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University of California,  
U.S. Department of  
Agriculture, and  
County of Monterey  
cooperating

1432 Abbott Street •  
Salinas, CA 93901

phone 831.759.7350  
fax 831.758.3018

[http://  
cemonterey.ucdavis.edu](http://cemonterey.ucdavis.edu)

## ADJUSTMENT OF SEASONAL FERTILIZER APPLICATION AND ITS EFFECT ON TISSUE NUTRIENT LEVELS, FRUIT YIELD AND QUALITY

Mark Bolda, UCCE Santa Cruz County

**I**ntroduction: Many raspberry growers currently, in the early spring, apply nitrogen in the form of a soluble solid fertilizer such as urea as a top or side dress to the plant row, which is then washed down deeper into the soil by a following rain or irrigation. These amounts, often several tens of pounds of actual nitrogen per acre, are quite large compared to the rest of the season, and while the plant uptake of nitrogen is higher during this early period of growth, the plant's capacity to absorb nitrogen can easily be exceeded.

Later applications of nitrogen and fertilizers are done through the drip irrigation system. These applications are often less than a few pounds of actual nitrogen per acre and take place from once a week to once a month. These applications of nitrogen fertilizer should continue through the growing season, including through flowering and fruiting. While it is a commonly held belief that nitrogen application during fruiting causes soft, reduced quality fruit, recent research suggests this belief might be unfounded. Other factors, such as irrigation practices and disease management may have a larger effect on fruit quality than limited nitrogen use during flowering and fruiting.

It is hypothesized that California growers can achieve better caneberry yields and more fertilizer efficiency by significant adjustment to their fertility practices. Indeed, recent research in caneberries in Oregon suggests that large reductions in early season fertilizer use coupled with increases in in-season fertilizer rates result in more and higher quality caneberries.

This study is designed to investigate large adjustments to early and in-season fertilizer rates on fruit yields and quality as well as test the consequences of these adjustments on plant tissue and soil mineral contents. This information will be important to the caneberry industry since it reduces the environmentally harmful use of large amounts of nitrogen in the early winter season, while potentially offering enhanced plant productivity from more effectively timed fertilizer applications.

### Materials and Methods:

A test plot consisting of 4 treatments of four replicates was set up in a well functioning field of Heritage red raspberry. Rates of applied nitrogen consisted of a grower standard, and modifications of both the early and in-season supplemental nitrogen applications (see Table 1 below). Fertilizer was applied as per grower procedure, i.e. as a top dress in the early season, and later as an irrigation drip tape applied liquid supplement.

**Harvest and Fruit Evaluation:** Measurement of fruit yield was done by an established procedure counting flowers and weighing fruit for a yield estimate. Fruit quality measurements was performed twice times during the harvest season in August and September by taking 15 fruit from each treatment replicate, holding for five days at 38°F, holding at room temperature for one day and then evaluating quality of the fruit by grading it good or unmarketable.

**Table 1:** Fertilizer application scheme, expressed in lbs of nitrogen (N) per acre.

	Nitrogen Fertilizer Regimen*
1.	Grower standard early season, grower standard in-season (43 lbs + 8 lbs = 51 lbs mineral N)
2.	½ grower standard early season, twice grower standard in-season (21.5 lbs + 16 lbs = 37.5 lbs mineral N)
3.	No grower standard early season, twice grower standard in-season (0 lbs + 16 lbs = 16 lbs mineral N)
4.	Grower standard early season, no grower standard in-season (86 lbs + 0 lbs = 86 lbs mineral N)

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**Table 2:** Actual amounts of fertilizer applied, expressed in lbs of nitrogen per acre.

Date	Fertilizer Type	Grower Standard (lb N/A) GS	½ Grower Standard (lb N/A) ½ GS	0 grower standard (lb N/A) 0 GS	Twice grower standard (lb N/A) 2 GS
2/6/07	15.5-0-0-19	15	7.5	0	30
2/23/07	15.5-0-0-19	9	4.5	0	18
3/7/07	15.5-0-0-19	10	5	0	20
3/27/07	15.5-0-0-19	9	4.5	0	18
6/14/07	15.5-0-0-19	2	4	4	0
7/2/07	15.5-0-0-19	2	4	4	0
7/20/07	15.5-0-0-19	2	4	4	0
8/1/07	15.5-0-0-19	2	4	4	0
<b>Total (lb/A)</b>	-	<b>51</b>	<b>37.5</b>	<b>16</b>	<b>86</b>

**Tissue Sampling:** Plant tissue samples were taken at four critical points in the development of the raspberry plant, namely; initial vegetative growth, flowering, green fruit and harvest. Replicate samples were a composite of 12 leaves. The total number of composite samples per event was 16, for a total of 64 leaf samples for the entire study.

To overcome the subjectivity posed by sampling the “youngest mature leaf”, leaves from 4 to 7 nodes from the tip were sampled.

Amount of total carbohydrate in raspberry canes has been related to fruitfulness. Total and type of carbohydrates were evaluated to determine resource allocation of canes in the various fertilizer treatments once during the growing season. A cane was removed from each treatment replicate plot on 10/18/2007, and a section from 0.9 m to 1.2 m cut out, dried and sent to the UC ANR Analytical Laboratory for analysis.

**Soil Sampling:** Soil samples were taken at the same time as leaf tissue samples above. Soil sampling was done in a standard pattern, taking 8" deep samples from the base of the raspberry hedgerow. Replicate samples were composite of 5 cores and had KCl extracts taken from them. In addition to the replicated samples beginning in March, a non-replicated sample from each treatment was taken in February prior to commencement of fertilizer placement.

**Rust Evaluation:** The literature reports a positive correlation of rust incidence with higher nitrogen use. To test this, an evaluation of rust was done on June 13, and September 20, 2007. Fifteen leaves on each side of each treatment replicate approximately at 2.5 feet from ground level were evaluated and observed rust given as a percentage of leaf coverage.

**Cane Diameter:** Cane diameter is often strongly correlated with cane fruiting potential, so one measurement of cane diameter was made after the season was over, on December 13, 2007. Measurements were made at the very base of eight fruited canes per treatment replicate.

