University of California
Agriculture and Natural Resources
Intermountain Research & Extension Center

RESEARCH REPORT
Number 134, 2011

The Influence of Irrigation and Metam Sodium on Russet Potato Yield and Potato Early Dying Suppression in 2010

Rob Wilson, Center Director/Farm Advisor; Don Kirby, Superintendent of Agriculture; Brooke Kliewer & Kevin Nicholson, Staff Research Associates. University of California Intermountain Research & Extension Center, 2816 Havlina Rd. Tulelake, CA. 96134 Phone: 530/667-2719 Fax: 530/667-5265
Email: rgwilson@ucdavis.edu

Introduction: Separate trials were conducted at the Intermountain Research and Extension Center to evaluate the effect of irrigation scheduling or metam sodium (Vapam) fumigation on potato yield in fields with a history of potato early dying (PED). *Verticillium dahliae* is considered the primary causal agent of early dying. PED severity in potatoes is influenced by irrigation and excessive soil moisture. The irrigation trial examined the influence of irrigation frequency on potato yield and quality in a field with moderate PED pressure.

Two metam sodium fumigation trials evaluated the influence of metam sodium rate on potato yield and quality in fields with high PED pressure. One fumigation trial involved fall shank injection application before spring planting Russet Burbank. The other fumigation trial involved a fall spray rototill-incorporated application before spring planting 25 Russet potato varieties.

Irrigation Scheduling Trial

General Trial Information:

Location:	IREC, Tulelake, CA
Soil Type:	Tulebasin mucky silty clay loam
Planting Date:	May 14
Vine Kill Date:	September 16: Roll vines and application of Reglone at labeled rate
Days to Vine Kill:	125 days
Harvest Date:	October 8
Irrigation:	Solid-set sprinklers (2 irrigation schedules)
Plot Size:	12 beds by 30 ft (only harvested middle 20 ft)
In-Row Spacing:	10 inches
Row Spacing:	36 in wide beds (12 beds wide, harvested middle 4 rows)

Number of Reps:	4 replications
Fertilizer:	195-246-6-84
Weed Control:	Cultivation and Outlook (pre-emergence), Matrix and Sencor (post-emergence)
Insecticides:	None
Fungicides:	Maxim (seed treatment), Quadris & Blocker (in-furrow at planting), Bravo and Quadris (foliar application)
Fumigation:	None

Irrigation Treatments and Data Collection:

Two irrigation schedules were evaluated in the trial. One schedule allowed soil moisture to reach 40% depletion between irrigation events. This scheduling resulted in less frequent irrigation with more applied water per irrigation event. The other schedule (B) allowed soil moisture to reach 20% depletion between irrigation events. This scheduling resulted in more frequent irrigation with less applied water per irrigation event. Irrigations for both treatments were scheduled using a combination of monitoring soil moisture (watermark sensors) and crop evapotranspiration. The trial was planted on May 14th using Russet Burbank seed. Verticillium wilt symptom ratings were taken on August 24th using a rating of 0-9 scale with 9 equal to 90-100% of the potato canopy showing signs of disease. The trial was harvested on October 8th. Potatoes from each plot were run across a gradeline to determine tuber yield, size distribution, quality, and internal discoloration. The percent coverage of black dot sclerotia on the lower 8 inches of potato stems was estimated in each plot by evaluating 20 stems per plot.

Results:

Total applied water for both irrigation schedules was similar at the end of the growing season, and irrigation schedules matched crop ET throughout the growing season (Figures 1 and 2). Irrigation scheduling had no influence on visual Verticillium wilt symptom ratings or the percentage of black dot sclerotia coverage on lower stems (data not shown). Irrigation scheduling did not influence total tuber yield and tuber quality (Table 1). Next year the research team plans to evaluate similar irrigation treatments in a field with high Verticillium wilt pressure using Russet Norkotah (a variety very susceptible to Verticillium wilt) to determine the influence of irrigation scheduling under a worst case scenario for early dying severity.

Table 1. Influence of Irrigation Scheduling on Russet Burbank Yield, Disease Symptoms, and Applied Water. Tulelake 2010.

