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Crop Notes

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BACTERIAL LEAF SPOT OF LETTUCE: SEVERE IN 2009

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Bacterial leaf spot of lettuce is characterized by black, angular lesions.

Bacterial leaf spot of lettuce has been affecting Salinas Valley crops for many years. The disease was first noted in California in 1964 and became an economic concern in the 1990s. Bacterial leaf spot now occurs in the Salinas Valley, to some degree, every season. However, in 2009 the disease was widespread and caused significant damage to lettuce.

Symptoms. Early symptoms of bacterial leaf spot are small (1/8 to 1/4 inch), water-soaked spots that usually occur only on the older, outer leaves of the plant. Lesions are typically angular in shape because the pathogen does not penetrate or cross the veins in the leaf. Lesions quickly turn black—this is the diagnostic feature of this disease. If disease is severe, numerous lesions may coalesce, resulting in the collapse of the leaf. Older lesions dry up and become papery in texture, but retain the black color. Lesions rarely occur on newly developing leaves. If disease is severe, secondary decay organisms (bacteria, *Botrytis cinerea*) can colonize the leaves and result in a messy soft rot of the plant. In many cases in 2009 this secondary soft rot decay was more damaging to lettuce yields than the primary bacterial leaf spot disease itself. Bacterial leaf spot can occur on iceberg, romaine, leaf, and butterhead lettuce types.

Pathogen. Bacterial leaf spot is caused by *Xanthomonas campestris* pv. *vitians*. The pathogen can be isolated on standard microbiological media and produces yellow, mucoid, slow growing colonies typical of most xanthomonads. This bacterium is a pathogen mostly limited to lettuce, though under greenhouse conditions several weeds in the same plant family can develop bacterial leaf spot disease when inoculated. To our knowledge, naturally infected weeds showing leaf spot symptoms in the field have not been documented. Some researchers indicate that *X. campestris* pv. *vitians* from lettuce can infect very different plants such as pepper and tomato when such are artificially inoculated; however, naturally infected pepper and tomato have never been found. Bacterial leaf spot disease of lettuce should not be confused with other Xanthomonas diseases. For example, bacterial spot disease of tomato and pepper is caused by a distinct pathovar (*Xanthomonas campestris*. pv. *vesicatoria*); this pathogen will not infect lettuce.

Disease cycle. The pathogen is highly dependent on wet, cool conditions for infection and disease development. Splashing water from overhead irrigation and rain disperses the pathogen in the field and enables the pathogen to infect significant numbers of plants. The pathogen can be seedborne, though the extent and frequency of seedborne inoculum is not currently known. If lettuce transplants are grown from infested seed, the pathogen may become established on plants during the greenhouse phase of growth.

The bacterium can survive for up to five months in the soil. Therefore, infected lettuce crops, once disked into the soil, can supply bacterial inoculum that can infect a subsequent lettuce planting. The bacterium has

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also been found surviving epiphytically on weed plants, though the significance of this factor is not known.

Control. Clearly the elimination or reduction of the use of overhead sprinkler irrigation will significantly curtail this disease in all situations, except when rains occur. Some resistant lettuce lines have been identified, though resistance is not widely available in currently used cultivars. Residual bacterial inoculum, left in the soil following an infected lettuce crop, will potentially cause problems for the next lettuce planting unless that planting is delayed for five months or longer. Therefore, crop rotation schemes will need to be evaluated if bacterial leaf spot is a chronic problem in fields heavily planted to lettuce. Effective foliar sprays have not been identified for this disease.

The exact role of seedborne inoculum is not currently known. We have no information on how frequently commercial seed lots might be infested and to what degree. Thresholds (the levels at which seedborne inoculation becomes economically important) for bacterial leaf spot have not been established. Therefore, additional research might be useful in assessing frequency of contaminated seed lots, sensitivity and accuracy of currently used seed tests, and in establishing seed testing standards and thresholds.

Lettuce bacterial leaf spot was especially severe in 2009.

SPINACH DOWNY MILDEW: OUTLINING THE CHALLENGES

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Downy mildew results in yellow lesions on spinach, making the leaves unmarketable.