## Results:

Tissue nitrogen measured in leaf blades (Table 1) was significantly higher in March in the grower standard and twice grower standard plots than other treatments, and tissue nitrogen remained higher in the twice grower standard plots than other plots through June.

As evidenced by the accompanying charts (Table 2), use of twice the grower standard rate of nitrogen resulted in significantly higher levels of soil nitrate in April and March. Interestingly, significantly higher levels of nitrate were again available in September in the twice grower standard treatment although no additional fertilizer applications to that treatment had been made after March.

While it is a commonly held belief that nitrogen application during fruiting causes soft, reduced quality fruit, recent research suggests this belief might be unfounded.

Amount of total carbohydrate in raspberry canes has been related to fruitfulness.



## ONLINE RESOURCES OFFERED TO THE PUBLIC BY THE UC ANR

### **Carbon calculator helps Californians understand, reduce their climate impact**

A new Web-based portal developed at the University of California, Berkeley, provides consumers with specific, personalized information they need to reduce their emissions of greenhouse gases. This new portal, found at <http://www.CoolCalifornia.org>, is the only "carbon footprint calculator" that can be used to evaluate both direct and indirect emissions of greenhouse gases related to individual lifestyle choices. It provides localized emissions estimates for transportation, housing, food, goods and services, as well as resources that can help users make more climate-friendly choices.

### **Advice to grow by**

More than 40 California counties have a University of California (UC) Cooperative Extension Master Gardener Program staffed by UC-trained volunteer master gardeners who answer public inquiries and provide UC research-based information on all areas of plant health and gardening practices. This free service provides horticultural assistance to the public via telephone, plant clinics, demonstrations, talks, web sites, and the mass media covering vegetable gardening, trees, pesticides, recycling, soils, lawns, disease, insects, house plants, and related topics. Samples of insects, weeds and diseased plants may often be taken to the county office for diagnosis. The UC Statewide Master Gardener Program's Website includes links to county program Web sites. Log on to <http://camastergardeners.ucdavis.edu> and click on "Find Your Local Master Gardener," then select the name of your county to find: directions to the office; the hot-line phone number; news about invasive pests, pertinent information about gardening classes and clinics; newsletters; demonstration gardens, and more information specific to your locale.

### **Entomology news online**

to inform and educate the public on various activities and research projects, the Department of Entomology at the University of California, Davis, maintains a new section at <http://entomology.ucdavis.edu/news/index.html>. Some of the offerings include a collection high resolution photos of bees taken in 2008 and 2008; photos taken in a queen bee insemination class taught by bee breeder-geneticist Susan Cobey at <http://entomology.ucdavis.edu/news/beephotos.html>; and a PowerPoint from the Harry H. Laidlaw Jr. Honey Bee Research Facility.

## **DRY BULB ONION WEED CONTROL STRATEGIES**

**University of California Cooperative Extension, Monterey County**

**Richard Smith, Vegetable Crops and Weed Science Farm Advisor**

2007 was an interesting year for weed control in onions. There were four new herbicide uses registered for this crop: 1) Goal Tender at the first true leaf stage; 2) Prowl H2O for use at the loop stage; and 3) Outlook at the second true leaf stage. The fourth material, Nortron for pre and postemergence use, was registered late in the year and not in time for the 2007 growing season. As a result of these registrations, onions growers have additional tools for managing common broadleaf weeds; in addition, Outlook will be useful for controlling yellow nutsedge.

The registration of Goal Tender for use at the first true leaf stage allows for control of weeds earlier in the production cycle. Depending on weather conditions, the first true leaf stage occurs 28 to 35 days after the first germination water. Catching weeds at this stage increases the possibility of killing them more effectively than waiting an additional 7-10 days for the second true leaf stage and spraying with Goal 2XL (Table 1). From the table it is clear that Goal 2XL is also effective applied at the first true leaf stage, but it is more damaging to the yield of onions if used at this early stage.

Prowl H2O was registered for use at the "loop" stage of onions (i.e. when the flag leaf is emerging but the tip of the leaf is still in the soil thereby forming a loop). Prowl is not safe for use on onions as a preemergence application, however, once the onions have germinated and emerged the material can be safely applied. The timing of this application is typically 14-16 days following the first germination water. Prowl has no postemergence activity and applications made 2 weeks following the germination water do not control emerged weeds. Therefore applications of Prowl at the loop stage is not a stand alone treatment, but must be followed by post emergence treatments. In both 2006 and 2007, Prowl H2O applied at the loop stage and followed by Goal Tender at the first true leaf stage provided excellent weed control and excellent safety to the yield of onions (see Table 2 for 2007 results).

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As a result of four new herbicides registered in 2007 for use on onions growers have additional tools for managing key weeds in onions.



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Outlook was registered for use in onions in California in April of 2007. Applications are to be made no earlier than the second true leaf stage; however, by this growth stage in this area nutsedge is emerged in many fields. Outlook does not have post emergence activity against nutsedge. This creates a dilemma for the use of this material. In order to evaluate ways to make this herbicide work we evaluated 1) first true leaf applications and 2) burning back the nutsedge with an acid based fertilizer and then applying Outlook to control the regrowth. In short, 1<sup>st</sup> true leaf applications did not significantly reduce yields in the 2007 studies. Acid based fertilizer (i.e. 7-7-0-7 was used in these studies) burned the tops of the nutsedge sufficiently to allow the Outlook to control new emerging leaves. Outlook provided about two months of nutsedge control which allowed the onions to achieve reasonable size before nutsedge regrowth commenced (Table 3). Outlook also reduced the number of nutsedge nutlets in the soil over the untreated control at the end of the season which indicates that the Outlook may have the ability to reduce nutsedge pressure in the subsequent crop following onions. We had trials in a heavily nutsedge infested and a low infestation part of the same field. Yield evaluations of the two trials indicate that plots in the heavily infested trial that were treated with acid fertilizer and Outlook had 22.6% lower yield than the low infestation trial where Outlook but no acid fertilizer were applied; however, the yield of the untreated plots in the heavily infested trial were 43.3% than the untreated in the low infestation trial. These data give an indication that we may be hurting the yield to some extent by applying the acid fertilizer, but the nutsedge, if left uncontrolled, is reducing the yield of the onions to a far greater extent.