	Total Yield (cwt/A)												
	U.S. No. 1's (cwt)												
Treatment	Total 1's	12-16 oz	8-12 oz	4-8 oz	<4 oz	>16 oz	2's & Culls	Total	% 1's	# Stolons attached to tubers*	Stem End Necrosis **	Total Applied Water (inch)	# of Irrigation Events
Irrigation Schedule A	345	33	92	220	92	8	26	471	73	5	2	23	15
Irrigation Schedule B	343	26	97	221	115	9	19	486	71	6	2	22	25
Mean	344	29	94	220	103	8	23	479	72	5	2	22	20
LSD {0.05}	NS	NS	NS	NS	21	NS	NS	NS	NS	NS	NS	NS	NS

In this trial, two irrigation schedules were compared.

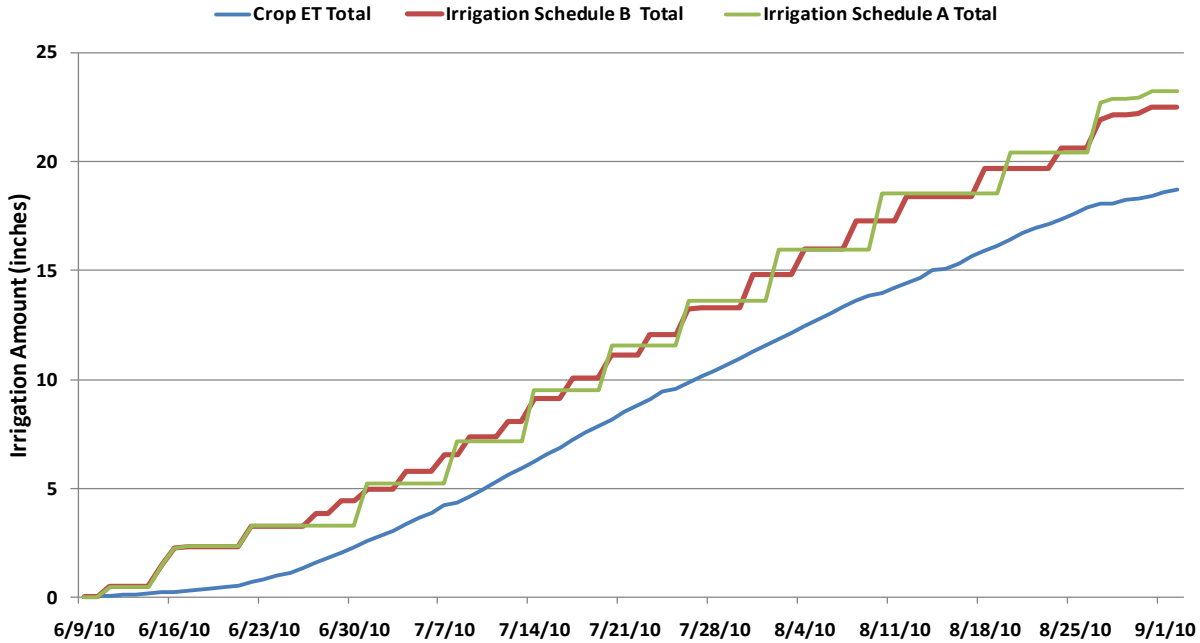
Irrigation Schedule A let soils reach 40% depletion before each irrigation (less frequent irrigation with more water applied per irrigation).

Irrigation Schedule B let soils reach 20% depletion before each irrigation (more frequent irrigation with less water applied per irrigation).

* The average number of stolons attached to tubers per plot. 20 tubers were sampled per plot.

