

## Weed Management in Strawberries 2020 and 2021



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## SUMMARY

Devrinol® (napropamide), Dual Magnum® (S-metolachlor) and Matrix® (rimsulfuron) were evaluated as potential drip applied herbicides for in-season applications under the mulch film to control hard-to-reach weeds. Outlook® (dimethenamid-P) was evaluated as a pretransplant application in strawberry. Devrinol and Dual Magnum were safe to strawberry applied by drip chemigation and did not reduce yields. Unfortunately, the weed population was light in these studies, and it is hard to determine if they add much weed control benefit. Rimsulfuron and dimethenamid-P tended to be injurious to strawberry and no further work is recommended with these products. Dual Magnum has promise as a strawberry herbicide, the crop is tolerant and the weed control good especially when applied before transplanting.

Cereal rye is well suited to the climate in California strawberry production regions. Planted in the furrows it grows rapidly so that it slows potential for soil erosion in sloping fields. Other benefits include weed suppression. A study was conducted at Cal Poly to evaluate the benefits of rye in preventing soil erosion and suppressing weeds. Due to the dry winter little benefit was observed in terms of preventing soil erosion.

## INTRODUCTION

The transition from methyl bromide (MB) to alternative fumigants requires innovative weed management strategies for California strawberries. Alternative fumigants are less effective on weeds than MB, while labor costs for hand-weeding continue to increase. The use of herbicides to supplement fumigants is a viable strategy to contain or reduce hand-weeding costs for California strawberries. Objectives of the work presented here were to evaluate the tolerance of strawberry and weed control efficacy from several herbicide treatments: (1) Evaluate pre-transplant spray and post-transplant drip-injection applications of napropamide and S-metolachlor for weed control and strawberry tolerance. (2) Evaluate pre-transplant spray and post-transplant drip-injection herbicide applications for yellow nutsedge (*Cyperus esculentus* L.) control and crop tolerance in strawberries at Salinas, CA. (3) Evaluation of furrow-planted cereal rye to reduce soil erosion in strawberry production. The long-term objective of this project is to contain or reduce weed control costs for California strawberry producers.

**Objective 1. Evaluate pre-transplant spray and post-transplant drip-injection applications of napropamide and S-metolachlor for weed control and strawberry tolerance.**

## METHODS

The trial was conducted at the USDA-ARS Spence Research facility near Salinas, CA. Herbicides evaluated were napropamide (Devrinol 50DF) at 2.0 and 4.0 lb. ai/A, S-metolachlor (Dual Magnum 7.63EC) at 0.33 lb. ai/A, rimsulfuron (Matrix 25SG) at 0.0156 and 0.0313 lb. ai/A, and flumioxazin (Chateau 51WDG) at 0.1 lb. ai/A. The trial design was a randomized complete block with four replications. Each replicate was a single, 48-inch-wide strawberry bed by 30 ft. long. A no-herbicide control was included in the trial. Napropamide, S-metolachlor, rimsulfuron and flumioxazin were applied pre-transplant (PRE) on October 3, 2019, to the bed-top soil. Treatments were applied in 40 GPA using a CO<sub>2</sub> backpack sprayer, with two TeeJet® VS 8002 nozzles centered over the bed. Mulch film was installed October 5, 2019, and then fumigated with drip applied Triform 80 at 233 lb./A October 17, 2019. 'Cabrillo' was transplanted November 13, 2019, at 41 days after PRE-herbicide applications. Napropamide, S-metolachlor and rimsulfuron treatments were injected through the drip irrigation system on December 11-12, 2019, at 28-29 days Post-transplant (POST).

Weed densities and weed biomass were assessed on January 30, March 5, and April 9, 2020. Crop injury estimates were made January 14, February 27, and April 14, 2020. Crop stand counts were made January 14, February 27, and April 14, 2020. Plant canopy diameters were measured on February 12 and April 23, 2020. From these data, plant canopy perimeters were calculated. Strawberry fruit was harvested 1-2 times per week from April 27 through September 4, 2020. Strawberry yields were recorded at each harvest date, and cumulative season totals calculated. All data were subjected to analysis of variance in Agricultural Research Manager (ARM), and mean separation was performed using LSD ( $P=0.05$ ).

