

CALIFORNIA LEAFY GREENS RESEARCH PROGRAM

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WEED MANAGEMENT SYSTEMS FOR LEAFY GREENS

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ABSTRACT

Dual Magnum was evaluated for use as a pre-transplant herbicide for lettuce. Prior research demonstrated it to be safe on traditional 30-day-old lettuce transplants. However, the latest transplanting technology uses plants that are about 20 days old, and these lettuce plants are more sensitive to Dual Magnum than 30-day-old plants. Lettuce transplants at 2, 3, 4 and 5-leaf stages were transplanted into soil treated with Dual Magnum at 0.33 pints/A. Transplants at the 3 to 5-leaf stages were tolerant to this rate of Dual Magnum while the 2-leaf transplants were less tolerant. Another part of the project evaluated the use of Dual Magnum at 0.16, 0.33, 0.51 and 0.67 pints/A. Results indicated that rates greater than 0.5 pint/A were more apt to injure young lettuce transplants. The results clearly indicate that the focus of research should be on lower rates of Dual Magnum when used with Plant Tape technology. Tank mixes of Dual Magnum plus Kerb were evaluated and found that Dual Magnum plus Kerb improves control of weeds that Kerb does not control, such as common sowthistle. Dual Magnum plus Kerb did not help improve control of common purslane or burning nettle, compared to Kerb alone. The best role for Dual Magnum should be in 30-day-old transplants; and where young transplants are used, Dual Magnum should be used at a rate less than 0.5 pints per acre in combination with Kerb. Kerb applied through surface and buried drip tape was compared to surface spray application of Kerb. Kerb applied in the drip system did not provide effective weed control- likely due to failure of the Kerb to be pushed across the width of the bed. We are conducting further work on this in 2020 to solve the issue.

OBJECTIVES

The long-term goal of this project is to provide leafy vegetable growers with tools and information that leads to cost-effective and labor-efficient weed management systems that will be sustainable in the long-term. The objectives of this project were to determine the minimum size of lettuce transplants that are tolerant to Dual Magnum (*S*-metolachlor), and the minimum

rate of Dual Magnum alone and in tank mix with Kerb required for effective weed control in transplanted lettuce. The third objective was to optimize weed management practices for direct-seeded lettuce in combination with full-season drip irrigation.

PROCEDURES

Determine the minimum size of lettuce transplants that are tolerant to Dual Magnum

The tolerance of 2nd- through 5th-leaf lettuce transplants to Dual Magnum 7.62EC was evaluated at Salinas, CA during September to November 2019. The experiment was conducted at the Hartnell research farm, on Antioch sandy loam soil, fine, smectitic, thermic Typic Natrixeralf (53% sand, 32% silt, and 15% clay) with a pH of 7.0 and organic matter content of 2.1%. Head (cv. Quest) and Romaine (cv. Abilene) lettuce transplants of 2, 3, 4 and 5-leaf stages were transplanted into soil previously treated with Dual Magnum or pronamide (Kerb 3.3SC). The trial was arranged in a randomized complete block design, with treatments replicated four times. Each replicate consisted of a single bed, 40” wide by 20’ long.

Dual Magnum at 0.33 pts. product/A and Kerb at 1.9 pts. product/A were applied pre-transplant (PRE) to plots assigned to one of the four growth stage transplants on September 6, 2019. A weed-free check was included for comparison to herbicide treatments. The weed-free check was hand weeded every 1 to 2 weeks. All treatments were spray applied in water at 40 GPA with a CO₂ backpack sprayer, using a single-nozzle wand with a Tee-Jet EVS 8002 nozzle centered over the bed. Head and Romaine lettuce plugs at the 2, 3, 4 and 5-leaf stages were transplanted into all plots using two plant lines per bed at 12” in-row and 12” between-rows on September 9 (Table 1). The weed-free check was planted with 4-leaf plugs of each cultivar. The plots were sprinkler irrigated for 2 hours, immediately following transplanting, to set the transplants and activate the herbicides. The trial was irrigated weekly, using buried drip tape; and cultivated twice during the trial period. The lettuce was fertilized through the drip tape at 2 to 3-week intervals, with 20% ammonium nitrate: for a total of 110 lbs. N/acre. The entire trial was covered with floating row cover to protect from bird damage.