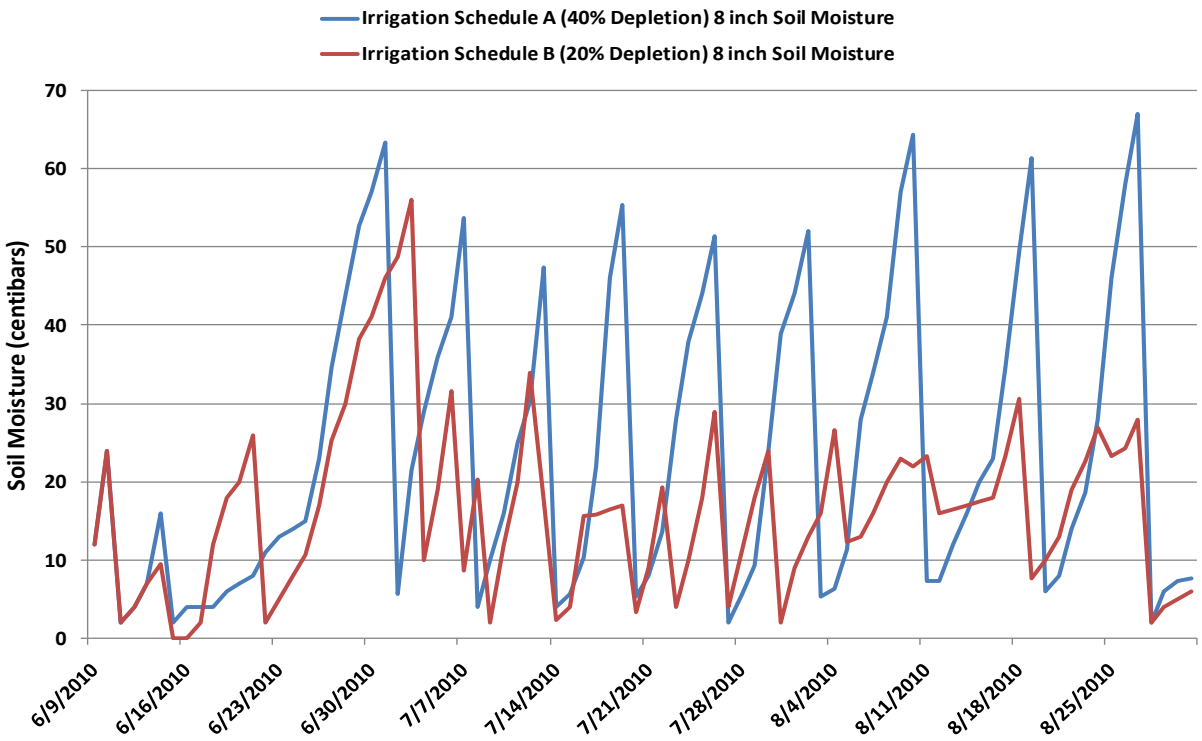
** The average number of tubers with stem end necrosis per plots. 10 tubers were sampled per plot.

Figure 1. Tracking Irrigation Schedules A & B with Potato Water Crop Use



*Irrigation amounts for both schedules exceeded crop ET to account for 80% irrigation system efficiency.

Figure 2. Soil Moisture Comparison of Irrigation Scheduling A & B Using Watermark Sensors



Fall Shank Injected Metam Sodium Trial in Russet Burbank Potatoes

General Trial Information:

Location:	IREC, Tulelake, CA
Soil Type:	Tulebasin mucky silty clay loam
Planting Date:	May 13
Vine Kill Date:	September 16: Roll vines and application of Reglone at labeled rate
Days to Vine Kill:	126 days
Harvest Date:	October 6
Irrigation:	Solid-set sprinklers
Plot Size:	4 beds by 40 ft (harvested middle 2 rows)
In-Row Spacing:	10 inches
Row Spacing:	36 in wide beds
Number of Reps:	4 replications
Fertilizer:	195-246-6-84
Weed Control:	Cultivation and Outlook (pre-emergence), Matrix and Sencor (post-emergence)
Insecticides:	Movento and Coragen (aerial application)
Fungicides:	Maxim (seed treatment), Quadris & Blocker (in-furrow at planting), Bravo and Quadris (foliar application)

Fumigation Application and Data Collection Methods:

Vapam was fall applied at three rates, 18.8, 37.5 and 56.3 gallons/acre plus an untreated control in mid-September before spring planting a Russet Burbank potato crop. Vapam was shank injected at soil depths of 3, 7, and 12 inches with shanks spaced 7 inches apart using a custom applicator on September 15th. Visual Verticillium wilt symptom ratings were taken on August 18th using a 0-9 scale where 9 equaled 90-100% of canopy showing signs of disease. The trial was harvested on October 6th. Potatoes from each plot were run across a gradeline to determine tuber yield, size distribution, quality, and internal discoloration. Post treatment Verticillium colonies per gram of soil were estimated in each plot from soil collected at the time of planting.

