CWSS Research Update and News

Information on Weeds and Weed Control from the California Weed Science Society

Volume 18, Number 1

In This Issue

CWSS—Research Update and News—July, 2026

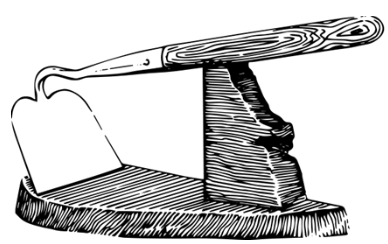
Message from the Editor

CWSS Members,

I hope everyone's summer has been going well and that the weed control efforts have been effective with the most up-to-date management programs.

This issue contains research from around the state that covers multiple systems, including weed management in melon crop with herbicide programs and mechanical finger weeders; nutsedge management in cilantro; the dynamics of ditch vegetation, pest, and natural enemy communities; herbicide application programs for dryland perennial grasses; and preemergence herbicide programs for weed management in citrus crop systems.

Currently, the CWSS Board and Conference Session Chairs are planning our next CWSS annual meeting, which will be held at the Portola Hotel & Spa at Monterey Bay, January 20-22, 2027.



Thank you,

Clebson Gonçalves

CWSS Director - Non-Conference Education

Controlling In-row Weeds with Post Plant Applications of Pre-emergent Herbicides

Scott Stoddard
UCCE Merced County

Introduction:

Preemergent herbicides can be an important component of a weed management program in melon production in California. They work by inhibiting weed germination and thus can greatly reduce potential weed problems before they appear. Effectiveness is usually improved when they are incorporated, either by tillage or with sprinklers, into the upper 2" of soil. Incorporation before planting is both efficient and effective, but often the movement of soil during planting/transplanting moves the soil and herbicides, resulting in little weed control in the plant row. The result is that hand weeding is often still required. Furthermore, preemergent herbicides are more effective on transplanted melons, as the same mode of action that suppresses weed germination can also reduce crop germination. Both ethalfluralin (Curbit) and pendimethalin (Prowl), for example, are labeled for use in melons but only can be applied after crop emergence.

Hand weeding or robotic cultivators can be used to control weeds in the plant row. However, another alternative is the finger weeder, a simple mechanical cultivator capable of removing weeds from the plant row. The system uses interlocking rubber fingers to remove small weeds in the plant row once transplants are established, or direct seeded plants that have an established root system. Unfortunately, finger weeders are effective only if the weeds are very small, which limits their use to a very short period during the cropping season. However, finger weeders should be able to safely incorporate preemergent herbicides back into the plant row, which would greatly expand the amount of time they could be used. Finger weeders have the added benefit of being simple, reliable, and inexpensive as compared to the robotic cultivators currently available.

Objectives:

1. Evaluate weed control, time, and costs associated using finger weeders to incorporate preemergent herbicides as part of a conventional weed management program in direct-seeded melons at the UC Westside Research and Extension field station (WSREC).

2. Evaluate pre and post herbicide programs in comparison to mechanical finger weeders.

Methods:

Trials were conducted in 2024 and 2025 at the UC Westside Research and Extension Center (WSREC), near Five Points in Fresno County. The objective was to evaluate weed control, crop safety, and costs associated with using a finger weeder to incorporate pre-emergent herbicides within the plant row after planting as part of a conventional weed management program. Herbicide treatments were bensulide (Prefar) 6 qts/A pre plant incorporated (PPI), halosulfuron (Sandea) 1 oz/A 14 days POST, ethalfluralin (Curbit) at 4 pts/A 14 days POST, metolachlor (Dual Magnum) at 1.5 pints/A POST, pendimethalin (Prowl) 1.5 pints/A POST, trifluralin (Treflan) at 1.5 pints/A POST, and Prefar 6 qts/A applied POST. Prefar was applied before weeds and planting to all treatments except for an untreated control. Prefar was also applied post-plant to evaluate if timing improved weed control for this herbicide. An untreated control and finger weeder cultivation treatments were included for comparison.