Table 1. Critical trial events and dates

Application Intervals:	
PreTransplant	9/6/19
Transplanting Date:	9/9/19
Lettuce Type / Variety:	Romaine (Abilene) Head (Quest)
Evaluations:	
Weed Control	9/27/19
Stand	9/24/19
Crop Injury	9/23/19 10/4/19 10/21/19
Harvest	11/6-18/19

Weed densities were measured on September 27, 2019. Crop injury estimates, using a rating scale of 0 = no injury, 10 = crop death, were made September 23, October 4 and 21, 2019.

Lettuce stand counts (number of viable plants per 15' of row) were made September 24, 2019. Healthy lettuce heads were harvested, counted and weighed on November 6-18, 2019 (Table 1). All data were subjected to analysis of variance, and mean separation was performed using LSD (P=0.05).

RESULTS. Weeds present in the trial were nettle-leaf goosefoot (*Chenopodium murale* L.), common purslane (*Portulaca oleracea* L.), and burning nettle (*Urtica urens* L.). Neither Dual Magnum nor Kerb controlled goosefoot relative to the weed-free check (Table 2). Dual Magnum 0.33 pt/A did not control purslane or nettle, while Kerb was fairly effective on these weeds. Dual Magnum was less effective on total weeds than Kerb. Lettuce stands in the 2nd-leaf plants were reduced by early growth bird damage, not herbicide injury. Neither Dual Magnum nor Kerb reduced lettuce stands among the 3rd, 4th or 5th-leaf stage (Table 3).

Table 2. Weed densities on 9/27/19; approximately 3-weeks after transplanting.

Treatments	Rate (pt/A)	Goosefoot	Purslane	Burning Nettle	Total Weeds
		1000s/A			
Dual Magnum	0.33	189 a	249 a	72 a	618 a
Kerb	1.9	156 a	38 b	33 b	341 b
Weed-free Check	---	0 b	0 b	0 b	0 c
LSD (P = .05)		96.2	53.9	36.6	133.6
Treatment Prob (F)		0.0014	0.0001	0.0024	0.0001

Table 3. Lettuce stand at approximately 2 weeks after transplanting

Treatments	Rate (pt/A)	Growth Stage	Crop Stand	
			Head	Romaine
			No./15' bed ¹	
Dual Magnum	0.33	2 nd -Leaf	13.5 b	12.3 b
Kerb	1.9	2 nd -Leaf	12.8 b	11.0 c
Dual Magnum	0.33	3 rd -Leaf	14.8 a	14.5 a
Kerb	1.9	3 rd -Leaf	15.0 a	14.7 a
Dual Magnum	0.33	4 th -Leaf	14.8 a	15.0 a
Kerb	1.9	4 th -Leaf	14.8 a	15.0 a
Dual Magnum	0.33	5 th -Leaf	15.0 a	14.7 a
Kerb	1.9	5 th -Leaf	15.0 a	14.5 a
Weed-free Check	---	4 th -Leaf	14.8 a	14.8 a
LSD (P = .05)			1.2	1.0
Treatment Prob (F)			0.0033	0.0001

¹ Crop stand losses in the 2nd-leaf treatments were due to bird damage.

Dual Magnum caused little injury to head lettuce and slight to moderate injury to Romaine lettuce at the 2nd-leaf stage. Dual Magnum appears to be safe when applied to Romaine at the 3rd through 5th-leaf stage (Table 4).

Table 4. Crop injury estimates 2, 4 and 6 weeks after transplanting.