Downy mildew disease, caused by *Peronospora farinosa* f. sp. *spinaciae*, is the most important disease problem facing the extensive spinach industry in California. In recent years, several new downy mildew races have appeared in the state in rapid succession, raising great concerns about the ability to manage this threat and causing the industry to consider research strategies to address the problem.

In October 2009, a downy mildew "summit meeting" was held in Salinas to discuss this concern. Sponsored by UC Cooperative Extension, the California Leafy Greens Research Board, and seed industry leaders, the intent of the meeting was to mobilize all components of the spinach industry and to generate ideas for research and collaborations.

In recent years a number of new races have occurred on spinach in California.

The major concern is the recent proliferation of races. While downy mildew has been around California spinach fields for decades, the last few years have seen the development of four or five new races. Each new race potentially overcomes the resistance factors in the cultivars being planted at that time, leaving the crop susceptible to severe damage. This Salinas spinach meeting helped bring out several points:

1. Basic information on the pathogen biology is missing. Information is needed regarding exact conditions for infection, mechanisms of genetic change and the rise of new races, how the pathogen survives the winter, and other aspects. Very pressing is the question of the importance of seedborne inoculum. Researchers have found downy mildew survival structures on spinach seed. However, it is unknown whether this seedborne inoculum is important, how commonly it occurs, or whether the pathogen on seed is alive and able to cause downy mildew on the germinating seedling.
2. Role of organic spinach in epidemics remains unknown. Some suggest that organic spinach plantings, by virtue of using untreated seed (presuming seedborne inoculum, discussed above) or lacking effective fungicides, might be a source of new races. These hypotheses are derived from field observations related to some of these recent outbreaks, plus the 2003 stoppage of synthetic fungicide treatments used on seed for organic plantings. However, from a research-based perspective such assertions are yet unproven and require investigation. A connection here may be possible, but requires research to substanti-

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ate such a link.

3. Integrated management steps must be used. There is consensus that standard IPM disease strategies must be employed and improved upon. Resistant cultivars will remain a foundational piece of such a program. Judicious use of effective fungicides will remain important. Timely disking of harvested, old, or severely diseased fields is warranted. Failure to destroy these fields results in "green bridges" in which pathogen inoculum from the old fields can "bridge" over and infect newly planted fields. For organic production, effective fungicides need to be developed.
4. Research is needed. Certainly more research is needed to fill in the knowledge gaps regarding basic biology of the mildew, disease development, inoculum sources, role of seedborne downy mildew, sources of genetic resistance of spinach, and improved fungicides.
5. A model for collaboration and progress. Growers of conventional and organic spinach, seed industry personnel, plant breeders, pest control advisors, allied industry members, and researchers must team together to work on solutions. It is hoped that this October meeting in Salinas will be the first of many steps taken to build such cooperation and develop responses to the spinach downy mildew challenge in California.

Research is needed on the basic biology of the spinach downy mildew pathogen.

2009 SPINACH WEED CONTROL RESEARCH UPDATE

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Background: In the spring of 2008 Helm Chemical Corporation announced that they were suspending production of RoNeet which at the time was the only preemergence herbicide for use on spinach. Given that sugar beets is the main market for RoNeet with 1,185,000 acres in the US in 2007 vs 47,700 acres of spinach, it may be that the impact of roundup ready sugar beets on the use of this herbicide may have influenced manufacturing decision. Interestingly, in recent days, Helm Agro announced that they are resuming production of RoNeet. This is good news for the spinach industry.

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We are always interested in finding alternative weed control strategies for vegetable crops in order to provide more options and to strengthen weaknesses in existing strategies. In the summer of 2008 a 24c registration for Dual Magnum was granted for use spinach. The Dual Magnum registration is a welcome addition to the weed control materials available for use on spinach, however as the label is currently written, there are two barriers to its use in the Salinas Valley: 1) there is a 50 day preharvest interval and 2) there is a 12 month plant back restriction to lettuce. Both of these issues limit the usefulness of the Dual Magnum label in the Salinas Valley. However, there are efforts being conducted by the IR4 program and US EPA to make these label issues less restrictive. For instance, there are efforts to reduce the preharvest interval for Dual Magnum to 20 days and to reduce the lettuce plant back interval as well.

We are always interested in finding alternative weed control strategies. Over the past two years we have been examining the use of low rates of Lorox as possible preemergence spinach herbicide. Its safety varies by soil type and characteristics.