Prefar (bensulide) at 6 qts/A was applied to select plots on preformed beds using a tractor mounted spray boom with TeeJet 8002 nozzles and 25 gpa water volume, then incorporated to 3" using a power rotary cultivator. Melon cultivar 'Infinite Gold' was transplanted on May 21, 2024, using cone mechanical transplanters on 18" spacing, or direct seeded 3 days later, on June 23, 2025, on a 12" spacing. After planting, the field was sprinkle irrigated one time, then irrigated via subsurface drip irrigation for the remainder of the season. The trial was cultivated using the finger weeder using the 14" fingers at 3.5 mph. Immediately prior to cultivation, applications of Sandea, Curbit, Dual Magnum, Prowl, Treflan, and Prefar were made as a band application on either side of the plant row to minimize contact with foliage (band width of about 2 feet, or 30% of broadcast). Herbicides were applied with a CO2 backpack sprayer at 38 psi with a single Tee Jet 8002 flat fan nozzle. Melons were about 4 – 6 true leaves when treatments were applied (Figure 1).

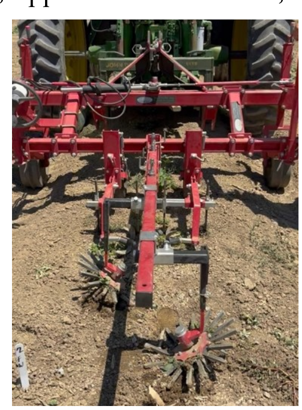


Figure 1. *Finger weeder setup for melons, July 2025.*

Plot size for the herbicide treatments was 1 bed (80") by 75 ft; the cultivation treatments were 1 bed by 300 feet. The experimental design was a RCB split block with 4 replications, with main plots the herbicide treatments and split plots the finger weeder cultivation treatment. Therefore, herbicide treatments could be compared with and without incorporation.

All plots were cultivated to remove weeds outside of the herbicide band on shoulders and furrows. Imidacloprid was injected after crop emergence for aphid control, and the field was sprayed once with Safina (afidopryopen) and bifenthrin for whiteflies and stinkbugs. Nitrogen fertilizer was injected through the drip tape during the season to supply about 100 lbs N/A.

Weed pressure was dominated by a mix of broadleaf annual weeds, but in both years annual morning glory and volunteer melons were especially bad at this location. Other weeds included field bindweed, pigweed, purslane, and nightshade. There were very few grasses at this location, and no grass herbicides were applied. All plots were hand weeded approximately 6 weeks after treatment and weeding times recorded. Weed ratings were limited to the center 2 ft of the bed. Ratings were based on a subjective scale using a 0 – 10 system, where 0 = no weeds and 10 = 100% weed cover in the treated area of the plot.

Yield estimates were made by counting the number of melons within each plot within the standard sizes of 18, 15, 12, 9, 6, and Jumbos per box. Two melons from each plot in one rep were tested for soluble sugars using a hand held digital refractometer. Treatment rate and timing information is shown in Table 1.

Table 1. *Herbicide and cultivation treatments.*

No post plant incorporation	**With in-row incorporation (finger weeder)**
1. Untreated control	1. UTC (finger weeder only)
2. Prefar (bensulide) 6 qts/A pre-plant incorporated (PPI) only.	2. Prefar PRE + finger weeder post
3. Prefar 6 qts/A PPI + Sandea 1 oz/A POST 14 days over-the-top	3. Prefar + Sandea POST incorporated
4. Prefar 6 qts/A + Curbit 4 pts/A POST 14 days directed band	4. Prefar + Curbit POST incorporated
5. Prefar 6 qts/A + Dual Magnum 1.5 pints/A POST 14 days directed band	5. Prefar + Dual Magnum POST incorporated
6. Prefar 6 qts/A + Prowl 1.5 pints/A POST 14 days directed band	6. Prefar + Prowl POST incorporated
7. Prefar 6 qts/A + Treflan 1.5 pints/A POST 14 days directed band (2025 only)	7. Prefar + Treflan POST incorporated
8. no pre-plant, Prefar 6 qts/A POST 14 days (2025 only)	8. no pre-plant, Prefar POST incorporated

Results:

In 2024, the finger weeder worked well, significantly reducing weed pressure about half as compared to the untreated control. For example, at 4 weeks after treatment, weed control averaged across all herbicides was 50.7%, but 86.4% when herbicides + the finger weeder was used (Figure 2). Herbicides by themselves also significantly improved weed control on all evaluation dates as compared to the untreated control. When the herbicides were used in conjunction with the finger weeder, weed control was further improved. With the exception of Prefar, all of herbicides worked well when incorporated, with over 90% weed control at 4 weeks after application. Hand weeding times and subsequently hand weeding costs were lowest in the Curbit and Sandea treatments when combined with the finger weeder incorporation.