Treatments	Rate (pt/A)	Growth Stage	Crop Injury					
			Head			Romaine		
			2 weeks	4 weeks	6 weeks	2 weeks	4 weeks	6 weeks
			0 = no injury, 10 = crop death					
Dual Magnum	0.33	2 nd -Leaf	0.0	0.3	1.0 a	0.8	3.3 a	3.0 a
Kerb	1.9	2 nd -Leaf	0.0	0.0	0.3 b	0.5	0.5 cd	0.8 bcd
Dual Magnum	0.33	3 rd -Leaf	0.0	0.0	0.1 b	0.3	2.0 b	0.8 bcd
Kerb	1.9	3 rd -Leaf	0.0	0.0	0.0 b	0.0	0.3 cd	0.3 cd
Dual Magnum	0.33	4 th -Leaf	0.0	0.0	0.3 b	1.3	2.4 ab	1.5 b
Kerb	1.9	4 th -Leaf	0.0	0.0	0.0 b	0.0	0.0 d	0.0 d
Dual Magnum	0.33	5 th -Leaf	0.0	0.0	0.0 b	0.8	1.4 bc	1.3 bc
Kerb	1.9	5 th -Leaf	0.0	0.0	0.0 b	0.0	0.0 d	0.0 d
Weed-free check	---	4 th -Leaf	0.0	0.0	0.0 b	0.0	0.0 d	0.0 d
LSD (P = .05)			0.0	0.24	0.48	1.0	1.2	1.01
Treatment Prob (F)			1.0000	0.4613	0.0040	0.1293	0.0001	0.0001

Table 5. Crop yield: Number, fresh weight and size of healthy heads.

Treatments	Rate (pt/A)	Growth Stage	Head			Romaine		
			1000s/A	tons/A	gm/head	1000s/A	tons/A	gm/head
Dual Magnum	0.33	2 nd -Leaf	19.6 d	18.8 bc	865 ab	20.9	17.0	725
Kerb	1.9	2 nd -Leaf	20.9 cd	19.2 bc	845 ab	20.9	15.9	689
Dual Magnum	0.33	3 rd -Leaf	23.0 bcd	19.3 bc	767 bc	21.7	18.2	770
Kerb	1.9	3 rd -Leaf	24.8 abc	26.3 a	955 a	23.5	24.1	926
Dual Magnum	0.33	4 th -Leaf	28.2 a	20.3 bc	661 cd	20.4	15.4	703
Kerb	1.9	4 th -Leaf	24.8 abc	21.6 ab	788 abc	23.0	22.2	890
Dual Magnum	0.33	5 th -Leaf	25.6 ab	22.1 ab	790 abc	23.5	19.4	756
Kerb	1.9	5 th -Leaf	26.1 ab	18.5 bc	643 cd	22.2	20.1	816
Weed-free check	---	4 th -Leaf	26.1 ab	15.8 c	548 d	24.3	19.8	733
LSD (P = .05)			4.1	5.3	167.7	4.4	5.5	179.7
Treatment Prob (F)			0.0050	0.0360	0.0013	0.5778	0.0596	0.1270

Dual Magnum or Kerb applied to head lettuce at the 2nd-leaf stage had reduced head numbers (Table 5). This yield reduction is most likely a result of the stand loss caused by the early bird damage, not due to the herbicide treatments. Neither treatment reduced weights and size of head lettuce transplanted at the 3rd through 5th-leaf stages, compared to the weed-free check. Dual Magnum reduced weights and size of mature heads for head lettuce transplanted at the 3rd-leaf stages, compared to Kerb applied PRE. Neither Dual Magnum nor Kerb applied PRE significantly reduced numbers, weights and size of mature heads for Romaine lettuce transplanted at the 2nd through 5th-leaf stages.

Conclusions are that Dual Magnum at 0.33 pt/A or Kerb at 1.9 pt/A are safe to apply to head and Romaine lettuce plugs transplanted at the 3rd through 5th-leaf stages.

Determine the minimum rate of Dual Magnum alone and in tank mix with Kerb required for effective weed control in transplanted lettuce (field station trial).

The weed control efficacy of Dual Magnum alone and in tank mix with Kerb was evaluated at Salinas, CA during September to November 2019. The experiment was conducted at the Hartnell research farm, in the soils described in the trial above. Head (cv. Quest) and Romaine (cv. Abilene) lettuce transplants of 4 to 5-leaf stage were transplanted into soil treated previously with Dual Magnum alone or in combination with Kerb. The trial was arranged in a randomized complete block design, with treatments replicated four times. Each replicate consisted of a single bed, 40” wide by 20’ long.