In summary, controlling weeds earlier in the growth cycle at the first true leaf stage offers some important advantages that should be considered in planning broadleaf weed control programs for onions. In addition, in sites heavily infested with yellow nutsedge, Outlook can provide significant control of this weed. If nutsedge is emerged by the 2<sup>nd</sup> true leaf stage, acid fertilizers can be used to burn back the nutsedge and give the Outlook a chance to control new emerging leaves of nutsedge. Outlook reduced the number of nutsedge nutlets formed during the onion crop and, and it is possible this reduction in nutlets could reduce issues with this weed in subsequent crops. For a copy of the complete 2007 trial results, go to our website: <http://cemonterey.ucdavis.edu/> and go to the vegetable crop weed science program section.

Table 1. Weed and weeding time evaluations between Goal Tender And Goal 2XL applied at two timings.

Treatments	Number of true leaves	Total Weeds 1000's/A	Weeding Time Hours/A
Goal Tender	1 <sup>st</sup>	5.44	2.4
Goal Tender	2 <sup>nd</sup>	21.78	4.1
Goal 2XL	1 <sup>st</sup>	3.92	2.4
Goal 2XL	2 <sup>nd</sup>	13.72	3.3
Untreated	---	178.17	20.7

Table 2. Weed counts, phytotoxicity ratings and time of weeding time evaluations on May 14 and yield evaluations on October 11 and 16 – selected treatments.

Treatment	Material/A	Application Timing	Total Weeds 1000/A	Phytotoxicity Rating <sup>1</sup>	Weeding Time Hours/A	Yield Tons/A	Bulbs/A	Mean lbs/head
Untreated	---	---	460.7	0.0	46.4	60.9	120,063	1.01
Dacthal 6F	1.33 gals	Preemergence	87.1	0.3	8.2	64.6	114,754	1.12
Dacthal 6F	1.33 gals	Preemergence	108.9	0.0	7.0	57.3	127,005	0.90
Fb Goal 2XL	1.0 pt	2 <sup>nd</sup> true leaf						
Dacthal 6F	1.33 gals	Preemergence	57.7	0.0	6.2	64.7	135,173	0.95
Fb Goal Tender 4F	6.0 oz	1 <sup>st</sup> true leaf						
Goal Tender 4F	6.0 oz	1 <sup>st</sup> true leaf	236.3	0.0	22.2	69.5	122,513	1.12
Goal Tender 4F	0.5 oz	Preemergence	203.7	0.0	21.5	61.8	124,963	0.99
Goal Tender 4F	1.0 oz	Preemergence	72.9	0.0	8.0	61.0	121,288	1.00
Prowl H2O 3.8	24 oz	Loop stage	7.6	0.0	1.6	57.5	120,879	0.95
Fb Goal Tender	6.0 oz	1 <sup>st</sup> true leaf						
Scythe	3.0% v/v	1 <sup>st</sup> true leaf	149.2	3.7	14.7	57.9	120,063	0.96
LSD (0.05)	---	---	74.1	0.5	6.1	9.5	14,551	0.15

1 – Scale: 0 = no crop damage to 10 = crop dead.

Controlling weeds earlier in the growth cycle at the first true leaf stage offers some important advantages that should be considered in planning broadleaf weed control programs for onions.

In addition, in sites heavily infested with yellow nutsedge, Outlook can provide significant control of this weed.

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Table 3. Yellow nutsedge control rating on four dates, nutsedge nutlet count and weight in soil, and onion yield evaluations on September 27

Treatment	Material/A	Application Timing	Nutsedge control rating <sup>1</sup>				Nutlets/10 00 cm <sup>3</sup> soil	Nutlet Wt. Grams/1000 cm <sup>3</sup> soil	Onion Yield Tons/A	Onion Yield Bulbs/A	Onion Mean wt/head
			4/23	5/4	6/1	8/9					
7-7-0-7 Fb Outlook 6.0 Fb Outlook 6.0	35 gallons 7.0 oz 7.0 oz	1 <sup>st</sup> true leaf 1 <sup>st</sup> true leaf 14 days later	5.8	7.8	8.3	3.5	103.6 a	7.52 a	46.5	97,206	0.78
7-7-0-7 Fb Outlook 6.0	35 gallons 14.0 oz	1 <sup>st</sup> true leaf 1 <sup>st</sup> true leaf	6.7	8.0	8.6	3.5	61.8 a	5.28 a	47.2	89,854	0.86
7-7-0-7 Fb Outlook 6.0 Fb Outlook 6.0	35 gallons 7.0 oz 7.0 oz	1 <sup>st</sup> true leaf 2 <sup>nd</sup> true leaf 14 days later	2.3	4.2	8.1	3.1	116.8 a	7.51 a	45.7	88,220	0.84
7-7-0-7 Fb Outlook 6.0	35 gallons 14.0 oz	1 <sup>st</sup> true leaf 2 <sup>nd</sup> true leaf	2.8	5.3	8.0	3.3	98.2 a	6.21 a	46.3	90,181	0.84
Untreated	----	----	0.0	0.0	0.0	0.0	290.6 b	25.45 b	34.7	97,533	0.58
LSD (0.05)	----	----	0.9	1.1	0.6	0.6	123.8	8.90	9.9	n.s.	0.14

1 – Scale: 0 = no weed control to 10 = complete weed control.