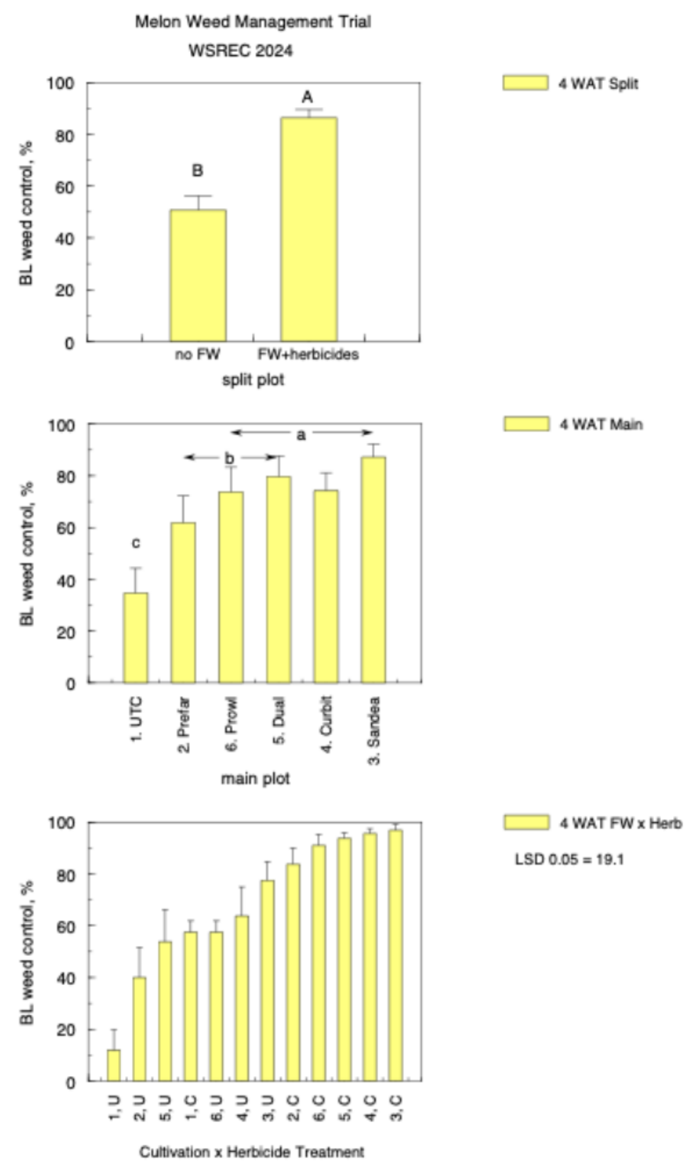


Figure 2. *Weed control as affected by cultivation (top), herbicide (middle), and the cultivation x herbicide interaction, 2024.*

CWSS

While there was only slight and temporally crop damage from the herbicides, the finger weeder caused about a significant 15% stand reduction at this location. However, this did not impact yield. Total marketable yield was 847 boxes per acre in the finger weeder treatments, as compared to 722 boxes/A where it was not used (Table 2). The best yielding treatments were Dual Magnum, Sandea, and Prowl were incorporated with the finger weeder, around 900 boxes/A. Furthermore, the Prefar + Prowl+finger weeder treatment resulted in the least small fruit size (15s and 18s). No differences were observed for fruit Brix, which was 12.2% across all treatments. There was a significant correlation between yield and weed control at the July evaluation date, with improved yield where weeds were controlled (Figure 5). Average yield with 80% or better weed control was about 900 boxes per acre, whereas yield was 650 boxes per acre at 20% weed control, a reduction of 28%.

In 2025, weed control from any treatment combination was marginal, and far less than 2024. This is primarily due to two main reasons: direct seeding and volunteer melons. Finger weeders work well when there is a clear size difference between the crop and emerging weeds. However, with direct seeded melons at this location, weeds were of a similar size and already emerged when the pre-emergent herbicides were applied. Furthermore, the dominant weed at this site was volunteer melons, which were unaffected by the herbicides used.