Results:

The rate of Shank-applied Vapam did not influence total Russet Burbank yield or post treatment Verticillium soil colony counts, but Vapam did increase U.S. No. 1 yield at rates ≥ 37.5 gal/A compared to the untreated control (Table 2). U.S. No. 1 yield did not differ between 37.5 and 56.3 gal/A. The 56.3 gal/A rate decreased stem end browning compared to the untreated control.

Table 2. The Influence of Fall-Applied Vapam using a Shank Injection Method on Russet Burbank Potatoes at IREC in 2010.

	Tuber Yield (cwt/A)										
Vapam	U.S. No. 1's (cwt)						2's &			Stem End	Post Trtmnt Vert. Colonies/
Rate	Total 1's	12-16oz	8-12oz	4-8oz	<4oz	>16oz	Culls	Total	% US 1's	Necrosis*	gram of soil**
Untreated	258	9	55	194	112	3	9	381	68	2.4	125
18.8 gal/A	263	11	58	194	113	2	12	390	68	2.8	186
37.5 gal/A	279	12	65	202	105	2	13	397	70	1.9	160
56.3 gal/A	285	15	67	204	101	3	14	402	71	1.7	125
Mean	271	12	61	199	107	2	12	393	69	2.2	149
LSD {0.05}	21	NS	NS	NS	NS	NS	NS	NS	2	0.6	NS

* The number of tubers with stem end necrosis per plot. 10 tubers were sampled per plot.

** Verticillium dahliae sclerotia colony count per gram of soil

Fall Rototill Incorporated Metam Sodium Trial in Russet Potatoes

General Trial Information:

Location:	IREC, Tulelake, CA
Soil Type:	Tulebasin mucky silty clay loam
Planting Date:	May 13
Vine Kill Date:	September 16: Roll vines and application of Reglone at labeled rate
Days to Vine Kill:	126 days
Harvest Date:	October 7
Irrigation:	Solid-set sprinklers
Plot Size:	2 beds by 20 ft (2 rows harvested for yield)
In-Row Spacing:	10 inches
Row Spacing:	36 in wide beds
Number of Reps:	4 replications
Fertilizer:	195-246-6-84
Weed Control:	Cultivation and Outlook (pre-emergence), Matrix and Sencor (post-emergence)
Insecticides:	Movento and Coragen (aerial application)
Fungicides:	Maxim (seed treatment), Quadris & Blocker (in-furrow at planting), Bravo and Quadris (foliar application)

Fumigation Application and Data Collection Methods:

Vapam was fall applied on September 12th at three rates, 37.5, 56.3, and 75 gallons/acre plus an untreated control before spring planting a potato crop. Vapam was applied with a spray boom and immediately incorporated with a rototiller in the top 6 inches of soil. Soil moisture and temperature were within label directions at time of application. Visual Verticillium wilt symptom ratings were taken on August 18th using a 0-9 scale where 9 equaled 90-100% of canopy showing signs of disease. The trial was harvested on October 7th. Potatoes from each plot were run across a gradeline to determine tuber yield, size distribution, quality, and internal discoloration. Verticillium colonies per gram of soil were estimated in untreated plots at the time of planting (165 colonies per gram of soil).

A Russet potato variety trial was accidentally planted over the entire plot area the spring following fumigation. Fortunately several of the entries were planted in every Vapam treatment. This subset of entries was used to run statistics. An unequal number of observations for individual variety by Vapam combinations prevented comparison of the interaction between Vapam and variety. The subset of potato entries included released varieties including Russet Norkotah and several numbered entries from public breeding programs. The average Verticillium wilt susceptibility rating for the subset of entries was 5.8 using a 0-9 scale where 9 equaled 90-100% of canopy showing signs of disease. As a comparison, the Verticillium wilt ratings for Russet Norkotah and Russet Burbank were 8.8 and 4.8 respectively.