Table 7. Trial No. 4. Weed control ratings on April 23, May 4 and June 1, 2007

No.	Treatment	Material/A	a.i./A lbs	Nutsedge			Shepherds Purse			Phytotoxicity		
				4/23	5/4	6/1	4/23	5/4	6/1	4/23	5/4	6/1
1	Basagran	8.0 oz	0.25	0.0	0.8	0.3	2.3	8.2	---	0.0	0.3	0.3
2	Basagran COC	8.0 oz 1.0%	0.25 0.72 gal	0.5	1.3	1.0	3.8	7.7	---	0.0	1.3	0.5
3	Basagran	16.0 oz	0.50	2.0	4.3	2.3	7.3	9.2	---	0.5	1.0	1.3
4	Basagran COC	16.0 oz 1.0%	0.50 0.72 gal	3.5	5.8	4.0	8.0	9.7	---	0.8	2.8	2.5
5	Basagran	32.0 oz	1.0	5.3	7.5	4.8	8.5	9.2	---	0.5	3.0	3.0
6	Basagran COC	32.0 oz 1.0%	1.0 0.72 gal	6.8	8.3	6.5	9.5	10.0	---	1.5	5.3	4.5
7	Basagran Outlook COC	16.0 oz 14.0 oz 1.0%	0.50 0.66 0.72 gal	4.0	9.0	9.3	7.0	10.0	---	0.8	4.5	4.0
8	Untreated	---	---	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0	0.0
	LSD (0.05)	---	---	0.9	1.2	0.8	1.8	1.9	---	0.9	0.9	1.0

In theory, water management should be more efficient with drip, and nitrogen can be applied with no cultural constraints; this means that good lettuce yield and quality should be attainable with lower rates of both water and nitrogen application than with sprinkler irrigation.

## EFFICIENT NITROGEN MANAGEMENT IN DRIP-IRRIGATED LETTUCE PRODUCTION

Tim Hartz, Extension Vegetable Specialist, UCD and Richard Smith, Farm Advisor, Monterey County

Drip irrigation is revolutionizing lettuce production on the coast. The transition to drip brings opportunities and challenges. In theory, water management should be more efficient with drip, and nitrogen can be applied with no cultural constraints; this means that good lettuce yield and quality should be attainable with lower rates of both water and nitrogen application than with sprinkler irrigation. However, those benefits are not automatic. Our work several years ago with celery growers transitioning to drip suggested that growers use widely differing practices, and that significant improvements in both drip irrigation and N fertigation management were possible.

In 2007 we began a series of trials examining irrigation and fertilizer management in drip-irrigated lettuce. Two field trials were conducted in Monterey County, both planted in June for August harvest. In each field we installed valves in individual drip lines so that we could create a 'reduced N fertigation' treatment by turning them off during selected fertigation events. Individual plots were 4 beds wide and 200 feet long, and were replicated 4 times in each field. Prior to the first N fertigation, soil samples were collected to determine the amount of residual soil NO<sub>3</sub>-N present in the root zone. Table 1 gives the details of all fertilizer applications. To document the irrigation volume applied water meters were installed in individual drip lines in each field and monitored for the final 4-5 weeks of the season.

We also evaluated whether phosphorus fertilization was required for maximum crop productivity. Our prior research showed that, in sprinkler-irrigated fields, P fertilization was not required when soil test P level was greater than 50-60 PPM (based on the Olsen extraction method); we wanted to document that this held true in drip-irrigated fields as well. In the first trial the grower did not apply P because of the high soil test level; we created four plots in which P was broadcast and incorporated preplant. In the



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second trial the grower applied an acid-based P fertilizer at planting as an anticrustant; we established four plots that did not receive the anticrustant spray.

In neither field did P fertilization improve lettuce yield (Table 2). This confirmed our prior research, and suggests that growers can skip P fertilization in fields with Olsen soil test P > 50 PPM, at least in warm soils. Since soil P is less available in cool soil, using a threshold of 60 PPM during spring planting is a reasonable safeguard. Soil test P level in fields not receiving P fertilization will decline slowly, but highly enriched fields may not require P fertilization for several years. Continuing to fertilize soils above this agronomic threshold will tend to increase the P concentration in field runoff. Water quality monitoring throughout the Salinas Valley has shown persistently high PO<sub>4</sub>-P concentration; eliminating P fertilization of high P soils should over time improve water quality.

In both fields the growers were judicious with water application, applying < 80% of reference evapotranspiration (ET<sub>0</sub>) over the final month of the season. In both fields there was also substantial residual soil NO<sub>3</sub>-N at the time the growers began N fertigation. As a rough approximation, each PPM NO<sub>3</sub>-N in a soil sample representing the top foot of soil represents approximately 4 lb N/acre, so the residual NO<sub>3</sub>-N in these fields represented approximately 80-100 lb of available N/acre. This level of residual N is quite common in coastal lettuce fields, and represents a 'free' resource that growers can utilize.

N fertigation totals were 127 and 153 lb N/acre in fields 1 and 2, respectively. In both fields the reduced N fertigation treatment had statistically

equivalent lettuce yield compared to the grower N treatment, while saving 77 and 107 lb N/acre. This ability to reduce N application to quite low levels (below a seasonal total of 100 lb N/acre in both fields) without affecting lettuce yield can be attributed to several factors. 1) Due to careful irrigation management, leaching volume, and consequently nitrate loss, was low; 2) Significant residual soil NO<sub>3</sub>-N was present in both fields; and 3) lettuce does not require large amounts of N uptake for maximum growth. When we sampled at harvest the total amount of N in the above-ground biomass was only around 100 lb N/acre. This fits with our previous experience; over more than a dozen lettuce fields that we have monitored over the years, N uptake has consistently been in the range of 90-120 lb N/acre. Of the average of 92 lb N/acre that the growers applied above the reduced N fertigation treatment, only a tiny fraction of it was even taken up by the crop; the rest remained in the soil, susceptible to leaching.

Fertilizer prices are going through the roof, and regulatory pressure to reduce nutrient concentration in surface water is building. Drip irrigation can help lettuce growers address both issues, but only if it is managed efficiently. Efficient drip management requires:

1. conservative irrigation to limit leaching volume
2. use of an N fertigation plan that recognizes that lettuce has only a modest N requirement
3. willingness to adjust that general N fertigation plan to utilize residual soil NO<sub>3</sub>-N

We will be conducting additional drip trials in 2008 to refine management practice recommendations.

**W**e have observed N uptake by lettuce to be in the range of 90 - 120 lbs N/A.

**F**ertilizer prices are going through the roof, and regulatory pressure to reduce nutrient concentration in surface water is building.

Table 1. Initial soil fertility characteristics and fertilizer application.