While the effect of the finger weeder was marginal, in-row cultivation did significantly ($p = 0.05$) reduce broadleaf weeds across all herbicide treatments on the three evaluation dates on July 23, Aug 6, and at harvest reduction in hand weeding time or cost. Cost estimates were highly variable, and ranged from $89.80 to $444 per acre. The use of the finger weeder in the untreated plots dramatically improved weed control, from about 10% to 50%, which is similar to what occurred in 2024. However, there were only slight benefits observed with any herbicide used in conjunction with the finger weeder, and the herbicide x cultivation interaction was not significant on any evaluation date, which implies that the benefit of using the finger weeder worked equally with all herbicides. While the main effect of herbicide ($p = 0.13$) was not significant, nonetheless there were significant differences in herbicide x cultivation combinations.

Best overall weed control occurred with the Sandea (halosulfuron) + finger weeder treatment, which provided about 61% control one week after treatment, and over 80% control at harvest (Figure 3).

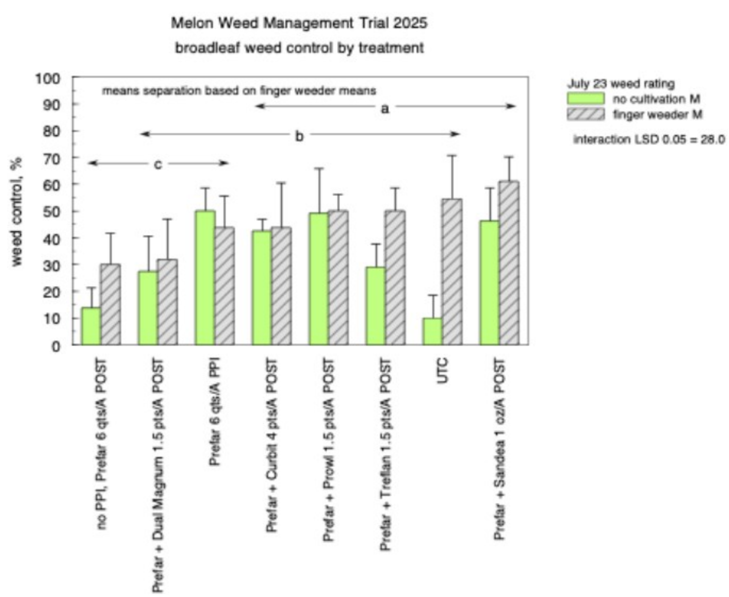


Figure 3. *Weed control 1 week after treatment as affected by cultivation and pre-emergent herbicide, WSREC 2025.*

Table 2. *Cantaloupe melon yield as affected by herbicide and cultivation treatment,WSREC 2024.*

	boxes/A			TMY	size	
Main plot (herbicide)	>6	9	12	boxes/A	% 15-18	Avg Brix
1 UTC +/- finger weeder	75	440	126	641	22.3	11.8
2 Prefar 6 qts/A PRE +/- finger weeder	136	420	121	678	29.4	12
3 Prefar PRE fb Sandea 1 oz/A +/- finger weeder	159	573	161	893	11.4	13.3
4 Prefar PRE fb Curbit 4 pints/A +/- finger weeder	73	717	25	814	22.6	12
5 Prefar PRE fb Dual 1.5 pints/A +/- finger weeder	152	293	303	748	18.4	12.1
6 Prefar PRE fb Prowl 1.5 pts/A +/- finger weeder	136	596	203	935	8.2	11.8
LSD 0.05	ns	ns	ns	199	12.9	ns
Split Plot (finger weeder)						
no post plant cultivation	109	441	173	722	20.5	11.6
finger weeder cultivation	135	572	140	847	16.9	12.7
LSD 0.05	ns	80	27.7	69	ns	1.1
Herbicide x cultivation interaction p-test	*	ns	ns	ns	ns	ns
Average	122	506	156	785	18.7	12.2
CV, %	52.3	25.9	29.2	14.5	33.3	14.3

TMY = Total Marketable Yield, the sum of size 6 or larger, size 9, and size 12 or smaller.
LSD 0.05 = Least significant difference at the 95% confidence level. NS = not significant. --- = not enough data to perform statistical anal
CV% = coefficient of variation

Total market yield (size 6, 9, and 12 combined) was 430 boxes/acre in the finger weeder treatments as compared to 381 boxes/acre where it was not used (Table 3). Only the size 9 category was a significant difference observed, with better yields in all herbicide treatments compared to the untreated control. Herbicides did not significantly improve total market yield as compared the untreated control, nor was there an impact on small fruit (% 15 + 18) production.