Over the past two years we have been examining the use of low rates of Lorox as a possible preemergence herbicide for use on spinach. Comparing weeds controlled by RoNeet, Dual Magnum and Lorox, it can be seen that Lorox would strengthen weed control options for spinach (Table 1). Lorox has some safety on spinach, but the safety varies by soil type and soil characteristics. This article will give an update on two years of research with Lorox, as well as a timing trial with Dual Magnum.

Methods: ***Herbicide Evaluation Trials:*** Nine trials were conducted in 2008 and 2009. All trials were small plot evaluations conducted in commercial spinach production fields with cooperating growers and PCA's. We made an effort to locate the trials on different soil types to develop an idea of the safety and efficacy of the materials under different conditions. Each trial was sprayed post planting prior to the first germination water. Weed control ratings, phytotoxicity and yield evaluation were conducted for each trial. ***Dual Magnum Preharvest Timing Trial:*** One trial was conducted to evaluate pre-planting applications of Dual Magnum in order to comply with the 50 day pre harvest interval for Dual Magnum on spinach. The trial was conducted with Bob Riddle of Integrated Crop Management and Fresh Farms in San Ardo. All Dual Treatments were applied on July 1 with a commercial application rig to shaped 80-

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inch beds. After application the material was incorporated with preirrigation water and, immediately prior to planting, the beds were mulched. The spinach was planted on July 21 and irrigated on July 22. The soil was Mocho silt loam.

Results: ***Herbicide Evaluation Trials:*** There is a trend that indicates that over nine trials conducted in 2008 and 2009 all preemergence herbicides reduced the yield of spinach from the untreated control (Table 2). On average, both RoNeet at 1.25 pint/A and Dual Magnum at 0.3 pint/A reduced yield by over one ton/A and Lorox at 0.4 lb of material/A reduce the yield by over two tons/A. This data needs to be looked at in conjunction with the impact of these materials on weeding cost as RoNeet at 1.25 pint/A, Dual Magnum at 0.3 pint/A and Lorox at 0.4 lb of material/A reduced hand weeding time 59.8, 56.8 and 75.2% over the untreated control, respectively, in two trials in 2008. These trials indicate that spinach is very sensitive to preemergence herbicides but that the herbicides improve the efficiency of hand weeding operations. In the case of Lorox, the soil type was critical in determining its safety to the spinach. Interestingly, Lorox was safer on the sandy loams along the river, but completely unsafe on the eastside coarse sandy loams (Table 3).

The take home message for this work is that for all the preemergence herbicides used on spinach, the rate a soil type are critical to the safety of these materials on spinach. Based on these and other trial data, Tessenderlo Kerley will be deciding if they want to continue examining the potential of registering Lorox on spinach.

Dual Magnum Preharvest Timing Trial: Dual magnum at 0.75 and 1.00 pint/A applied 3 to shaped beds three weeks prior to planning provided good weed control (Table 4). The 0.75 pint was safer than the 1.0 pint/A rate and provided equal weed control. This technique can be used in situations where a grower wishes to use Dual Mangum, but there are insufficient days to harvest if the Dual Magnum is applied at planting.

Table 1. Comparison weeds controlled by RoNeet, Dual Magnum and Lorox

Weed Species	RoNeet	Dual Magnum	Lorox
ANNUAL BLUEGRASS	C	C	C
BURNING NETTLE	P	C	C
CEREALS	N	N	P
CHICKWEED	C	C	C
CLOVER	P	N	P
COMMON GROUNDSEL	C	N	C
HENBIT	C	-	C
KNOTWEED	P	N	P
LAMBSQUARTERS	C	P	C
LONDON ROCKET	N	N	C
LOVEGRASS	C	C	C
MALVA	P	P	C
MUSTARD	N	N	C
NETTLE LEAF GOOSEFOOT	C	P	C
NIGHTSHADE, BLACK	P	C	C
NIGHTSHADE, HAIRY	C	C	P
PIGWEED	C	C	C
PINEAPPLE WEED	C	-	C
PURSLANE	C	C	C
SHEPERDSPURSE	P	P	C
SOWTHISTLE	C	P	C
SPRANGLETOP GRASS	C	C	N
SWINE CRESS	-	P	C
WILD RADISH	N	N	C
YELLOW NUTSEDGE	P	P	P

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Over nine trials RoNeet at 1.25 pint/A and Dual Magnum at 0.3 pint/A reduced yield by over one ton/A and Lorox at 0.4 lb/A reduced yield by over two tons/A as compared to the untreated control.