Results:

All Vapam rates increased total potato yield, U.S. No. 1 potato yield, and ≥ 8 ounce tuber size categories when compared to the untreated control (Table 3). The 75 gal/A rate had the highest total yield and U.S. No. 1 potato yield with 467 and 356 cwt/A respectively. Total yield and U.S. No. 1 potato yield did not differ between the 37.5 and 56.3 gal/A rate.

Recent increases in cost for metam sodium and fumigation application bring the economic benefit of fumigation into question. Vapam increased total yield and U.S. No. 1 potato yield, but an important question is "Does the additional pack-out revenue from increased yield exceed the cost of Vapam application?" Table 4 shows the Vapam treatment cost, potato revenue, and difference between revenue and treatment cost for each Vapam rate. Revenues were calculated using a four year average of fresh market potato prices and a packing shed cost of $5.75/cwt. The 37.5 and 75 gal/A rates produced $97 and $116/A additional pack-out revenue respectively after subtracting the cost of Vapam. The 56.3 gal/A rate resulted in a loss of $13/A because the yield increase did not outweigh the increased cost of Vapam compared to the 37.5 gal/A rate.

The influence of potato price on net potato revenue for the 37.5 and 75 gal/A Vapam rates is shown in Figure 3. Additional revenue was calculated using total yield results from this study and the treatment costs listed in Table 4. The breakeven potato price using this scenario was approximately $6.04/Cwt for the 37.5 gal/A rate and $6.60 for the 75 gal/A rate.

Results suggest metam sodium fumigation is likely cost-effective under current prices in fields with high Verticillium wilt pressure and/or when growing a susceptible variety. The cost-effectiveness of Vapam rate is likely dependent on variety disease resistance and disease pressure in the field.

Yield and Vapam treatment effects in the shank-injection and rototill-incorporated fumigation trials should not be evaluated in a side-by-side comparison. The trials used different potato varieties, and the Verticillium density (colonies per gram of soil) in the untreated control differed between trials.

Special Thanks to the California Potato Research Advisory Board for funding support and Mike Davis's Lab, UC Davis Plant Pathologist, for analyzing soil samples for Verticillium colonies in the soil.

Table 3. The Influence of Fall-Applied Vapam using a Rototill Incorporation Method- Averaged Across Russet Potato Varieties at IREC in 2010.

	Tuber Yield (cwt/A)											
	U.S. No. 1's (cwt)									Average	Tuber	Tuber
Vapam Rate	Total 1's	12-16oz	8-12oz	4-8oz	<4oz	>16oz	Culls	Total	% US 1's	Tuber Size (oz)	Stem End Necrosis*	Vascular Discoloration*
Untreated	295	33	95	167	60	17	25	396	74	6.1	4	0.6
37.5 gal/A	335	46	116	172	55	22	29	441	76	6.5	4	0.7
56.3 gal/A	326	47	119	159	52	26	29	433	75	6.6	4	0.7
75 gal/A	356	53	121	182	54	30	27	467	76	6.6	4	0.5
Mean	328	45	113	170	55	24	27	434	75	6.5	4	1
LSD (0.05)	16	6	11	9	NS	5	NS	15	NS	0.2	NS	NS

* The number of tubers with stem end necrosis or vascular discoloration per plot. 10 tubers were sampled per plot.