Dual Magnum at 0.17, 0.33 and 0.50 pts./A, Kerb at 1.9 pts./A, and Dual Magnum at 0.17, 0.33 and 0.50 pts./A tank mixed with Kerb at 1.9 pts./A were applied pre-transplant (PRE) on September 27, 2019. Weed-free checks were weeded every 1 to 2-weeks. All treatments were spray applied as described for the previous trial. A mechanical transplanter, two plant lines per bed at 12” in-row spacing and 12” between-rows, was used to transplant head and Romaine lettuce plugs at the 4th to 5th-leaf stage on September 30 (Table 6). The plots were sprinkler irrigated for 2-3 hours, immediately following transplanting, to set the transplants and activate the herbicides. The trial was irrigated weekly, using buried drip tape; and cultivated twice during the trial period. The lettuce was fertilized through the drip tape at 2 to 3-week intervals, with 20% ammonium nitrate: for a total of 70 lbs. N/acre. To prevent bird damage; the entire plot was covered with a floating row cover for the first 6 weeks after planting.

Table 6. Critical trial events and dates

Application Intervals:	
PreTransplant	9/27/19
Transplanting Date:	9/30/19
Lettuce Type / Variety:	Head (Quest) Romaine (Abilene)
Evaluations:	
Weed Control	10/17/19
Stand	10/18/19
Crop Injury	10/14/19 10/28/19 11/12/19
Harvest	11/21/19 (Head) 11/22/19 (Romaine)

Weed density counts were assessed on October 17, 2019. Crop injury estimates, using a rating scale of 0 = no injury, 10 = crop death, were made October 14 and 28, and November 12, 2019. Lettuce stand counts (number of viable plants per 20’ of bed; single plant line per variety) were made October 18, 2019. Lettuce was harvested counted and weighed November 21 (Table 6). All data were subjected to analysis of variance, and mean separation was performed using LSD (P=0.05).

RESULTS. Weeds present were common purslane and burning nettle (Table 7). The Dual Magnum plus Kerb tank mix did not appear to improve control of purslane more than Kerb

alone. The Dual Magnum plus Kerb tank mix may improve control of burning nettle and total weeds somewhat compared to Kerb alone but the difference was not significant. None of the Dual Magnum or Kerb treatments reduced head or Romaine lettuce stands (Table 8).

Table 7. Weed densities per acre on 10/17/19, at 17 days after transplanting.

Treatments	Rate (pts./A)	Applic. Interval	Purslane	Burning Nettle	Total Weeds
			1000s/A		
Dual Magnum	0.17	PRE Trans	1716 ab	91 bc	2062 ab
Dual Magnum	0.33	PRE Trans	948 bc	157 b	1425 bc
Dual Magnum	0.5	PRE Trans	643 c	99 bc	934 cd
Kerb	1.9	PRE Trans	198 c	83 bc	539 cd
Dual Magnum + Kerb	0.17 + 1.9	PRE Trans	217 c	36 c	403 cd
Dual Magnum + Kerb	0.33 + 1.9	PRE Trans	107 c	33 c	327 d
Dual Magnum + Kerb	0.5 + 1.9	PRE Trans	392 c	28 c	524 cd
Weedy Check	---	---	2176 a	305 a	2860 a
Weed-free Check	---	---	0 c	0 c	0 d
LSD (P = .05)			995	115	1096
Treatment Prob (F)			0.0009	0.0005	0.0002

Table 8. Lettuce stand at 18 days after transplanting.

Treatments	Rate (lbs. ai/A)	Applic. Interval	Crop Stand	
			Head	Romaine
			No./20' row	
Dual Magnum	0.17	PRE Trans	26.3	23.7
Dual Magnum	0.33	PRE Trans	27.3	24.3
Dual Magnum	0.5	PRE Trans	28.0	26.3
Kerb	1.9	PRE Trans	24.7	25.5
Dual Magnum + Kerb	0.17 + 1.9	PRE Trans	26.5	26.0
Dual Magnum + Kerb	0.33 + 1.9	PRE Trans	28.3	25.5
Dual Magnum + Kerb	0.5 + 1.9	PRE Trans	26.5	25.8
Weedy Check	---	---	27.0	25.3
Weed-free Check	---	---	26.3	26.0
LSD (P = .05)			3.0	2.0
Treatment Prob (F)			0.4014	0.1678

None of the Dual Magnum or Kerb treatments caused any significant crop injury to head and Romaine lettuce. Tank mixes of Dual Magnum + Kerb appear to be safe on head and Romaine (Table 9).