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Table 2. Yield of individual 2009 trials and summary of 2008 and 2009 trial yields (tons/A)

Treatment	Material Per Acre	Lbs a.i./A	Trial 1 2009	Trial 2 2009	Trial 3 2009	Trial 4 2009	Average 2009	Average 2008	Average 2008&09
RoNeet 6E	1.25 pt	0.93	10.1	7.0	9.6	5.6	8.1	8.0	8.05
Dual Magnum 7.63	0.3 pt	0.29	9.2	5.5	9.3	5.3	7.3	8.9	8.10
Dual Magnum 7.63	0.5 pt	0.48	9.9	NA	NA	NA	NA	7.4	7.40
Lorox 50	0.2 lb	0.1	10.8	7.6	11.0	5.8	8.8	8.5	8.64
Lorox 50	0.4 lb	0.2	10.7	2.5	10.0	5.4	7.2	6.9	7.05
Lorox 50	0.8 lb	0.4	10.3	0.5	5.4	2.2	4.6	1.7	3.15
Untreated	—	—	10.9	8.3	10.9	5.9	9.0	9.8	9.40
Pr>Treat			0.215	<0.001	<0.001	<0.001			
Pr>Block			0.133	0.201	0.009	0.051			
$LSD_{0.05}$			NS	2.7	1.3	0.3			

Table 3. Soil analyses of 2008 and 2009 spinach weed trials

Trial	Soil Type	Significant yield reduction with Lorox at 0.2 lb a.i./A[1]	Organic matter	Sand %	Silt %	Clay %
2008 No. 2	Arnold Loamy	No	1.16	62	18	20
2008 No. 4	Greenfield fine sandy loam	Yes	0.84	47	28	25
2008 No. 5	Chualar loam	Yes	0.82	68	16	16
2009 No. 1	Metz fine sandy loam	No	0.87	55	29	16
2009 No. 2	Chualar Loam	Yes	0.89	73	18	9

1 – Significantly less than the untreated control

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Table 4. Evaluation of Dual Magnum applied three weeks prior to planting to comply with the 50 day preharvest interval. Weed counts taken on August 6 - sixteen days after planting.

Treatment	Material Per Acre	Lbs a.i./A	Purslane	Malva	Other weeds	Total weeds	Phyto
Dual Magnum	0.50 pint	0.48	41.3	0.8	1.3	43.3	0.0
Dual Magnum	0.75 pint	0.72	4.0	1.8	2.3	8.0	0.8
Dual Magnum	1.00 pint	0.96	1.0	2.8	4.3	8.0	1.3
Untreated	----	----	3.0	11.8	21.8	36.5	0.0
Pr>Treat			<0.001	<0.001	<0.001	0.002	0.005
LSD 0.05			16.4	3.7	5.7	17.0	0.7

EVALUATION OF POLYACRYLAMIDE (PAM) FORMULATIONS FOR CONTROLLING SUSPENDED SEDIMENTS AND NUTRIENTS IN SPRINKLER RUN-OFF

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Introduction

The renewal of the conditional waiver for agricultural discharge and proposed total maximum daily loads (TMDL) for nutrients and sediments may increase requirements for growers to implement best management practices that minimize impairments to surface and ground water quality on the Central Coast. Though many growers have made progress in implementing practices that reduce the impacts of agriculture on water quality, such as reducing fertilizer inputs, improving irrigation scheduling, and using drip irrigation, additional management tools could help achieve more dramatic improvements to water quality.

Overhead sprinklers, which are widely used on the Central Coast for vegetable production, often cause run-off. Although the volume of run-off is minimal or none on many fields, on some soil types the run-off can be as much as 20% of the applied water. Sediment concentrations and turbidity levels can be especially high in run-off from sprinklers because the force of the falling water droplets degrade soil aggregates and suspend sediments in the run-off. Significant amounts of phosphorus, nitrogen, and some classes of pesticides, such as pyrethroids, which adsorb to the suspended sediments, are also transported in the run-off.