## RESULTS

Crop injury and Weed Control.

Rimsulfuron applied POST caused slight (9 to 18%) injury to strawberry. Rimsulfuron applied PRE caused moderate to severe (28 to 49%) strawberry injury. Symptoms were stunting and slight yellowing of foliar canopy. Napropamide applied PRE or POST resulted in <20% injury to strawberry. Symptoms were slight stunting of foliar canopy (Table 1). S-metolachlor caused very little crop injury whether applied PRE or POST.

The most common weed in the trial was Lesser swine-cress (*Lepidium didymum* L.). Due to low, patchy weed pressure none of the herbicide treatments reduced lesser swine-cress or total weed densities relative to the non-treated control.

**Table 1.** Crop injury estimates and weed densities.

Treatments	Rate	Timing	Crop injury (%)			Total
	lbs. ai/A)		1/14/20	2/27/20	4/14/20	No.
Non-Treated	0	---	0 f	0 e	0 e	472
Napropamide	2.0	POST	3 ef	4 e	5 de	363
Napropamide	4.0	POST	8 de	9 cde	8 cde	545
S-metolachlor	0.33	POST	3 ef	1 e	1 e	182
Rimsulfuron	0.01	POST	10 cd	16 cd	9 cde	363
Rimsulfuron	0.03	POST	15 c	18 c	18 bc	182
Napropamide	2.0	PRE	1 ef	4 e	3 e	109
Napropamide	4.0	PRE	14 cd	18 c	15 cd	182
S-metolachlor	0.33	PRE	0 f	6 de	1 e	0
Rimsulfuron	0.01	PRE	35 b	31 b	28 ab	290
Rimsulfuron	0.03	PRE	44 a	49 a	36 a	290
Flumioxazin	0.1	PRE	0 f	1 e	0 e	0
LSD (P = .05)			7.1	10.2	10.1	476
Prob (F)			0.0001	0.0001	0.0001	0.4200

Canopy perimeters and fruit yield: Napropamide at 4.0 and rimsulfuron at 0.0156 and 0.0313 lb. ai/A applied PRE reduced crop canopy perimeters below those of the non-treated control (Table 2).

None of the herbicide treatments reduced fruit yield compared to the non-treated control (Table 2).

**Table 2.** Crop foliage perimeters and fruit yield.

Treatments	Rate Lb. ai/A	Timing	Perimeters (inches)		Fruit yield	
			2/12/20	4/23/20	Kg/pla	Tons/A
Non-Treated	0	---	19.5 ab	39.0	1.53	26.4
Napropamide	2.0	POST	20.8 a	37.6	1.46	25.7
Napropamide	4.0	POST	18.8 ab	37.1	1.50	25.6
S-metolachlor	0.33	POST	18.3 ab	35.8	1.49	27.8
Rimsulfuron	0.01	POST	19.3 ab	36.6	1.41	24.5
Rimsulfuron	0.03	POST	19.2 ab	34.9	1.44	25.1
Napropamide	2.0	PRE	19.2 ab	41.9	1.53	27.9
Napropamide	4.0	PRE	13.8 c	35.1	1.40	23.8
S-metolachlor	0.33	PRE	19.1 ab	40.8	1.53	26.3
Rimsulfuron	0.01	PRE	14.5 c	37.4	1.42	25.3
Rimsulfuron	0.03	PRE	12.5 c	32.9	1.36	23.3
Flumioxazin	0.1	PRE	17.6 b	35.7	1.50	26.5
LSD (P = .05)			2.4	5.2	0.22	3.61
Prob (F)			0.0001	0.0553	0.8566	0.2698

## CONCLUSIONS

Napropamide applied at 4.0 lb. ai/A as a pre-transplant spray causes early season stunting of strawberry plant canopy; however, the plants outgrow this injury. Napropamide appears to be safe on strawberry plants where applied as either a pre-transplant spray or a post-transplant dripline injection.

Rimsulfuron applied at 0.0156 and 0.0313 lb. ai/A as a pre-transplant spray is moderately injurious to early season strawberry plants and causes early season stunting of strawberry plant canopy. The plants outgrow the foliar yellowing and remain slightly stunted as the season progresses; yet this damage does not reduce fruit yields. Rimsulfuron is probably not a good option for strawberry due to potential for injury.