Table 9. Crop injury estimates at 2, 4 and 6 weeks after transplanting.

Treatments	Rate (lbs. ai/A)	Applic. Interval	Head			Romaine		
			2 weeks	4 weeks	6 weeks	2 weeks	4 weeks	6 weeks
0 = no injury, 10 = crop death								
Dual Magnum	0.17	PRE Trans	0.0	0.0	0.0	0.0 b	0.8 ab	1.0
Dual Magnum	0.33	PRE Trans	0.0	0.0	0.0	0.3 b	0.4 bc	0.3
Dual Magnum	0.5	PRE Trans	0.0	0.3	0.3	1.5 a	1.4 a	1.1
Kerb	1.9	PRE Trans	0.0	0.0	0.0	0.0 b	0.0 c	0.0
Dual Magnum + Kerb	0.17 + 1.9	PRE Trans	0.0	0.0	0.0	0.3 b	0.3 bc	0.4
Dual Magnum + Kerb	0.33 + 1.9	PRE Trans	0.0	0.0	0.0	0.0 b	0.0 c	0.4
Dual Magnum + Kerb	0.5 + 1.9	PRE Trans	0.0	0.0	0.0	1.0 a	0.9 ab	0.8
Weedy Check	---	---	0.0	0.0	0.0	0.0 b	0.0 c	0.0
Weed-free Check	---	---	0.0	0.0	0.0	0.0 b	0.0 c	0.0
LSD (P = .05)			0.0	0.24	0.24	0.66	0.75	1.00
Treatment Prob (F)			1.0000	0.4613	0.4613	0.0004	0.0058	0.1767

None of the Dual Magnum or Kerb treatments reduced yield in numbers, weights and size of head and Romaine lettuce plugs transplanted at the 4th to 5th-leaf stage (Table 10).

Table 10. Crop yield: Number and fresh weight of marketable lettuce heads.

Treatments	Rate (lbs. ai/A)	Applic. Interval	Head			Romaine		
			11/21/19			11/22/19		
			1000s/A	tons/A	gm/head	1000s/A	tons/A	gm/head
Dual Magnum	0.17	PRE Trans	36.6	29.6	740	30.0	18.8	569
Dual Magnum	0.33	PRE Trans	36.6	27.7	696	29.4	20.0	620
Dual Magnum	0.5	PRE Trans	32.0	25.6	739	32.7	19.2	536
Kerb	1.9	PRE Trans	33.3	28.7	787	33.4	20.4	557
Dual Magnum + Kerb	0.17 + 1.9	PRE Trans	37.3	30.2	737	30.7	18.5	546
Dual Magnum + Kerb	0.33 + 1.9	PRE Trans	34.0	28.3	762	30.7	17.9	525
Dual Magnum + Kerb	0.5 + 1.9	PRE Trans	34.0	26.3	707	32.7	20.4	562
Weedy Check	---	---	34.7	24.8	649	28.8	17.4	550
Weed-free Check	---	---	34.0	25.5	680	33.3	21.9	595
LSD (P = .05)			5.7	4.5	153	6.1	5.5	127
Treatment Prob (F)			0.6167	0.1861	0.7194	0.6763	0.7942	0.8716

In conclusion, pretransplant treatments of Dual Magnum at 0.17, 0.33 and 0.50 pts./A, either alone or as a tank mix with Kerb at 1.9 pts./A, are safe to apply to head and Romaine lettuce plugs transplanted at the 4th to 5th-leaf stages. The Dual Magnum plus Kerb tank-mix may provide better weed control than Kerb alone in species like sowthistle, but not on others like common purslane where Kerb is quite effective.