Sediment concentrations and turbidity levels can be especially high in run-off from sprinklers because the force of the falling water droplets degrade soil aggregates and suspend sediments in the run-off.

Our previous field trials conducted in the Salinas Valley from 2003-2006 demonstrated that concentrations of suspended sediments and associated nutrients and pesticides in sprinkler run-off could be greatly reduced by adding small amounts of polymer to irrigation water. Specifically, anionic polyacrylamide (PAM) polymer was injected into the irrigation water to achieve a 5 ppm concentration. The small amount of polymer in the irrigation water flocculated out suspended sediments, reducing sediment concentrations by an average of 90% in the run-off. Linear polyacrylamides have been used successfully for erosion control in furrow irrigation in Idaho and eastern Washington since the early 1990s and are a recommended practice of the Natural Resource Conservation Service that can be cost-shared through the EQIP program.

Although PAM showed much promise as a tool for reducing sediment concentrations in preliminary trials, questions have remained on the best methods for injecting PAM into pressurized irrigation systems, and as to how often applications are needed to maximize the erosion control benefits. Also different formulations of liquid PAM polymers are available for commercial use but there are few comparisons of their water quality benefits. This report describes the results of trials conducted in commercial lettuce fields in the Salinas valley to evaluate the water quality benefits of 2 liquid PAM formulations (water-based and mineral oil based) and the effect of repeated applications on control of suspended sediments and nutrients.

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Description of field trials

Four trials were conducted in commercial romaine lettuce fields (2 trials in 2007 and 2 trials in 2008) to evaluate PAM effects on sprinkler run-off. Soil characteristics at trial sites were summarized in Table 1. All fields were irrigated with solid-set impact sprinklers. Individual plots measured 3 to 6 acres in area.

The following treatments were compared: Soilfix® PAM®, Terawet PAM®, and an untreated control (no polymer added). PAM was injected into the main sprinkler line to achieve a 5 ppm concentration in the irrigation water. The treatments were rotated among plots so that each plot received each PAM treatment during 3 consecutive irrigations. In addition to the 3 treatments described above, a 4th treatment consisting of an untreated control treatment, in which no polymer was applied during the 3 irrigations, was included in trials 2-4. By comparing the moving untreated control, which received PAM in previous irrigations, to the stationary untreated control, which never received PAM, we were able to assess the residual effects of PAM on water quality.

PAM Formulations
The trials compared 2 different water soluble liquid PAM products: Terawet PAM25®, a 25% anionic polyacrylamide product which included water and humectant substances as inert ingredients, and Ciba Soilfix® which was a 50% anionic polyacrylamide product with mineral oil as an inert ingredient.

PAM injection methods
PAM polymers were injected into the main lines of the sprinkler system by 2 different methods: 1. A batch solution of 0.25% polymer was premixed in a tank prior to the irrigation and injected using a high pressure centrifugal pump at a rate of 0.8-1.2 gal/min to achieve a 5 ppm PAM concentration in the irrigation water, 2. A Seepex® dosing (progressive cavity) pump was also used to inject the liquid PAM products (without prior dilution) at rates of 0.5 to 1 ounce/min directly into the mainline to achieve a 5 ppm concentration.

Summary of Results

Average reduction in turbidity in the irrigation run-off was 95% for Soilfix and 91% for PAM25 compared to the moving untreated control treatment.

<u>PAM effects on suspended sediments and turbidity</u> Both PAM products significantly reduced sediment, turbidity and total phosphorus concentrations in the sprinkler run-off (Tables 3 and 4) relative to the moving control treatment. Treatments effects were significantly different at sites 2-4 but not at site 1 (data not presented). Average reduction in suspended sediments in the irrigation run-off was 91% for Soilfix and 74% for PAM25 in comparison to the moving untreated control (Table 4). Average reduction in turbidity in the irrigation run-off was 95% for Soilfix® and 91% for PAM25® compared to the moving untreated control treatment (Table 4). The average reduction in total suspended sediments relative to the fixed location control treatment for trials 2-4 was 96% for Soilfix® PAM and 84% for PAM25® (Table 5). The average reduction in total turbidity relative to the fixed location control treatment for trials 2-4 was 92% for Soilfix PAM and 90% for PAM25. The reduction in suspended sediments and turbidity in the run-off was not statistically different between the Soilfix® and PAM25® products.