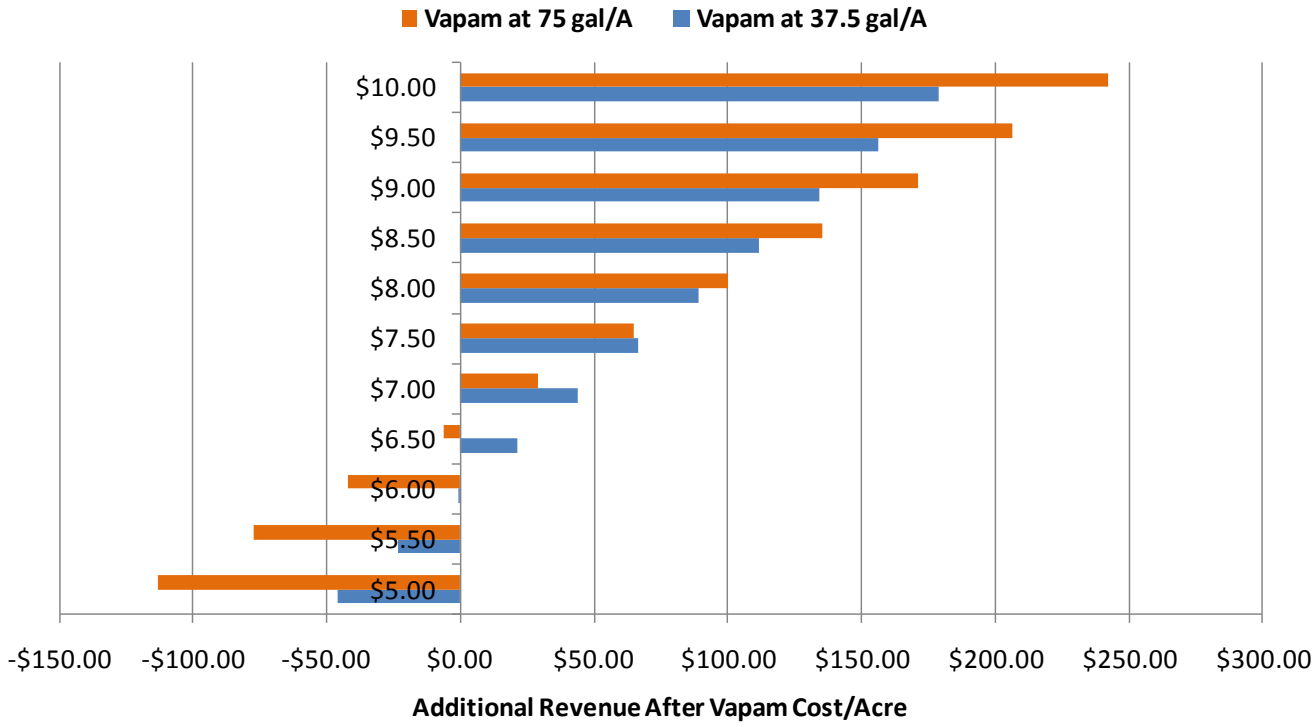
Table 4. The Additonal Revenue Created From Fall-Applied Vapam using a Rototill Incorporation Method- Averaged Across Russet Potato Varieties at IREC in 2010.

	Per Acre Values			
Vapam Rate	Treatment Cost	Total Revenue	Added Pack-Out Revenue	Additional Revenue After Vapam Cost
Untreated	N/A	$2,240	N/A	N/A
37.5 gal/A	271.88	$2,609	$369	$97
56.3 gal/A	370.58	$2,598	$357	-$13
75 gal/A	468.75	$2,825	$585	$116

Cost Assumption:
1 gallon of Vapam = $5.25
Application of Vapam= $75/Acre

Figure 3. Influence of Potato Price per Cwt on Economics of Vapam Fumigation

-Vapam Cost Assumption: $271/A for 37.5 gal/A and $469/A for 75 gal/A
-Revenue was calculated by multipying the difference in total yield from the untreated control by price/Cwt



The University of California prohibits discrimination or harassment of any person on the basis of race, color, national origin, religion, sex, gender identity, pregnancy (including childbirth, and medical conditions related to pregnancy or childbirth), physical or mental disability, medical condition (cancer-related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services (as defined by the Uniformed Services Employment and Reemployment Rights Act of 1994: service in the uniformed services includes membership, application for membership, performance of service, application for service, or obligation for service in the uniformed services) in any of its programs or activities. University policy also prohibits reprisal or retaliation against any person in any of its programs or activities for making a complaint of discrimination or sexual harassment or for using or participating in the investigation or resolution process of any such complaint. University policy is intended to be consistent with the provisions of applicable State and Federal laws. Inquires regarding the University's nondiscrimination policies may be directed to the Affirmation Action/Equal Opportunity Director, University of California, Agriculture & Natural Resources, 1111 Franklin Street, 6th Floor, Oakland, CA 94607, (510) 987-0096.