PREIRRIGATION IMPACTS ON SUBSEQUENT WEED EMERGENCE

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INTRODUCTION

On the Central coast of California direct-seeded vegetables such as broccoli and lettuce are grown on raised beds. Extensive tillage is the norm in this production system with the objective of creating a smooth seedbed that is suitable for the planting of small-seeded vegetable crops such as lettuce (Ryder 1999, Fennimore and Jackson 2003). During dry weather, creating a smooth seedbed for planting requires irrigation of the raised beds, followed by drying to the appropriate soil moisture before the final tillage (Masiunas et al. 1997). We tested the hypothesis that lengthening the time interval between pre-plant irrigation and crop planting may improve weed control by allowing time for more weeds to emerge so that they can be removed with pre-plant tillage. Because irrigated vegetable fields often have the option of several irrigation systems such as sprinkler and furrow irrigation, we compared these two major preplant irrigation systems. The study objectives were: 1) to compare short versus long time intervals between pre-plant irrigation and tillage, and 2) to compare the level of preplant weed germination stimulus with sprinkler and furrow irrigation.

METHODS

Site description. In field studies conducted at the USDA-ARS station at Salinas, CA, spring lettuce was planted at Spence farm and fall lettuce was planted at Hartnell farm. Soil at Hartnell farm is an Antioch sandy loam, and at Spence farm is a Chualar loamy sand. Cropping history included vegetable crops such as lettuce, broccoli, and winter cover crops of oats and mustard at Spence and Hartnell farm, respectively. These two sites are about 5 miles apart and vary in their weed species richness and diversity; Hartnell farm had fewer weed species but higher weed densities than Spence farm.

Pre-irrigation studies were conducted on 40-in raised beds and treatments included; furrow irrigation 1 and 2 weeks prior to planting, sprinkler irrigation 1 and 2 weeks prior to planting, and a control with no pre-plant irrigation. Experimental designs in the 2002 spring planting were 3 by 3 Latin square block design for the pre-irrigation, each block was 100 ft long by 16 beds wide. Blocks were split for the two time intervals (7 or 14 days) and further split between three preemergence herbicide rates (pronamide 0, 0.6 and 1.2 lb ai/A), applied to two beds in each block one day after crop seeding. Furrow irrigation was used to water the beds to near saturation. Sprinkler irrigation plots were watered for approximately 7 hrs during which time about 1.75 in of water was applied.

Plots were seeded with romaine (var. green tower) in two planting lines with 2-inch in-row spacing. After lettuce seeding, pronamide was applied on the bed tops in a 22-inch band using a CO_2 tractor mounded sprayer. Following pronamide application, all plots were sprinkler irrigated for 3 hrs (equivalent to 0.75-inches of rain).

The fall 2002 and both spring and fall 2003 pre-irrigation studies had a randomized complete block design with three to four replicates, with block size of six 40-inch beds wide by 100 ft long, similar to the spring 2002 study. After the initial pre-irrigation and seeding, all plots were subjected to uniform horticultural practices common for lettuce production in the Salinas Valley such as sprinkler irrigation, hand weeding and cultivation, and fertilizer application (Ryder 1999).

Weed counts were performed before bed shaping, prior to crop thinning 21 days after crop seeding, and before any hand weeding or cultivation. Weed densities were measured in two 2.7 ft^2 sub-samples per treatment (one per each center bed); weeds were identified and recorded by species. The time required for hand weeding during lettuce thinning was recorded. Lettuce yield was evaluated by harvesting one 10 ft seed line in each of the two center beds. Number of lettuce heads and fresh weights were recorded.

Statistical analyses. All data analyses were performed on the averages of the two sub-samples. Data were subjected to arcsine, logarithmic or square root transformation as required after consideration for normality and heterogeneity. Data were subjected to a two way block-designed ANOVA with interaction, using proc. mixed in SAS. When blocks had no significant effect, data were tested again with a two way ANOVA with interaction, for the effect of the different pre-irrigation and herbicide treatments, using proc. GLM in SAS. Single degree-of-freedom (df) linear contrasts were used to compare efficacy of different time intervals (7 vs. 14 d), pre-irrigation methods, and herbicide rates at P = 0.05 (SAS 1991).

RESULTS AND DISCUSSION

Post-plant weed evaluations. All studies demonstrated that pre-irrigation followed by preplant tillage reduced weed densities during the crop establishment period, i.e. approximately the first 21d after crop seeding (Table). These early season weeds present the highest risk for yield lost in many leafy vegetable (Roberts and Stokes 1965, Roberts et al. 1977, Shem-Tov and Fennimore 2002). Insufficient time interval between pre-plant furrow irrigation and bed shaping did not improve weed control and even increased weed densities in spring plantings (Table). Lonsbary et al. (2003) also demonstrated the importance of time interval between pre-plant irrigation and cultivation of stale-seedbed as a method to improve weed control in cucumbers. If a short pre-plant interval is to be used, sprinkler pre-plant irrigation is the recommended method.