<u>PAM effects on nutrients levels in run-off</u> Average reduction in total P in the irrigation run-off was 67% for Soilfix® and 43% for PAM25 compared to the moving control treatment (Table 4). The average reduction in total P relative to the fixed located control treatment for trials 2-4 was 77% for Soilfix® PAM and 60% for PAM25® (Table 5). Soilfix® PAM also significantly reduced soluble P in run-off compared to the moving and fixed location control treatments (Tables 5 and 6). Soilfix® significantly reduced total P, soluble P, and total N more than PAM25®. The PAM treatments significantly reduced phosphorus loads relative to the moving untreated control treatment (Table 5).

The PAM treatments caused small or no reduction in the concentration of Nitrate-N, Total N, and K at most sites. Unlike results of past trials, high level of nitrate in the run-off limited the ability of PAM to reduce total N levels. The high levels of nitrogen at site 2 was caused by the grower injecting N fertilizer into the irrigation water during the 2nd and 3rd irrigation events and because the irrigation water had a high level of nitrate (Table 2). The irrigation water at site 4 also had a high concentration of nitrate (Table 2).

<u>PAM effects on run-off amounts</u> The PAM treatments had a modest effect on the volume of irrigation

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run-off relative to the moving control treatment (Table 3). PAM25 appeared to have the most effect on run-off volume. Reductions in run-off volume were also measured relative to the fixed control treatment for trials 2-4 (Table 5), which suggests that these products can modestly increase the infiltration rates of the soil types tested (Table 5). Irrigation run-off varied significantly between field sites (4.6% of applied water at site 1 and 51% of applied water at site 4), and may be attributed to the stage of the crop when the trials were conducted and soil type. The trial at site 1 was conducted during the germination of the crop, when the soil was not saturated. The trial at site 2 was conducted after the crop had received multiple irrigations, and therefore the soil would likely have been more saturated than at site 1.

Residual effect of PAM on suspended sediments and nutrients Comparison of the moving control treatment with the fixed-location control treatment at trials 2-4 demonstrated that prior applications of PAM continued to reduced suspended sediment, turbidity, and total P concentrations in the run-off when PAM was not applied (Table 5). The residual effect of PAM on total suspended sediments in the run-off increased with the number of previous applications of PAM (Figure 1).

Summary

The results of large scale trials conducted in commercial lettuce fields confirmed previous data showing that the addition of polyacrylamide polymer to irrigation water significantly reduced sediment and turbidity levels in sprinkler run-off. PAM was also found to reduce total and soluble phosphorus concentrations in run-off. We found less effect of PAM on total nitrogen concentration than we have previously reported, most likely because the effect of PAM on total N was masked by the high background level of nitrate in the irrigation water. Although no statistically significant differences were found between the two PAM formulations, suspended sediment concentrations were usually lower for the Soilfix PAM compared to the Terawet PAM25 and the Terawet appeared to increase infiltration more than the Soilfix product. These trials also showed that PAM had a residual effect on the quality of the run-off. Significant reductions in sediment and nutrients in sprinkler induced run-off may be achieved by alternating applications of PAM between irrigations.

The results of this and previous studies conducted on the central coast have demonstrated that polyacrylamide can be an important tool for growers to reduce sediment and nutrient losses in sprinkler run-off. PAM can also minimize aquatic toxicity of pyrethroid pesticides, which strongly bind to suspended sediments carried in irrigation run-off.

Table 1. Soil physical and chemical characteristics at trial sites 1, 2, and 4.

depth	pH	EC	SAR	TKN	Olsen P	Cation Exchange Capacity	Organic Matter	Sand	Silt	Clay
		dS/m		%	ppm	meq/100 g	%			
						site 1[x]				
0 - 1 ft	7.1	1.46	2	0.072	75	14.5	0.93	56	28	16
1- 2 ft	7.2	1.46	2	0.053	61	14.9	0.73	57	26	17
1 -3 ft	7.2	1.22	2	0.043	27	19.1	0.46	51	26	23
						site 2				
0 - 1 ft	7.4	0.74	1	0.054	144	10.0	0.84	66	21	13
1- 2 ft	7.4	1.04	2	0.042	97	9.1	0.67	68	20	12
1 -3 ft	7.3	1.70	2	0.029	60	7.7	0.38	69	19	12
						site 4				
0 - 1 ft	7.2	1.16	1	0.041	72	26.8	0.78	81	11	8
1- 2 ft	7.2	1.11	2	0.031	50	10.5	0.71	80	13	7
1 -3 ft	7.1	1.29	2	0.026	27	5.4	0.61	82	11	7

[x] sites 1 and 3 had similar soil types

Table 2. Chemistry and nutrient content of irrigation water from trial sites.