2019 Dual Magnum Evaluations on PlantTape™ Transplanted Lettuce

The trial was conducted in a commercial head lettuce field near Chualar, CA. The soil type at the site was Chualar loam. Head lettuce was planted with PlantTape™ July 1, 2019. The Plant Tape plants were 18 days old and had 2.5 leaves. Herbicide treatments were applied the day prior to transplanting on June 30. Materials were applied with a CO₂ backpack sprayer using a one-nozzle wand with an 8008EVS tip applying the equivalent of 41 gallons of water per acre. Plots were one-half of an 80-inch bed wide (3.33 ft.) by 15 feet long and randomized in a complete block design with four replications. The field was sprinkler irrigated for the whole growth cycle. Weed counts and phytotoxicity ratings were made on July 10 and 15 of 2019. Harvest evaluations were conducted on August 22, by harvesting and weighing 10 untrimmed plants from each plot.

Results: There was slight phytotoxicity in some Dual Magnum treatments on the July 10 evaluation date (Table 11). There is a trend indicating improved weed control with Dual Magnum at the 0.51 and 0.67 pint/A rates over the use of Kerb alone; however, there was noticeable phytotoxicity at the 0.51 and 0.67 pint/A Dual Magnum treatments on the July 15 and August 1 evaluation dates. The combination of 0.33 pint of Dual Magnum with 1.9 pint of Kerb had better weed control than Dual Magnum alone (Table 12). No difference in yield was observed between the treatments in this trial. In summary, Dual Magnum at lower rates (0.16 and 0.33 pint/A) in combination with Kerb at 1.9 pint/A had good safety and better weed control than Kerb by itself. The higher rates used in this trial (0.51 and 0.67 pint/A) had measurable phytotoxicity on this soil type, but no reduction in yield was measured.



Figure 1. A. Dual Magnum 0.51 pt./A stunting purslane, B. non-treated purslane, C. Dual Magnum stunting lettuce, and D. nontreated lettuce for comparison.

Table 11. Dual Magnum alone and in combination with Kerb: crop injury estimates and lettuce head weights at harvest.

Treatment	Rate Pt/A	Crop injury estimates			Head weight	
		0= safe; 10= dead				Lbs./ head
		July 10	July 15	August 1	August 22	
Dual Magnum	0.16	0.3	0.0	0.0	1.53	
Dual Magnum	0.33	0.0	0.0	0.0	1.49	
Dual Magnum	0.51	0.0	0.3	0.5	1.50	
Dual Magnum	0.67	0.5	1.3	1.3	1.46	
Dual Mag.+Kerb	0.16 +1.9	0.3	0.0	0.0	1.55	
Dual Mag.+Kerb	0.33+1.9	0.3	0.0	0.0	1.48	
Dual Mag.+Kerb	0.51+1.9	0.8	1.0	0.5	1.56	
Dual Mag.+Kerb	0.67+1.9	0.0	1.3	1.0	1.67	
Kerb	1.9	0.0	0.0	0.0	1.56	
Untreated	---	0.0	0.0	0.0	1.47	
LSD _{0.05}		ns	0.4	ns	ns	
Pr>F treat		0.3123	0.0000	0.1325	0.9090	

Table 12. Dual Magnum alone and in combination with Kerb: weed counts (No./acre) on two dates.

Treatment	Rate Pt/A	Shepherd's-purse		Purslane		Total weeds	
		July 10	July 15	July 10	July 15	July 10	July 15
		----- number 1,000 /A-----					
Dual Magnum	0.16	67	86	16	28	90	117
Dual Magnum	0.33	82	90	5	20	90	114
Dual Magnum	0.51	8	28	16	16	23	44
Dual Magnum	0.67	1	5	12	0	23	5
Dual Mag.+Kerb	0.16 +1.9	46	59	12	44	59	10
Dual Mag.+Kerb	0.33+1.9	39	51	20	20	59	70
Dual Mag.+Kerb	0.51+1.9	39	44	23	8	62	51
Dual Mag.+Kerb	0.67+1.9	28	8	5	0	31	8
Kerb	1.9	93	16	23	36	117	194
Untreated	---	1719	24	16	31	187	272
LSD _{0.05}		65,340	90	ns	30	78	107
Pr>F treat		0.0008	0.0003	0.8082	0.064	0.051	0.0002

Optimize weed management practices for direct-seeded lettuce in combination with full-season drip irrigation