Spring experiments. In both 2002 and 2003 planting, late season rain occurred after bed listing. However only in the 2003 study did weed emergence occur after bed listing. Weed densities were reduced by most pre-plant irrigation treatments; in some cases pre-plant irrigation with the long time interval of 14 d had similar or better weed control than the non pre-irrigated control treated with 1.2 lb/A pronamide (Table). The level of control demonstrated by the 14 d pre-irrigation may be sufficient for organic production of sensitive crops with no good herbicides. Weed densities in the spring 2002 planting, without pre emergence herbicide application, were: 124, 142, 68, 66 and 46 weeds m-1 for the no pre-irrigation control, furrow 7 d, furrow 14 d, sprinkler 7d and sprinkler 14d pre-plant irrigation, respectively. The weed densities measured 21d after crop seeding in the spring 2003 planting were: 225, 450, 213, 313 and 216 weeds m-1 for the non pre-irrigated control, furrow 7 d, furrow 14 d, sprinkler 7d and sprinkler 14d pre-plant irrigations, respectively. While the 2002 study demonstrated a good weed control provided by the pre-plant irrigation alone, the 2003 study showed improved weed control only in combinations of herbicide and pre-plant irrigation treatments (Table). In the 2003 study, pronamide did not improve weed control in plots that were not pre-irrigated.

Fall experiments. A high weed density in the fall 2002 planting demonstrated the importance of the pre-plant irrigation. Pre-plant irrigation alone reduced the weed densities from 575 weed m-1 to 477, 378, 409 and 472 weeds m-1, in the furrow 7 d, furrow 14 d, sprinkler 7d and sprinkler 14d pre-plant irrigated plots, respectively (Table). Similar reduction was noted in time required for hand weeding the plots. The combination of pre emergence herbicide application and pre-plant irrigation reduced the hoeing time by up to 50%. The first hand weeding, during thinning, and pre emergence herbicide application costs for romaine lettuce costs are 15% and 5%, respectively of the cultural practice costs (Tourte and Smith 2001). Orthagonal contrasts in both years, demonstrated significant differences in the weed densities and the hoeing time between the two time intervals (7 and 14 d) under sprinkler pre-plant irrigation, and between weed densities in plot pre-irrigated with furrow or sprinkler under the long time interval of 14d (data not shown). In the 2003 fall planting, lower weed densities were recorded, yet both pre-plant irrigation and pronamide rates had a significant effect on weed control and the time required for hoeing and hand weeding. The long pre-plant interval of 14 d had the best weed control and pre emergence herbicide application supplemented the pre-irrigation to achieve up to 80% weed control (Table). Orthagonal contrasts revealed a significant effect of the two time interval (7 and 14 d) and these differences were noticeable under the sprinkler pre-irrigation but not under the furrow pre-plant irrigation (data not shown). The two pre-plant irrigation methods (sprinkler and furrow) had a significant effect on the total weed densities (data not shown).

Lettuce yield. In general all the spring pre-plant irrigation treatments had similar fresh weights and head size, as the control. However, during the fall planting reduced yield mass and quality was noted in the no pre-irrigation control (data not shown). This reduce quality could be attributed to nitrogen phytoxicty caused by the fertilizer injected to the soil during bed listing, while part of the nitrogen applied to the pre-plant irrigated plots was lost before seeding and therefore did not show such response (Ajwa personal communication). This was not a problem for the spring planting since beds were exposed to few natural rainfalls that occurred between bed listing and the initiation of the study.

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Table: Weed densities, and the hoeing time required to thin and hand weed the 2002-3 lettuce plantings 21 d after planting.

Pre-irrigation treatment	Herbicide rate	Spring 2002		Fall 2002		Spring 2003		Fall 2003	
		Weed density	Hoeing time	Weed density	Hoeing time	Weed density	Hoeing time	Weed density	Hoeing time
	Lb ai/A	no. m-2	Sec 30 ft-1	no. m-2	Sec 30 ft-1	no. m-2	Sec 30 ft-1	no. m-2	Sec 30 ft-1
None	0	124	254	575	186	225	176	126.1	159
None	0.6	96	170	272	124	281	136	99.4	111
None	1.2	66	124	335	127	218	122	86.0	101
Furrow 7d	0	142	NA	477	158	450	173	68.6	109
Furrow 7d	0.6	36	NA	102	92	348	119	26.9	75
Furrow 7d	1.2	31	NA	94	96	167	97	25.8	80
Furrow 14d	0	68	159	378	146	213	164	75.1	158
Furrow 14d	0.6	109	124	106	95	157	113	37.5	99
Furrow 14d	1.2	38	95	122	91	161	105	33.7	85
Sprinkler 7d	0	66	NA	409	187	313	147	58.5	134
Sprinkler 7d	0.6	54	NA	242	126	135	96	35.2	86
Sprinkler 7d	1.2	28	NA	87	107	86	89	20.0	82
Sprinkler 14d	0	46	131	472	145	216	136	66.0	93
Sprinkler 14d	0.6	49	125	96	93	156	96	24.8	89
Sprinkler 14d	1.2	26	103	148	102	145	96	34.6	82
LSD 0.05		46	13	77	27	74	36	2	28

a- The time (sec.) required for thinning and hand weeding a 30 ft long bed of lettuce, data were analyzed as averages of the to sub-samples (paired beds).