Table 3. *Cantaloupe melon yield as affected by herbicide and cultivation treatment, WSREC 2025.*

	boxes/A			TMY	size	
Main plot (herbicide)	12	9	6	boxes/A	% 15-18	Avg Brix
1 UTC	122	143	50	316	12.2%	12.8
2 Prefar 6 qts/A PPI	138	270	70	478	8.7%	14.0
3 Prefar + Sandea 1 oz/A POST	190	212	57	460	17.0%	14.4
4 Prefar + Curbit 4 pts/A POST	157	228	42	426	9.0%	12.4
5 Prefar + Dual Magnum 1.5 pts/A POST	135	210	41	385	7.2%	10.0
6 Prefar + Prowl 1.5 pts/A POST	143	192	66	402	17.9%	13.6
7 Prefar + Treflan 1.5 pts/A POST	136	218	68	422	8.3%	14.0
8 no PPI, Prefar 6 qts/A POST	141	185	37	364	11.6%	13.6
LSD 0.05	ns	ns	ns	ns	ns	---
Split Plot (finger weeder)						
no post plant cultivation	144	187	51	381	12.6%	13.1
finger weeder cultivation	147	228	57	432	10.4%	---
LSD 0.05	ns	41	ns	ns	ns	---
Herbicide x cultivation interaction p-test	ns	ns	ns	ns	ns	---
Average	144.5	207.3	53.9	405.6	11.7	13.1
CV, %	40.7	38.4	76.1	31.3	64.1	---

TMY = Total Marketable Yield, the sum of size 6 or larger, size 9, and size 12 (number of melons per box).
LSD 0.05 = Least significant difference at the 95% confidence level. NS = not significant. --- = not enough data to perform statistical anal
CV% = coefficient of variation

While the herbicide x cultivation interaction was not significant, usually yields were better where the finger weeder was used. Best overall yields occurred when Curbit or Sandea were incorporated with the finger weeder (Figure 4). There was a significant correlation between yield and weed control at the September (end of season) evaluation date, with improved yield where weeds were reduced (Figure 5). Average yield with 80% or better weed control was about 500 boxes per acre, whereas yield was 300 boxes per acre at 20% weed control, a reduction of 40%.

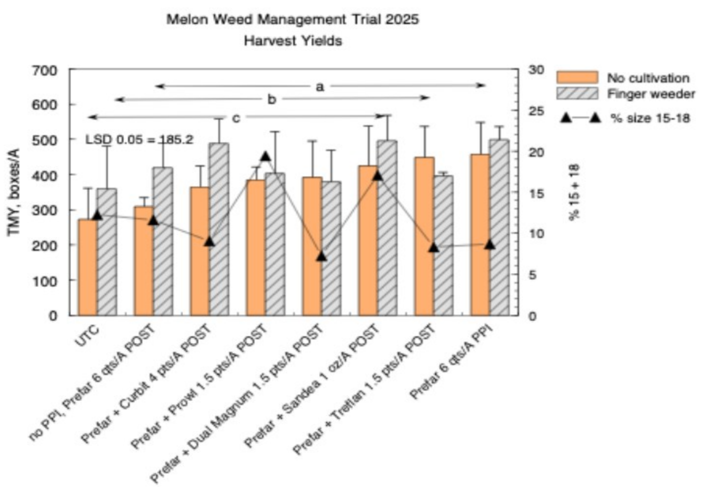
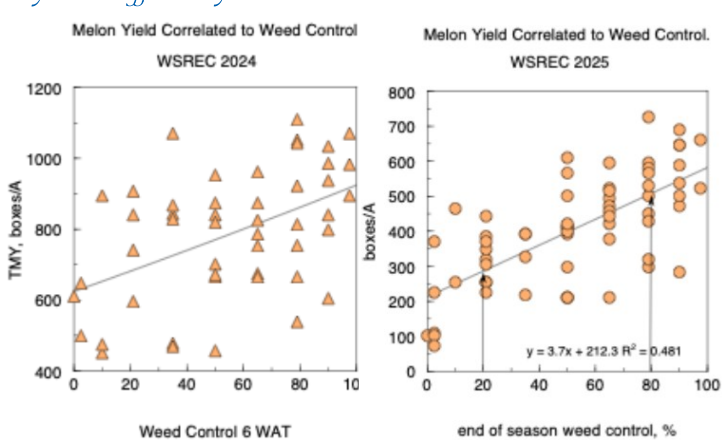