Site	pH	EC	TDS	SAR	Total Kjeldahl N	Ammonium-N	Nitrate-N	P (Total)	P (Soluble)	Total Suspended Solids	Turbidity
		dS/m	ppm		ppm						NTU
1	7.5	0.7	430	2.1	0.2	<0.05	6.9	<0.1	0.06	<4	1
2	8.0	1.0	580	2.3	0.2	<0.05	14.8	<0.1	0.07	9	2
3	8.4	0.6	350	2.7	0.4	<0.05	5.3	<0.1	0.07	50	26
4	8.2	1.0	702	1.4	0.8	0.78	51.1	<0.1	<0.05	26	13

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Table 3. Effect of PAM treatments on suspended sediments, turbidity, volume, and nutrient loads of sprinkler induced run-off (average of 4 sites).

Treatment Description	Total Suspended Solids	Turbidity	Run-off		Sediment load	Total P load	Total N load
	mg/L	NTU	gal/acre/irrigation	% of applied water	-------- lb/acre/irrigation --------		
Untreated Moving Control[x]	555	382	4964	21.5	28.2	0.076	1.069
PAM25	137	34	3961	18.1	5.0	0.031	0.467
Soilfix	42	20	4613	21.4	1.8	0.022	0.782
$LSD_{0.05}$	263	206	919	3.7	3.8	0.029	0.525
statistical significance[z]	***	***	*	NS[y]	**	**	*

[x] PAM was applied during previous irrigations

[y] not statistically significant

[z] symbols *,**,*** signify that treatment means are statistically different at the 90%, 95%, 99% confidence levels, respectively

Table 4. Effect of PAM treatments on chemistry and nutrient content of sprinkler run-off (average of 4 sites).

Treatment Description	pH	EC	Total Dissolved Solids	Total P	Soluble P	Total Kjeldahl N	Nitrate-N	Ammonium-N	Soluble K
		dS/m	---------------- ppm ----------------						
Untreated Moving Control[x]	8.1	1.08	720	1.51	0.38	15.7	29.0	7.94	3.9
PAM25	8.2	0.96	618	0.86	0.37	10.2	22.3	3.88	4.3
Soilfix	8.3	0.98	604	0.50	0.28	11.1	33.8	9.82	4.0
$LSD_{0.05}$	0.3	0.21	208	0.26	0.06	6.9	12.6	4.46	0.8
statistical significance[z]	NS[y]	NS	NS	***	***	NS	NS	**	NS

[x] PAM was applied during previous irrigations

[y] not statistically significant

[z] symbols *,**,*** signify that treatment means are statistically different at the 90%, 95%, 99% confidence levels, respectively

Table 5. Effect of PAM treatments on chemistry and nutrient content of sprinkler run-off relative to fixed control treatment (average of 3 sites).

Treatment Description	Total P	Soluble P	Total Kjeldahl N	Nitrate-N	Total Suspended Solids	Turbidity	Run-off
	% of fixed location control[x]						
Untreated Moving Control[x]	64	101	86	83	57	77	85
PAM25	40	99	81	80	16	10	71
Soilfix	23	69	50	86	4	8	76
$LSD_{0.05}$	10	22	35	31	15	32	17
statistical significance[z]	***	**	*	NS[y]	***	***	NS

[x] PAM was applied during previous irrigations

[y] not statistically significant

[z] symbols *,**,*** signify that treatment means are statistically different at the 90%, 95%, 99% confidence levels, respectively