**Objective 2. Evaluate pre-transplant spray and post-transplant drip-injection herbicide applications for nutsedge control and crop tolerance in strawberries.**

## METHODS

The trial was conducted at the USDA-ARS Spence Research facility near Salinas, CA. Herbicides evaluated were napropamide at 2.0 and 4.0 lb. ai/A, S-metolachlor at 0.33 and 0.5 lb. ai/A, rimsulfuron at 0.0156 and 0.0313 lb. ai/A, dimethenamid-P at 0.56 and 0.84 lb. ai/A and flumioxazin at 0.1 lb. ai/A. The low rates of napropamide and dimethenamid-P were each applied in a tank mix with the low rate of S-metolachlor. The low rate of rimsulfuron was applied through the drip line following the spray application of the low rate of S-metolachlor. The trial design was a randomized complete block with four replications. Each replicate plot was a single, 48-inch-wide strawberry bed by 30 ft. long. A non-treated control was included.

Sachets containing live yellow nutsedge nutlets were buried at 1-to-2-inch depth in bed tops (middle & shoulder) of each replicate on October 3, 2019, prior to herbicide spray treatments and plot tarping.

Napropamide, S-metolachlor, dimethenamid-P and flumioxazin were applied PRE on October 4, 2019, to the bed-top. The treatments were applied in 40 GPA using a CO<sub>2</sub> backpack sprayer, with two TeeJet EVS 8002 nozzles centered over the bed. Mulch film was installed on October 5, 2019, and the trial was fumigated with drip applied Triform 80 at 233 lb./A on October 17, 2019. 'Cabrillo' was transplanted November 13, 2019, at 41 days after PRE application of herbicide spray treatments. Rimsulfuron was injected through the drip irrigation system on December 11, 2019, 28 days POST.

Weed densities and fresh weights per 120 ft<sup>2</sup> were measured on January 31, March 5, and April 9, 2020. Nutsedge tuber mortality was assessed following removal of the sachets on January 8, potting the nutlets in sand on January 9 - 15, and counting living/emerged nutsedge plants on February 12 - 14, 2020. Crop injury estimates were made January 14, February 28, and April 14, 2020. Plant canopy diameters were measured on February 13 and April 16, 2020. From these data, plant canopy perimeters were calculated. Strawberry fruit was harvested one to two times per week from April 27 through September 4, 2020. Strawberry yields were recorded at each harvest date, and cumulative season totals calculated. All data were subjected to analysis of variance in ARM, and mean separation was performed using LSD (P=0.05).

## RESULTS

### Crop injury and Weed Control

Dimethenamid-P applied PRE at 0.56 lb. ai/A alone and with S-metolachlor at 0.33 lb. ai/A caused slight to moderate (11 to 29%) strawberry injury by late February; with plants outgrowing symptoms by start of harvest. Dimethenamid-P applied PRE at 0.84 lb. ai/A caused moderate (31 to 43%) injury to strawberry from which the crop did not recover (Table 3). Primary symptoms were stunting and slight yellowing of foliar canopy.

Napropamide applied PRE at 4.0 lb. ai/A caused slight (20%) injury to strawberry in the early season; with plants outgrowing symptoms by start of harvest (Table 3). Symptoms were slight stunting of canopy.

The weeds present in the trial were Lesser swine-cress (*Lepidium didymum* L.), willow herb (*Epilobium* spp.) and common groundsel (*Senecio vulgaris* L.). Due to very low weed pressure and highly variable population dispersal within the trial, none of the herbicide treatments significantly reduced numbers and biomass of individual species or total weeds relative to the non-treated control. None of the herbicide treatments significantly increased nutsedge nutlet mortality relative to the non-treated control (Table 3).