Figure 4. *Melon yield as affected by cultivation and herbicide treatments.*

Figure 5. *Correlation between late season weed control and melon yield in 2024 (left) and 2025 (right).*



Discussion:

The significant improvement in weed control when Dual, Curbit, and Prowl were incorporated with the finger weeder is not surprising, as these herbicides need water or mechanical incorporation to work effectively. Though not required on the label, Sandea also showed similar levels of improved control. The finger weeder is a cultivator that allows this incorporation to occur in the plant row after transplanting or crop emergence. In general, the finger weeder by itself reduced the number of broadleaf weeds in the plant row by about half as compared to doing nothing. When combined with the pre emergent herbicides evaluated in these trials, weed control was further significantly improved another 30 – 40%. However, wed control was marginal in 2025, rarely exceeding 50%. This likely occurred because in 2024 this trial used transplants, but was direct seeded in 2025. Many weeds germinated at the same time as the melons and thus were unaffected by the herbicide treatments; especially problematic was annual morningglory and volunteer melons from prior years. In general, the cultivation x herbicide interaction was not significant in these trials, which indicates that the benefits of the finger weeder apply equally across all herbicides. Total marketable yield was about 200 boxes more at 80% weed control as compared to 20%.

Acknowledgements:

Many thanks to Erik Kowes with TS&L Seed Company for melon seed donation and the crew at the UC WSREC for their help and cooperation. This research was funded by a grant from the California Melon Research Board.

Nutsedge Control in Cilantro with *S*-metolachlor

Oleg Daugovish, Maripaula Valdez-Berriz, and Abigail Brondos
UCCE-Ventura

Introduction:

A vigorous crop of cilantro can be easily outcompeted by most weeds. It took many years, trials and efforts to make prometryn and linuron labeled for cilantro. That use made growing cilantro in coastal California economically feasible year-around. However, these herbicides do not control yellow nustedge and this perennial weed has been increasingly troublesome, especially in warmer parts of the state and during warm seasons of the year. Nustedge infested fields often change hands between leases, while the weed persists without adequate commitment to control. In hand-harvested cilantro crop, the areas where nutsedge shoots mix with crop canopy remain unharvested by field crews, an instant yield loss. When the crop is cut by machine harvester for processing, there is still an expectation that it doesn't include nustedge.

S-metolachlor (Dual Magnum, DM) has been effective in suppressing nustedge in celery and strawberry in our past trials and we wanted to generate data to support its use in cilantro. Thus, the study targeted crop safety and nutsedge control in cilantro in Ventura County, CA.

Materials and Methods:

In 2024, our study at Oxnard evaluated three rates of DM (0, 0.33, 0.66, and 1 pint/A) sprayed after seeding, but before cilantro emergence. The soil was sandy loam. The cilantro variety 'Leisure' was seeded and drip-irrigated the day before application. Drip irrigated beds for direct seeded crops are increasingly common in Ventura County. In 2025, , we repeated the experiment at Camarillo and applied DM in the same manner as in Oxnard but the rates were 0, 0.67, 1.33, and 2.66 pints/A. The soil at Camarillo was clay loam and the cilantro variety was 'Santo.' These trials had treatments arranged in the RCBD with four replications and individual plots were 3ft wide and 15ft long.

In both trials we evaluated nustedge shoot emergence, scored cilantro injury on a scale from 0 (none) to 10 (dead), and harvested biomass from 3 ft-long subplots to estimate marketable crop yields.

Results:

At Oxnard, all rates of DM significantly reduced nutsedge shoot number 63-74% compared to untreated plots. Higher rates tended to provide greater control but the difference between rates was not significant ($p>0.05$) (Figure 1).