Work was conducted to compare Kerb and Dual Magnum applied by chemigation through surface and buried drip tapes. Kerb was applied at 2.5 and 5 pts./A through surface and buried drip tapes in the second irrigation. Dual Magnum was applied at 0.33 and 0.5 pts./A through surface and buried drip tapes 14 days after seeding (Table 13). Sequential treatments of Kerb at 2.5 pts./A followed by Dual Magnum at 0.33 pts./A through surface and buried drip tapes were also evaluated. The standard was spray applied Kerb at 2.5 and 5 pts./A over plots irrigated by buried drip tape. Two nontreated controls were included, with irrigation applied through surface and buried drip tapes. Sprinkler irrigation was not used in this trial at any time. The trial was arranged in a randomized complete block with four replicates. Data collected were weed control, crop injury estimates and yield (Table 13). Data were subjected to analysis of variance and mean separation was performed using Fisher's LSD.

Table 13. Critical trial events and dates

Critical Event	Date / Information
Crop:	Romaine Lettuce
Planting Date:	6/10/19
Emergence Date:	6/17/19
Cultivar:	Abilene
Application Intervals:	
Pre-Emergence Spray	6/12/19
Drip Injection at 2 nd Irrigation	6/14/19
Drip Injection at 14 Days Post Plant	6/26/19
Weed Counts:	7/1/19
Crop Injury:	7/1/19 (14-DPE) 7/15/19 (28-DPE) 7/29/19 (42-DPE)
Yield (Fresh Weight):	8/14/19 (58-DPE)

DPE = Days Post Emergence

The only treatments which controlled weeds were the surface spray applied Kerb treatments. The drip applied treatments provided poor weed control, we assume, because the Kerb was not on the entire bed surface where it is needed to control germinating weeds (Table 14). No injury was observed in this trial (Table 15), and generally, the yields were higher in the buried drip treatments than in the surface treatments (Table 16).

Table 14. Weed densities 3 weeks after planting.

Treatment	Rate (pt/A)	Timing	Applic Method	Drip Tape Location	Weed Density (No./1,000/A)		
					Common Purslane	Little Mallow	Total Weeds
Kerb	2.5	At 2 nd Irrig	Drip Inject	Buried	1,190 bcd	86 cd	1,391 bcd
Kerb	2.5	At 2 nd Irrig	Drip Inject	Surface	1,049 cd	126 bc	1,268 cd
Kerb	5.0	At 2 nd Irrig	Drip Inject	Buried	1,056 cd	110 bcd	1,308 bcd
Kerb	5.0	At 2 nd Irrig	Drip Inject	Surface	899 d	118 bcd	1,098 d
Dual Magnum	0.33	14-DPP	Drip Inject	Buried	1,405 abc	134 bc	1,711 abc
Dual Magnum	0.33	14-DPP	Drip Inject	Surface	1,718 a	123 bc	1,982 a
Dual Magnum	0.5	14-DPP	Drip Inject	Buried	1,134 cd	124 bc	1,397 bcd
Dual Magnum	0.5	14-DPP	Drip Inject	Surface	1,573 ab	201 a	1,882 a
Kerb f.b. Dual Magnum	2.5 0.33	At 2 nd Irrig 14-DPP	Drip Inject	Buried	1,044 cd	90 cd	1,235 d
Kerb f.b. Dual Magnum	2.5 0.33	At 2 nd Irrig 14-DPP					
Kerb f.b. Dual Magnum	2.5 0.33	At 2 nd Irrig 14-DPP	Drip Inject	Surface	887 d	129 bc	1,161 d
Kerb f.b. Dual Magnum	2.5 0.33	At 2 nd Irrig 14-DPP					
NonTreated	0	---	---	Buried	1,684 a	160 ab	1,954 a
NonTreated	0	---	---	Surface	1,431 abc	101 bcd	1,756 ab
Kerb	2.5	At Planting	Surf Spray	Buried	77 e	56 d	257 e
Kerb	5.0	At Planting	Surf Spray	Buried	17 e	79 cd	163 e
LSD (P = .05)					439	65	471
Treatment Prob (F)					0.0001	0.0168	0.0001