Field	Initial soil test (PPM)		Fertility treatment	Preplant fertilization (lb/acre)		N fertigation (lb/acre)				Total seasonal N (lb/acre)
	Olsen P	NO <sub>3</sub> -N		P <sub>2</sub> O <sub>5</sub>	N	first	second	third	fourth	
1	57	20	Grower N and P	80	42	50	39	38		169
			Grower N, no P		42	50	39	38		169
			Reduced N, no P		42	50	0	0		92
2	62	27	Grower N and P	72	18	76	31	31	15	171
			Grower N, no P			76	31	31	15	153
			Reduced N, grower P		18	0	0	31	15	64

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Table 2. Effect of fertility management on lettuce yield and biomass N content.

Field	Fertility treatment	Lettuce type	Seasonal N (lb/acre)	Lettuce yield (lb/plant)		Biomass N content (lb/acre)	Reference ET <sub>o</sub> (inches)	Drip irrigation applied (inches)
				total	marketable			
1	Grower N and P	head	169	2.29 b	1.61 b	98	6.2	4.9
	Grower N, no P		169	2.38 a	1.70 a	103		
	Reduced N, no P		92	2.31 b	1.63 ab	91		
2	Grower N and P	head	171	2.16	1.50	103	6.5	4.7
	Grower N, no P		153	2.18	1.43	114		
	Reduced N, grower P		64	2.27	1.56	101		
				ns	ns			

<sup>ns</sup> means not significantly different at  $p < 0.05$ ; means followed by the same letter not significantly different at  $p < 0.05$

## POSSIBLE NEW VIRUS ON CELERY

**Steven Koike, UC Cooperative Extension; Tongyan Tian, California Department of Food and Agriculture; Hsing-Yeh Liu, U. S. Agricultural Research Station**

**A**pium virus Y has been detected in California celery.

**C**elery growers and pest control advisors working with celery are advised to be aware of a possible new virus on this crop in California. In 2007, a few commercial celery plantings exhibited symptoms that were not typical of the common viruses that are occasionally seen in celery. Symptoms on lower leaves were variable and could consist of yellow or brown line patterns, yellow blotches, brown lesions, or in some cases distorted and twisted leaflets. Celery petioles could exhibit brown, sunken, elongated lesions. However, in some cases celery plants having symptomatic foliage did not have any petiole symptoms.

When celery sap was examined under a transmission electron microscope, thread-like (flexuous rod-shaped) virus particles were observed. Further research using molecular methods indicated that the celery might be infected with a virus named *Apium virus Y* (ApVY). In contrast, clinical tests were negative for the common *Celery mosaic virus* (CeMV), *Cucumber mosaic virus* (CMV), and *Tomato spotted wilt virus* (TSWV). Tests were also negative for *Impatiens necrotic spot virus* (INSV), which has recently been affecting lettuce in coastal California. Our preliminary research therefore indicated that ApVY might be involved with some of the symptoms observed in these 2007 fields. However, additional documentation will be needed before we can conclude that ApVY is responsible for all the diverse symptoms seen in these fields last year.

We believe that this is the first documentation of ApVY on celery in California. However, ApVY may not be new to California. In 2003, cilantro plants from fields in California showed mosaic, vein clearing and stunting symptoms. Comparison of the 2007 celery and 2003 cilantro viruses indicates that they are closely related and appear to be ApVY. We also tested parsley plants that were growing near the 2007 diseased celery; these parsley plants tested positive for ApVY even though they showed no virus disease symptoms.

Very little is known about ApVY. This pathogen has been reported on Apiaceae weeds in Australia and celery in New Zealand. The virus is aphid borne. Other aspects such as host range, whether it can be seedborne, or detailed characterization of the virus itself are not documented. Our research group will be investigating this virus. If you see possible virus problems on any of these (celery, cilantro, parsley) or other Apiaceae crops, please contact Steve Koike (UC Cooperative Extension; 1432 Abbott Street, Salinas CA, 93901; 831-759-7350).

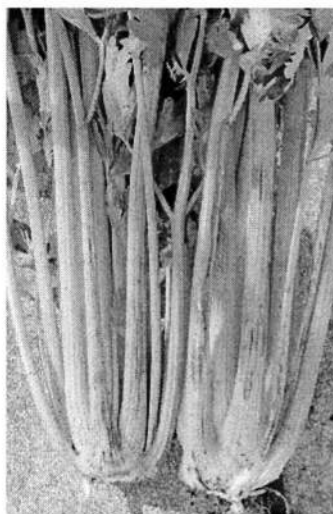
**C**ilantro and parsley are also hosts to ApVY.



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Leaves show various types of line patterns & blotches



Petioles may have brown, sunken lesions.

## WEED CONTROL STRATEGIES IN PEPPERS

**Richard Smith, Farm Advisor, University of California Cooperative Extension  
Monterey County**

**P**epper has various production systems, each with their own weed control challenges.

Peppers grown with plastic mulch has the best weed control options. In this system, Goal Tender is registered to apply prior to applying the plastic mulch which provides excellent control of one of the key problematic weeds in this area, malva. In addition, it is possible to fumigate with Vapam through the drip system once the plastic is in place which provides further control of other key weeds.

In transplanted and direct seeded pepper production systems, there are more weed control challenges. Early season weeds are generally under good control, but late season weeds can be difficult and expensive to deal with. This is particularly true in September and October when late emerging nightshade, sow thistle and malva can continue to grow vigorously. Our research has focused on looking for layby and postemergence materials that can provide a measure of control for late-season weeds. Layby applications are key in this regard because they apply preemergence materials as late in the growth cycle as is possible before the canopy closes. Dacthal is registered for layby use on peppers, but was only used on <1% of the pepper acreage in 2005. We have been working with Syngenta for several years to clarify the wording of the Dual Magnum label to specify its use as a layby application for peppers and

evidently this revised wording may be forthcoming in 2008.

Another strategy for controlling late season weeds is the use of a selective herbicide that does not harm the peppers, but controls key weeds. The grass herbicides Poast and Select Max are useful in this regard, but grass weeds are not generally problematic in our area. Sandea provides control of Yellow Nutsedge and other weeds, but has an 18 month plant back restrictions for lettuce and broccoli which is a problem on the Central Coast. Hooded applications of Shark and Scythe are registered for use on peppers, but they do not control weeds in the area where it is needed the most – in the seedline.