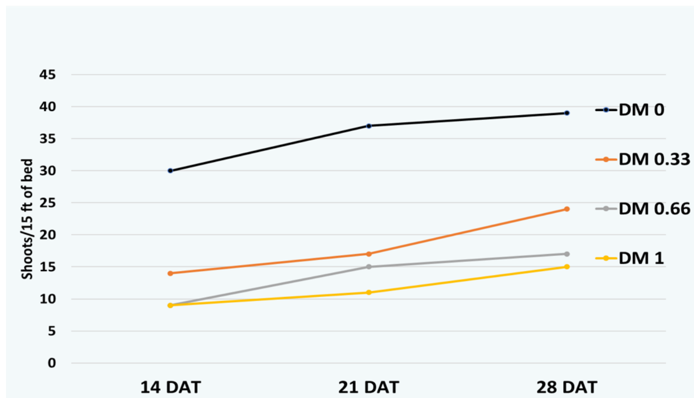


Figure 1. *Yellow nutsedge shoot germination in response to Dual Magnum (DM, pints/A) treatments in Oxnard, CA in 2024. Treatments with the same letter are not significantly different at p0.05.*

There were no significant differences in cilantro injury among treatments at Oxnard (Figure 2). Even though 1 pint/A rate of DM tended to have higher injury scores than the untreated cilantro, none of the scores were above 2 and the non-injured crop yielded similarly in all treatments ($p>0.05$, data now shown).

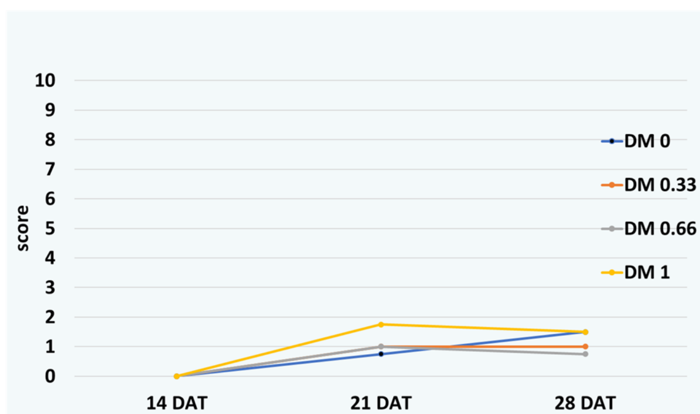


Figure 2. *Cilantro injury scores (0= none, 10=dead) in response to Dual Magnum (DM, pints/A) in Oxnard, CA 2024.*

Figure 3. *Yellow nutsedge shoots germinating in cilantro crop in in untreated beds (top left), at 0.33 (top right), 0.66 (bottom right) and 1 (bottom left) pint/A of DM after seeding (pre-emergence).*

At Camarillo, all rates of DM provided excellent (90-95%) control of resident broadleaf weeds (lambsquarters, burning nettle and common purslane) compared to about 180 plants/plot in untreated check, which had to be hand-weeded to prevent yield loses due to competition. Yellow nustedge shoot germination was controlled 67 and 48% by the 2.66 and 1.33 DM rates, respectively, but not by the 0.67 pint/A rate.

The high rate 2.66 pints/A of DM injured cilantro at the Camarillo trial (Figure 4). The crop was stunted and lagged behind in establishment. At the time of harvest, cilantro at this high rate of DM produced 35% less (p=0.01) marketable biomass than in other treatments. Cilantro in all other DM treatments yielded similarly to the untreated control (data not shown).

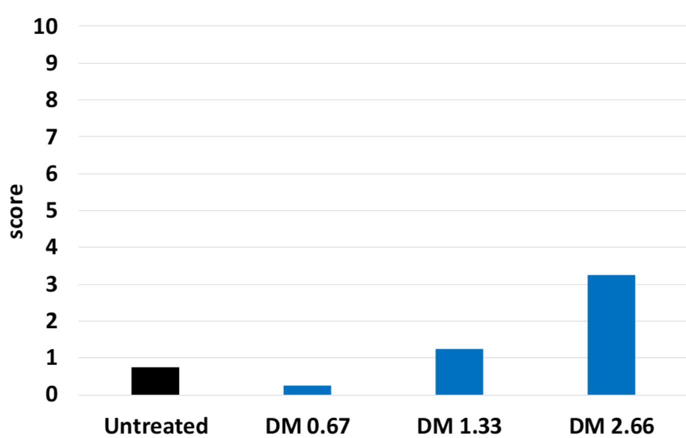


Figure 4. *Cilantro injury scores (0= none, 10=dead) at 28 DAT in response to Dual Magnum (DM, pints/A) at Camarillo, CA in 2025. Treatments with the same letter are not significantly different at p=0.05.*