**Table 3.** Crop injury estimates, weed densities and nutsedge viability.

Treatments	Rate (lb. ai/A)	Timing	Crop Injury 1			Weeds	Nutsedge
			1/14/20	2/28/20	4/14/20	1,000/A	Viable %
			% injury			1,000/A	Viable %
Non-Treated	0	---	0 f	0 f	0 f	290	97
Rimsulfuron	0.015	POST	11 cd	10 cde	9 cde	545	100
Rimsulfuron	0.031	POST	14 c	13 cd	18 b	182	100
S-metolachlor f.b. Rimsulfuron	0.33 0.015 6	PRE POST Drip	11 cd	6 def	10 bcd	0	100
S-metolachlor + Napropamide	0.33 + 2.0	PRE	11 cd	11 cde	4 def	109	100
S-metolachlor + Dimethenamid-P	0.33 + 0.56	PRE	20 b	28 b	15 bc	106	100
Napropamide	2.0	PRE	11 cd	11 cde	1 ef	363	100
Napropamide	4.0	PRE	20 b	16 c	8 c-f	182	100
S-metolachlor	0.33	PRE	1 ef	3 ef	1 ef	182	95
S-metolachlor	0.5	PRE	9 cd	9 c-f	6 def	0	95
Dimethenamid-P	0.56	PRE	20 b	29 b	11 bcd	182	100
Dimethenamid-P	0.84	PRE	31 a	43 a	31 a	0	98
Flumioxazin	0.1	PRE	6 de	13 cd	11 bcd	182	100
LSD (P = .05)			6.2	9.8	7.9	366.6	5.6
Prob (F)			0.0001	0.0001	0.0001	0.1833	0.4236



**Table 4.** Strawberry perimeters and fruit yields.

Treatments	Rate (lb. ai/A)	Timing	Perimeters (inches)		Fruit yield	
			2/13/20	4/16/20	Kg/plant	Tons/A
Non-Treated	0	---	20.9 ab	39.9 a	1.62	28.7
Rimsulfuron	0.0156	POST Drip	19.3 abc	36.4 cd	1.42	25.1
Rimsulfuron	0.0313	POST Drip	19.0 abc	35.3 d	1.50	26.0
S-metolachlor f.b. Rimsulfuron	0.33 0.0156	PRE Spray POST Drip	18.4 cd	35.4 d	1.50	26.5
S-metolachlor +Napropamide	0.33 + 2.0	PRE Spray	18.8 bc	38.8 abc	1.59	28.3
S-metolachlor +Dimethenamid-P	0.33 + 0.56	PRE Spray	16.6 de	35.7 cd	1.51	26.9
Napropamide	2.0	PRE Spray	18.8 c	39.6 ab	1.60	28.5
Napropamide	4.0	PRE Spray	16.5 de	35.6 d	1.55	28.1
S-metolachlor	0.33	PRE Spray	21.0 a	40.4 a	1.56	28.0
S-metolachlor	0.5	PRE Spray	18.1 cde	36.5 bcd	1.61	28.4
Dimethenamid-P	0.56	PRE Spray	16.1 ef	35.9 cd	1.58	27.2
Dimethenamid-P	0.84	PRE Spray	14.2 f	35.8 cd	1.56	27.1
Flumioxazin	0.1	PRE Spray	17.8 cde	36.2 cd	1.64	28.6
LSD (P = .05)			2.1	3.2	0.18	3.21
Prob (F)			0.0001	0.0068	0.5390	0.4626

Crop canopy perimeters and yields. The following treatments reduced crop canopy perimeters below that of the non-treated control: rimsulfuron at 0.0156 and 0.0313 lb. ai/A; S-metolachlor PRE at 0.33 followed by rimsulfuron POST drip at 0.0156 lb. ai/A; S-metolachlor at 0.33 + dimethenamid-P at 0.56 PRE spray; napropamide PRE at 4.0; S-metolachlor PRE at 0.33 and 0.5 lb. ai/A; dimethenamid-P PRE at 0.56 and 0.84; and flumioxazin PRE at 0.01 lb. ai/A.

None of the herbicide treatments reduced fruit yields relative to the non-treated control (Table 4).

## CONCLUSIONS

Rimsulfuron applied alone at 0.0156 and 0.0313 lb. ai/A as a post-transplant drip injection or following a S-metolachlor at 0.33 lb. ai/A PRE spray, is injurious to strawberry plants and causes early season stunting of strawberry plant canopy. No more work on rimsulfuron is recommended in strawberry.

Napropamide applied at 4.0 lb. ai/A as a pre-transplant spray causes minor, early season yellowing and stunting of strawberry plant canopy; however, the plants outgrow this injury, and the damage does not reduce crop stands or fruit yields. Napropamide appears to be safe on strawberry plants when applied as a pretransplant bed-top spray.