Prowl H2O was registered for use on peppers in 2008. It is registered for pretransplant and layby applications. This will provide a new and much needed tool for both pretransplant and layby use (see Table 1). We will be investigating its use in transplanted peppers in 2008. On direct seeded peppers, it is not registered for preemergence use, but there may be some potential to investigate delayed postemergence use, similar to the technique used on onions (see attached article).

In 2007 we examined pretransplant followed by layby treatments. Unfortunately, there was no

**I**n transplanted and direct seeded pepper production systems, there are more weed control challenges. Early season weeds are generally under good control, but late season weeds can be difficult and expensive to deal with.

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The registration of Prowl H2O will provide a useful weed control tool and our challenge will be to use this material, along with the other weed control materials, to their fullest potential to deal with weed control in peppers.

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significant difference between layby and non-layby treatments (Table 2). We tested a postemergence material that looked promising, but the company decided to not pursue its registration on peppers (data not shown). All materials yielded well, except Matrix which significantly reduced the yield (Table 3).

In summary, transplanted and direct seeded pepper grown without plastic mulch have more weed control challenges. The registration of Prowl H2O will provide a useful weed control tool and our challenge will be to use this material, along with the other weed control materials, to their fullest potential to deal with weed control in peppers.

Table 1. Weed control chart for pepper herbicides<sup>1</sup>.

WEED SPECIES	PREFAR	DACTHAL	SANDEA	VAPAM	DUAL MAG.	DEVIRINOL	GOAL	PARAQUAT	PROWL H2O	TREFLAN
CHICKWEED	P	C	C	C	C	C	N	C	C	C
GOOSEFOOT	P	C	-	C	P	C	C	C	C	C
GROUNDSEL, COMMON	N	N	C	C	N	C	C	C	N	N
HENBIT	N	P	-	C	-	N	C	C	C	C
KNOTWEED	C	P	-	C	N	C	P	P	C	C
LAMBSQUARTERS	C	C	N	C	P	C	C	C	C	C
LONDON ROCKET	N	P	C	C	N	C	P	C	P	N
MALVA	N	P	-	N	P	P	C	P	P	N
MUSTARD	N	P	C	C	N	P	C	C	P	N
NETTLE, BURNING	P	P	C	C	C	P	C	P	N	N
NIGHTSHADE, BLACK	N	P	N	C	C	N	C	C	N	N
NIGHTSHADE, HAIRY	N	P	N	C	C	N	C	C	N	N
NUTSEDGE, YELLOW	N	N	C	C	P	N	N	N	N	N
PIGWEEED	C	C	P	C	C	C	C	C	C	C
PINEAPPLE WEED	N	N	-	C	-	P	P	P	N	N
PURSLANE	C	C	P	C	C	C	C	C	C	C
SHEPERDSPURSE	N	N	C	C	P	P	P	P	P	N
SOWTHISTLE	N	P	C	C	P	C	C	P	N	N
BARNYARDGRASS	C	C	P	C	C	C	P	P	C	C
BLUEGRASS, ANNUAL	C	C	N	C	C	C	P	P	C	C

N = no control; P = partial control; C = good control; and - = unknown.

Table 2. Weed count (no. weeds per 20 ft<sup>2</sup>) and phytotoxicity ratings on September 5.

Treatment At transplanting	Material/A	Layby/Postemergence	Material/A	Night-shade	Shepherd's Purse	Purslane	Sow Thistle	Total weeds	Phyto <sup>1</sup>
Untreated	----	Untreated	----	1.0	5.5	0.3	2.3	10.3	0.0
Dual Magnum 7.62	1.50 pts	----	----	0.8	4.8	1.3	0.5	8.3	1.0
Outlook 6.0	0.80 pt	----	----	2.7	7.0	0.3	1.8	13.3	1.0
Spartan 4F	0.13 lb	----	----	1.7	4.5	1.5	1.3	11.8	0.0
Matrix SG25	0.12 lb	----	----	2.2	8.0	1.0	2.3	18.5	3.3
Dual Magnum 7.62	1.50 pts	Dacthal 6F	1.17 gal	0.	4.8	0.3	0.3	7.5	0.3
Dual Magnum 7.62	1.50 pts	Dual Magnum 7.62	1.50 pts	0.8	2.5	0.3	1.5	6.8	0.0
Outlook 6.0	0.80 pt	Dacthal 75W	9.3 lbs	0.8	7.0	0.0	1.0	10.3	0.0
Outlook 6.0	0.80 pt	Dual Magnum 7.62	1.50 pts	0.8	4.0	0.5	2.5	9.8	0.0
LSD (0.05)				2.1	4.2	1.0	2.2	6.4	1.7

1- Scale: 0=no crop injury to 10=crop dead

Table 3. Yield evaluation on October 22

Transplant Application Material/A	Layby/Post directed Application Material a.i./A	Reds			Green		Turning		Total Marketable		
		Tons/A	Fruit/A <sup>1</sup>	% red	Tons/A	Fruit/A	Tons/A	Fruit/A	Tons/A	Fruit/A	Mean (gr)
Untreated	Untreated	13.30	84.10	48.43	5.62	56.73	8.25	63.70	27.17	204.63	121.4
Dual Magnum 1.50 pt	----	13.25	69.03	55.05	3.30	36.35	7.87	49.40	24.45	154.78	146.3
Outlook 0.80 pt	----	11.10	69.40	44.98	5.32	50.23	7.30	60.45	23.70	180.13	119.8
Spartan 0.13 lb	----	13.48	81.65	57.03	3.92	43.68	5.75	51.05	23.12	176.43	119.7
Matrix 2.0 oz	----	9.20	50.63	52.70	4.00	43.70	3.15	23.70	16.37	118.03	126.8
Dual Magnum 1.50 pt	Dacthal 1.17 gal	11.65	72.68	52.05	3.20	30.63	6.85	50.23	21.72	153.53	128.4
Dual Magnum 1.50 pt	Dual Magnum 1.50 pt	12.70	83.33	54.13	3.62	40.03	6.37	49.00	22.70	172.35	119.9
Outlook 0.80 pt	Dacthal 1.17 gal	10.88	65.35	47.03	4.62	45.73	6.75	51.43	22.20	162.55	124.5
Outlook 0.80 pt	Dual Magnum 1.50 pt	12.03	76.35	54.08	3.37	34.70	6.27	50.23	21.70	161.30	122.0
LSD (0.05)		2.54	15.11	10.55	1.56	16.88	2.74	17.34	3.02	25.90	16.4

1 - Number of fruit in 1,000's



## OPTIMIZING SPRINKLER APPLICATION RATES: PRESSURE, NOZZLE SIZE AND LATERAL SPACING

Michael Cahn, Irrigation and Water Resources Advisor, UCCE Monterey Co.  
Arnett Young, Research Assistant, UCCE Monterey Co.  
Sharid Kamal, Staff Research Assistant, UCCE Monterey Co.

