches	#	days			%		
Winter, direct seeded	3	40	2	137	5.39	-7.70	89	0.96	0.87
Summer, direct seeded	6	40	2	87	6.51	-10.82	98	0.78	0.91
Summer, transplanted	1	80	5	87	5.35	-11.13	99	0.91	0.97
Summer, transplanted	2	40	2	87	3.34	-7.83	99	0.93	0.95

2. Link CropManage to the UC Davis SoilWeb tool.

CropManage was linked to the UC Davis SoilWeb tool so that users can determine the soil type and physical properties required to make irrigation and nutrient uptake decisions for their fields. When setting up a ranch, the user selects the field to query for soil type using the cursor (Fig 2.)



Soil Name:
Elder sandy loam, 0 to 2 percent slopes
Soil Series:
Elder
Soil Texture:
sandy loam

Soil Depth	Silt (%)	Sand (%)	Clay (%)	Organic (%)	Density (g/cm^3)	Soil Tension (cbar)	Mineralization Rate (lb N/acre/day)
1 ft	19.6%	67.4%	13%	2.5%	1.6	7	0.2
2 ft	19.6%	67.4%	13%	2.5%	1.6	5.8	0.2

Figure 2. Interface for selecting a soil type in CropManage using a mapping tool and UC Davis Soil Web.

3. <u>Automate CropManage to retrieve and display soil moisture data from fields</u>

This task was reduced due to a cut of 48% of the original funding request. UC ANR programmers added capacity to CropManage to import soil moisture data files and display in graphical and/or tabular form. An example of a graphical display of soil moisture tension data as viewed in CropManage is shown in Fig. 3. To save programming costs, a web tool provided by Google, is used for the graphical display. The ANR programmer also added the ability to import data files from third-party providers of soil moisture data. This feature will allow CropManage to be used by commercial companies providing soil moisture monitoring services to growers. Improvements still need to be made in the graphical interface for importing and displaying soil moisture data.

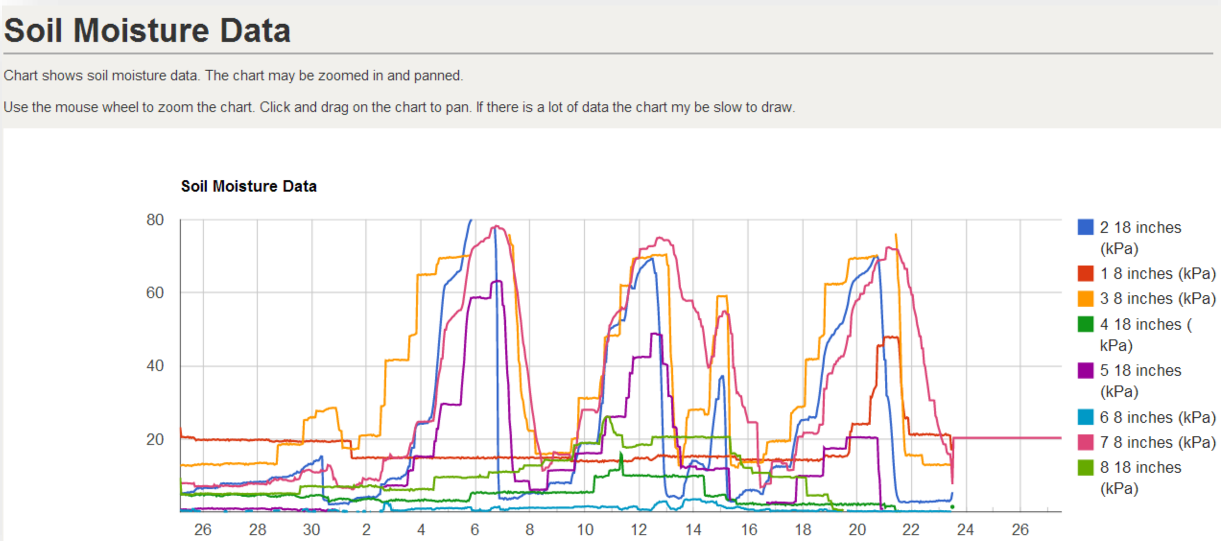


Figure 3. Soil moisture tension data displayed in CropManage.

4. Field demonstrate CropManage tool to growers and crop advisers

We reduced the number of participating growers from 3 to 2 for this task due to the cut-back in requested funding by 48%. We conducted demonstration trials in 2 commercial broccoli fields during the 2013 season. Plots, the width of a commercial harvester, and the length of the field, were managed either under the Grower's standard practice for irrigation or by following the recommendation of CropManage which uses the model of crop canopy and CIMIS reference ET data to determine water needs. Water savings compared to the Grower standard practice was approximately 50% (14 inches) during the drip phase of the crop. The reduced application of water increased the final soil nitrate concentration at harvest, indicating that less nitrate leached under the CropManage recommended practice.

Table 2. Applied nitrogen fertilizer and water, and yield results for broccoli strip trials.

Strip Trial #	Management treatment	Applied Water: Sprinkler	Applied Water: Drip	Fertilizer N	Final soil nitrate-N[x]	Marketable Yield	difference between
		-------- inches ----------		lbs/acre	lbs/acre	lbs/acre	%
		--- harvested 9/11/13 ---					
1	Grower	7.4	26.1	166	23.3	14006	
	CropManage	7.4	12.9	166	181.9	14741	5.2
		--- harvested 9/30/13 ---					
2	Grower	4.4	31.0	187	48.3	20930	
	CropManage	4.4	15.2	187	83.2	20382	-2.6
		--- Average ---					
	Grower	5.9	28.5	176	35.8	17468	
	CropManage	5.9	14.0	176	132.6	17561	1.3

[x] estimated after harvest for the 0 to 3 foot depth.

Information Transfer/Outreach Program

Despite a reduction in funding, we were able to carry out all proposed to tasks to improve CropManage capabilities and to demonstrate the decision support tool to growers. Fortunately matching funds were secured from a CDFA specialty crop block grant which were used to supplement this project. The field trials completed in commercial fields demonstrated that following CropManage recommendations can potentially reduce water use by 50% after crop establishment in broccoli.

Notable Achievements

Matching funds were secured from a California Department of Food and Agriculture specialty crop block grant were used to leverage this project in spite of a reduction in NIWR funding.