S-metolachlor applied at 0.5 lb. ai/A PRE is moderately injurious to early season strawberry plants; however, the plants outgrow this injury, and the damage does not reduce crop stands or fruit yields. S-metolachlor appears to be safe on strawberry plants when applied as a pretransplant bed-top spray.

Dimethenamid-P applied as a pre-transplant spray alone at 0.56 and 0.84 ai/A, or tank mixed with S-metolachlor at 0.33 lb. ai/A, is moderately injurious to early season strawberry plants and causes moderate early season stunting of strawberry plant canopy. No more work on dimethenamid-P is recommended in strawberry.

### Objective 3. Evaluation of furrow-planted cereal rye to reduce soil erosion in strawberry production.

## METHODS

The trial was conducted in field 35b at the Cal Poly State University campus in San Luis Obispo, CA (35°18'20.36" N 120°40'22.19" W). 'Merced' cereal rye seed was planted in the furrows (100 lb./A) of 135 linear ft strawberry beds (64 inches between bed centers, with a 12-in wide furrow). Of the 135 linear ft of bed, the upper 115 ft was sloped at 10% and 20 ft at the bottom was close to level. Cereal rye seed was broadcast into the furrows on November 7, 2019 and replicated three times. Each replicate consisted of 135 linear feet of furrow. Overhead sprinklers were used to irrigate the rye from November 7 through January 15, 2020. Foot-long rulers were placed into the furrows at a depth of 4 in to measure soil erosion or accumulation. Rulers were placed at four locations along the furrow: top (5 ft), middle (60 ft), bottom (115 ft) and end (135 ft). Two soil erosion measurements were taken: one on December 17 after 4.0 inches of rain was recorded between November 27 and December 8 and a second measurement on January 8, 2020, after 1.9 inches of rain was recorded between December 17 and 30, 2019. Weed densities were recorded monthly by randomly choosing four 9 × 9 in. areas and identifying weed species and their frequency in each furrow.

Three herbicide applications were made to kill cereal rye once it reached a height 26 inches. The first application was made on January 21 consisting of clethodim (Select Max) 16 fl oz/A, plus Kinetic (0.25% v/v) in 100 gal/A. The second application was made on February 11 using the same herbicides and rates but reducing the carrier volume to 45 gal/A. The last application was made on February 25 using Paraquat (1.3 pt./A) plus Kinetic (0.25% v/v) at 45 gal/A. Applications were made using a compressed CO<sub>2</sub> handheld backpack sprayer at 45 PSI with a single flat fan nozzle (DG8002VS yellow) (TeeJet Technologies, Clovis, CA). Data was subjected to t-test mean separation analysis.



## RESULTS AND DISCUSSION

Rainfall during the trial period (November 7 to January 8) was 5.69 and 13.3 inches for the year. This is below the average annual rainfall of 19 inches. Rain events were light and did not cause much erosion (Table 5). There was no significant difference in the amount of soil erosion between the rye-planted furrows and non-planted furrows. A year with higher rainfall is needed to adequately evaluate the effect on erosion.

Weeds identified within the trial were malva, stinging nettle, lambsquarters, prostrate knotweed, and common groundsel. No significant differences were recorded in the number of weeds in each treatment. Clethodim did not kill the cereal rye after the first two applications and a third application of Paraquat was needed to kill the cereal rye. At 26-inch height, the cereal rye may be too tolerant of clethodim. Future studies should investigate the susceptibility of cereal rye to clethodim at various growth stages. No phytotoxicity was recorded on the strawberry plants.

**Table 5.** Soil erosion and weed density measurements.

Treatment	Furrow height change (cm)				Number of weeds
	Top of slopes	Middle of slope	Bottom of slope	End of furrow	8 Jan
Control	0.2 a	-0.1 a	4.6 a	1.4 a	6.5 a
'Merced' cereal rye	0.2 a	0.2 a	1.9 a	1.5 a	2.9 a

z Numbers within a column followed by the same letter are not significantly different ( $\alpha=0.05$ ) per t-test simultaneous comparison calculated using ARM version 2020.0 (Gylling Data Management, Brookings, SD).