### Introduction

Although the use of drip has steadily increased in the Salinas Valley, solid set and hand move sprinklers remain a common sight during the growing season. Overhead sprinklers are less expensive than drip irrigation and the predominant method for establishing cool season vegetable crops. Some vegetables are almost exclusively irrigated with sprinklers, as the case with broccoli because of its lower value compared to other commodities, or because in the case of spring mix and baby spinach, the production practices are not compatible with drip.

Operating sprinklers to evenly distribute water helps produce uniform crops, as well as save water and minimize run-off. Also of importance for minimizing run-off, is to match the application rate of the sprinklers with the infiltration rate of the soil. Sprinklers that are running at high pressure or with large nozzles, or close lateral spacing may result in an application rate that considerably exceeds the infiltration rate of the soil. On some soils, especially if recently saturated from a previous irrigation, a high application rate will quickly lead to significant amounts of run-off. For example, on soils on the east side of the lower Salinas valley, which are prone to crusting, we have often measured as much as 20% of the applied water running off the lower end of fields.

Because of the wide spread use of the 1/2 inch brass impact sprinkler head on the central coast, we reexamined the relationship among nozzle size, pressure, and lateral spacing on the application rate of overhead sprinklers. We conducted our tests using new Rainbird 20JH impact heads and made repeated measurements of flow rates from nozzles of varying orifice diameters under a range of pressures. We also measured the distribution profile of these sprinkler heads at varying nozzle orifice diameters and under different pressures and used *Sprinkler Profile and Coverage Evaluation* (SPACE) software from the Center for Irrigation Technology at Cal State University Fresno to estimate distribution uniformities under different lateral spacings and pressure scenarios.

### Results of sprinkler head tests

The flow rates from Rainbird 20JH sprinkler heads for varying pressures and nozzle orifice diameters are presented in Table 1. The corresponding application rates to the field in units of inches per hour are presented in Tables 2-4 for lateral spacings of 30, 33.3, and 40 feet, respectively. Flow rates measured for the 20JH sprinkler head were about 0.3 gallons per minute (gpm) greater than values published by the Rainbird company. However, the relationship among pressure, nozzle orifice diameter, and flow rate was similar to previously published values.

**Effect of pressure on application rate** Raising pressure from 45 to 65 psi increased application rates by an average of 13% for all nozzle sizes (Table 1). Likewise, raising pressure from 40 to 60 psi increased application rates by average of 14% for all nozzle sizes. The percentage increase in applied water was highest for the smallest nozzles (3/32 inches), but the amount (gallons per minute) that the application rate was increased with increasing pressure was greatest for the largest orifice size (5/32 inches).

**Effect of nozzle orifice diameter on application rate** On average, increasing the orifice diameter from 7/64 inch to 1/8 inch increased the application rate by 31% for all pressures (Table 1). Increasing the orifice diameter from 7/64 inch to 9/64 inches increased the application rate by an average of 62% for all pressures.

**Effect of lateral spacing on application rate** Assuming sprinkler pipe lengths of 30 feet are used, then reducing the spacing between lateral lines from 33.3 feet (10, 40-inch beds) to 30 feet (9, 40 inch beds) would increase application rates by 11% (Tables 2 and 3). Reducing spacing from 40 feet (12, 40 inch beds) to 33.3 feet would increase the application rate by 20% (Tables 3 and 4).

**Optimizing application rate and distribution uniformity** Although increasing spacing between lateral pipes or reducing nozzle orifice diameter could be effective strategies to reduce application rates, in many instances, these changes would also reduce the distribution uniformity of the sprinklers. For example, a pre-

We conducted our tests using new Rainbird 20JH impact heads and made repeated measurements of flow rates from nozzles of varying orifice diameters under a range of pressures.

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vious analysis that we conducted on sprinkler uniformity using 7/64 inch nozzles demonstrated that increasing the distance between lateral lines beyond 30 feet decreased the uniformity of the applied water (Figure 1). In contrast, reducing pressure can lower application rates without significantly affecting uniformity. Results of another study that we conducted on sprinkler uniformity, demonstrated that decreasing pressure from 65 to 45 psi reduced the application rate by 18% but only reduced the uniformity by 1 to 2 percent (Figure 2).

#### Summary and conclusions

The application rate and distribution uniformity of overhead sprinklers can be optimized by using an appropriate combination of nozzle orifice diameter and lateral pipe spacing. Commonly in the Salinas Valley, growers use 7/64-inch nozzles with 30 to 33.3 foot spacing between lateral pipes or 1/8 inch diameter nozzles with 40 foot spacing between lateral pipes to achieve a high distribution uniformity with solid-set sprinklers and an application rate ranging from 0.24 to 0.28 inches per hour. Using nozzle sizes and/or lateral spacings substantially different from these combinations may adversely affect distribution uniformity or lead to high application rates. Operating overhead sprinklers at high pressures (>45 psi) is also unlikely to significantly improve uniformity of overhead sprinklers, but would increase run-off and waste money.

The combination of operating a pump at a pressure that is higher than necessary and losing water as run-off adds substantially to overall pumping costs. Assuming an electric rate of \$0.16 per kWhr and that a pump is lifting water from a 50 foot depth, the energy cost for pressuring sprinklers to 45 psi is \$38 per acre-foot of water. If the pressure is raised from 45 to 65 psi, then the pumping costs are an additional \$12 per acre-foot of water (30% higher costs). Also if 20% of the applied water is lost in run-off, then the additional water costs are \$22 per acre-foot (total of \$60 per acre-foot of water or 55% higher pumping costs).