Table 15. Romaine lettuce crop injury (0 =no injury, ≤2=safe, 10=dead)

Treatment	Rate (pt/A)	Timing	Applic Method	Drip Tape Location	Crop injury (0-10)		
					7/1/19 14-DPE	7/15/19 28-DPE	7/29/19 42-DPE
Kerb	2.5	At 2 nd Irrig	Drip Inject	Buried	0	0	0
Kerb	2.5	At 2 nd Irrig	Drip Inject	Surface	0	0	0
Kerb	5.0	At 2 nd Irrig	Drip Inject	Buried	0	0	0
Kerb	5.0	At 2 nd Irrig	Drip Inject	Surface	0	0	0
Dual Magnum	0.33	14-DPP	Drip Inject	Buried	0	0	0
Dual Magnum	0.33	14-DPP	Drip Inject	Surface	0	0	0
Dual Magnum	0.5	14-DPP	Drip Inject	Buried	0	0	0
Dual Magnum	0.5	14-DPP	Drip Inject	Surface	0	0	0
Kerb f.b. Dual Magnum	2.5	At 2 nd Irrig	Drip Inject	Buried	0	0	0
	0.33	14-DPP					
Kerb f.b. Dual Magnum	2.5	At 2 nd Irrig	Drip Inject	Surface	0	0	0
	0.33	14-DPP					
NonTreated	0	---	---	Buried	0	0	0
NonTreated	0	---	---	Surface	0	0	0
Kerb	2.5	At Planting	Surf Spray	Buried	0	0	0
Kerb	5.0	At Planting	Surf Spray	Buried	0	0	0
LSD (P = .05)					0.0	0.0	0.0
Treatment Prob (F)					1.000	1.000	1.000

Table 16. Romaine lettuce crop yield (stand, fresh weight/tonnage and size) at harvest.

Treatment	Rate (pt/A)	Timing	Applic Method	Drip Tape Location	Stand	Fresh Weight	Tonnage	Size
					(no./7' bed)	(kg/7' bed)	(tons/A)	(g/plant)
Kerb	2.5	At 2 nd Irrig	Drip Inject	Buried	16.8 a-d	13.0 abc	26.8 abc	778 bc
Kerb	2.5	At 2 nd Irrig	Drip Inject	Surface	15.0 de	11.1 d	22.9 d	738 bcd
Kerb	5.0	At 2 nd Irrig	Drip Inject	Buried	16.3 b-e	14.7 a	30.3 a	902 a
Kerb	5.0	At 2 nd Irrig	Drip Inject	Surface	16.8 a-d	11.8 bcd	24.2 bcd	708 cd
Dual Magnum	0.33	14-DPP	Drip Inject	Buried	17.3 abc	13.3 ab	27.5 ab	771 bcd
Dual Magnum	0.33	14-DPP	Drip Inject	Surface	16.5 a-e	12.0 bcd	24.7 bcd	728 bcd
Dual Magnum	0.5	14-DPP	Drip Inject	Buried	16.3 b-e	11.9 bcd	24.5 bcd	733 bcd
Dual Magnum	0.5	14-DPP	Drip Inject	Surface	16.0 cde	11.4 cd	23.5 cd	715 cd
Kerb f.b. Dual Magnum	2.5	At 2 nd Irrig	Drip Inject	Buried	16.0 cde	12.1 bcd	24.9 bcd	756 bcd
	0.33	14-DPP						
Kerb f.b. Dual Magnum	2.5	At 2 nd Irrig	Drip Inject	Surface	15.3 de	10.5 d	21.5 d	686 cd
	0.33	14-DPP						
NonTreated	0	---	---	Buried	14.8 e	11.1 d	22.7 d	749 bcd
NonTreated	0	---	---	Surface	18.0 ab	12.3 bcd	25.2 bcd	681 d
Kerb	2.5	At Planting	Surf Spray	Buried	18.3 a	14.7 a	30.2 a	817 ab
Kerb	5.0	At Planting	Surf Spray	Buried	17.3 abc	14.2 a	29.1 a	817 ab
LSD (P = .05)					2.0	1.9	3.9	95.3
Treatment Prob (F)					0.0224	0.0002	0.0002	0.0027