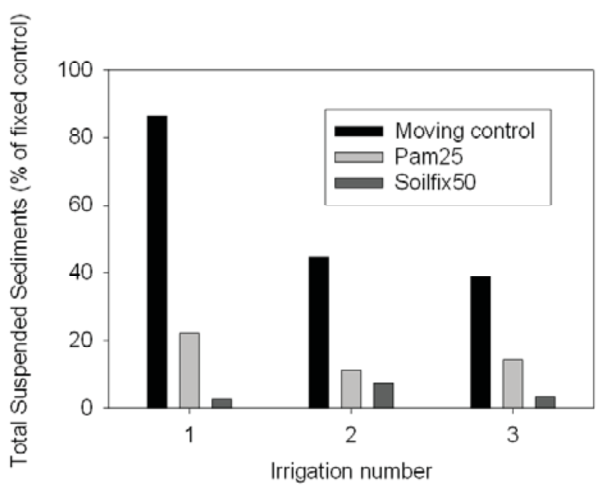

Figure 1. Effect of PAM and moving control treatment on total suspended sediments with increasing number of irrigations expressed as a percentage of the fixed location control treatment. PAM was previously applied before irrigations 2 and 3 in the moving control treatment.

UNIVERSITY *of* CALIFORNIA

Agriculture & Natural Resources

Cooperative Extension • Monterey County

University of California Cooperative Extension, Monterey County

2010 Irrigation and Nutrient Management Meeting and Cover Crop and Water Quality Field Day

Tuesday, February 23

7:45 a.m. to 3:00 p.m.

RAIN OR SHINE

Irrigation and Nutrient Management Meeting: Salinas Community Center, 940 North Main Street, Salinas

7:45	**Registration and Refreshments**
8:00	***Nitrogen Management Studies: Field Scale Evaluations*** Tim Hartz, Extension Vegetable Specialist, UC, Davis
8:30	***Nitrate Leaching Evaluations in Lettuce Production*** Aaron Heinrich, Staff Research Associate, Monterey County Cooperative Extension
9:00	***Nutrients in Surface Waters of Production Agriculture Watersheds*** Sarah Greene, Preservation Inc.
9:30	***Irrigation Management and Impact on Nitrate Leaching and Fertilizer Use Efficiency*** Mike Cahn, Irrigation and water resources Farm Advisor, Monterey County
10:00	***Break***
10:30	***Practical Soil Nitrate Testing and Fertilizer Management*** Richard Smith, Vegetable Crops and Weed Science Farm Advisor, Monterey County
10:50	***Ag Water Enhancement Program (AWEP)*** Bob Fry, Natural Resources Conservation Service (NRCS), Davis
11:10	***Polyacrylamide (PAM) Update: Formulations, Control of Chlorpyrifos in Runoff*** Mike Cahn, Irrigation and water resources Farm Advisor, Monterey County
11:40	***Salinas Valley Water Project Update*** Manuel Quezada (invited), Water Resources Engineer, Monterey County Water Resources Agency
12:00	***Conclusion and travel to lunch and field demonstration site***

Vegetable Furrow Bottom Cover Crop Field Trial Demonstration
D'Arrigo Brothers Farms – off Old Stage Road

12:45	***Lunch – on Site*** Pizza lunch
1:30	***Field Demonstration and Discussion*** ***Discussion of the Impact of Low-Residue Cover Crops on Winter Fallow Beds on Runoff and Water Quality*** Mike Cahn and Richard Smith, University of California Cooperative Extension;
2:30	***Conclusion***

* **Sponsors:** University of California Cooperative Extension; Resource Conservation District (RCD); Community Alliance with Family Farmers (CAFF)
* **Continuing Education, Certified Crop Advisor and Water Quality Credits have been requested**
* **For more information call Richard Smith 759-7357 or Michael Cahn 759-7377**

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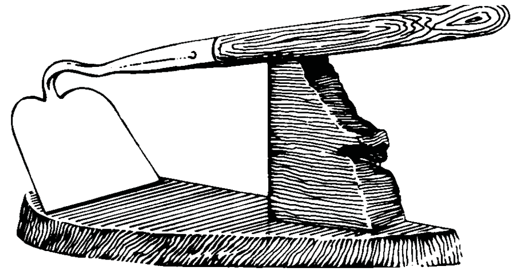
University of California and U.S. Department of Agriculture cooperating.



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- Management of weeds in organic crops
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- What's new in weed control from Industry

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