Table 1. Sprinkler flow rates under varying pressures and nozzle diameters (Rainbird 20JH).

Pressure psi	Nozzle diameter (inches)				
	3/32	7/64	1/8	9/64	5/32
	Sprinkler application rate gpm				
40	1.69	2.49	3.30	4.10	4.90
45	1.80	2.63	3.45	4.27	5.10
50	1.89	2.74	3.59	4.43	5.28
55	1.97	2.83	3.70	4.57	5.44
60	2.02	2.91	3.80	4.69	5.58
65	2.06	2.97	3.88	4.79	5.70
70	2.07	3.01	3.94	4.87	5.81

Table 2. Sprinkler application rate for varying pressures and nozzle diameters for a solid set spacing of 30 × 30 feet (Rainbird 20JH).

Pressure psi	Nozzle diameter (inches)				
	3/32	7/64	1/8	9/64	5/32
	Sprinkler application rate inches/hour				
40	0.18	0.27	0.35	0.44	0.52
45	0.19	0.28	0.37	0.46	0.54
50	0.20	0.29	0.38	0.47	0.56
55	0.21	0.30	0.40	0.49	0.58
60	0.22	0.31	0.41	0.50	0.60
65	0.22	0.32	0.41	0.51	0.61
70	0.22	0.32	0.42	0.52	0.62

Low rates measured for the 20JH sprinkler head were about 0.3 gallons per minute (gpm) greater than values published by the Rainbird company.

Operating overhead sprinklers at high pressures (> 45 psi) is also unlikely to significantly improve uniformity of overhead sprinklers, but would increase run-off and waste money.

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Table 3. Sprinkler application rate for varying pressures and nozzle diameters for a solid set spacing of 30 × 33.3 feet (Rainbird 20JH).

Pressure psi	Nozzle diameter (inches)				
	3/32	7/64	1/8	9/64	5/32
	Sprinkler application rate				
	inches/hour				
40	0.16	0.24	0.32	0.39	0.47
45	0.17	0.25	0.33	0.41	0.49
50	0.18	0.26	0.35	0.43	0.51
55	0.19	0.27	0.36	0.44	0.52
60	0.19	0.28	0.37	0.45	0.54
65	0.20	0.29	0.37	0.46	0.55
70	0.20	0.29	0.38	0.47	0.56

Table 4. Sprinkler application rate for varying pressures and nozzle diameters for a solid set spacing of 30 × 40 feet (Rainbird 20JH).

Pressure psi	Nozzle diameter (inches)				
	3/32	7/64	1/8	9/64	5/32
	Sprinkler application rate				
	inches/hour				
40	0.14	0.20	0.26	0.33	0.39
45	0.14	0.21	0.28	0.34	0.41
50	0.15	0.22	0.29	0.36	0.42
55	0.16	0.23	0.30	0.37	0.44
60	0.16	0.23	0.30	0.38	0.45
65	0.16	0.24	0.31	0.38	0.46
70	0.17	0.24	0.32	0.39	0.47

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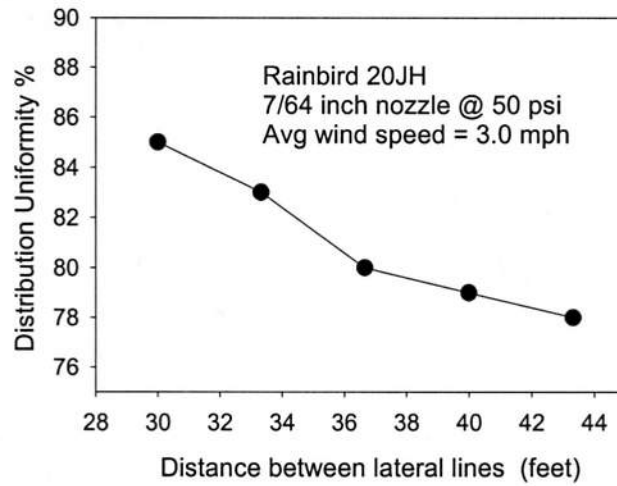


Figure 1. Effects of lateral line spacing on distribution uniformity of overhead sprinklers (head spacing on pipe is 30 feet.)

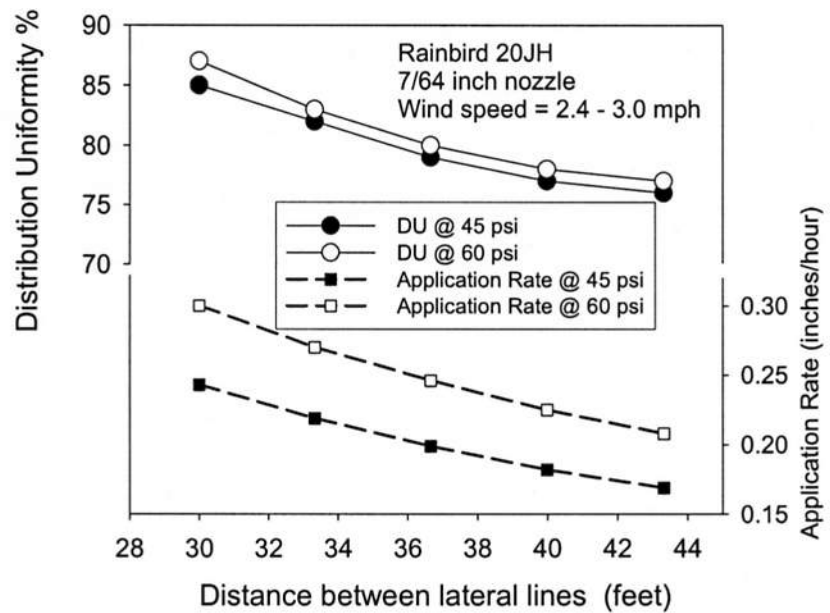


Figure 2. Effects of pressure and lateral line spacing on distribution uniformity and application rate of overhead sprinklers (head spacing on pipe is 30 feet.)