Discussion:

These trials at the two locations in Ventura County showed that DM rates 0.66-1.33 pint/A were safe when applied after seeding cilantro and pre-emergence. These treatments can provide good control of yellow nustedge. Even though germination of this troublesome perennial weed was not fully contained by DM application, the reduction in nustedge stands was impactful enough to allow harvest in nutsedge-infested fields. The herbicide does not currently have the label for cilantro, but when secured, it will become an important tool in environments where nutsedge proliferates and prevents production of non-competitive crops for which no economic control tools are currently available.

Vegetation Composition of Agricultural Drainage Ditches Influences Pest and Natural Enemy Communities

Abigail Brondos, Maripaula Valdes-Berriz, and Oleg Daugovish
UCCE-Ventura

Introduction:

Agricultural drainage ditches often maintain year-round vegetation which may include wind-dispersed weeds, invasive plants, and non-native plants that host insect pests for nearby agricultural areas. Improperly managed ditches can become overrun with problematic weeds that can invade neighboring crops and facilitate the spread of agriculturally harmful insect pests[4, 6, 10]. These weeds and the pests they host cause billions of dollars in crop loss and can be difficult to control for multiple years. However, little research has explored vegetation composition in ditches in an agricultural, urban, and natural habitat matrix.

As one of the most agriculturally important counties in California, producing about $2 billion annually,[1] Ventura county is vulnerable to insect pests that can utilize common ditch vegetation as refugia and for overwintering. Pests such as diamondback moth (*Plutella xylostella*), lygus (*Lygus hesperus*), and western flower thrips (*Frankliniella occidentalis*), a common vector for Impatiens Necrotic Spot Virus (INSV), cause millions of dollars' worth of crop loss and increase pesticide use. In this study, we examined vegetation structure and composition in eight agricultural ditches in Ventura County between November 2023 and September 2024, as well as its relationship to the abundances of these three key insect pests (diamondback moth, lygus, and western flower thrips) and a variety of beneficial arthropods.

Materials and Methods:

Eight agricultural drainage ditches were selected within the Oxnard-Camarillo plain in Ventura County, California where vegetation surveys and arthropod samples were collected in November 2023, and March, June, and September 2024. Vegetation surveys were conducted along a 20 meter transect parallel to the waterline using 1m^2 quadrats placed on the lower and upper side of the transect every 5 meters for a total of 10 quadrats per site. In each quadrat we collected species composition, percent coverage, and phenological data. Using data collected from the vegetation surveys, arthropods were collected from 2 to 3 plant species with an average cover above 5% at each ditch site using a modified Makita blower/vacuum (Photo 1). For each plant species, we took 5 samples of 15 seconds each. Collected arthropod samples were placed in a freezer until they were cleaned, sorted, and identified to the lowest taxonomic level possible or desired.

Impatiens Necrotic Spot Virus (INSV) was tested in ten different weed species with the highest counts of western flower thrips. Leaves exhibiting possible symptoms were collected and tested using the Agdia immunostrips and pouches for INSV.

Photo 1. *Modified Makita blower/vacuum complete with 3D printed parts and custom mesh bags for collecting arthropod samples.*

Photo 2. *Maripaula Valdes-Berriz collecting arthropods using the modified Makita vacuum (Left). Oleg Daugovish and Maripaula Valdes-Berriz collecting vegetation data during the September sample round (Right).*

Results:

Vegetation Surveys:

The vegetation surveys revealed that among all sampled ditches the mean percent vegetation cover ($p = 0.006$), thatch cover ($p = 0.003$), and bare ground cover ($p = 0.04$) changed significantly across the sampling dates (Figure 1). There was also a significant increase in vegetation cover between March and June with average vegetation cover peaking at 66% in June. There was a slight decline in vegetation cover in September, but not enough for a significant difference. Thatch cover decreased consistently across November, March, and June, with June having the lowest average thatch cover. Bare ground cover, meaning the average percent with no vegetation or thatch significantly decreased from peak bare ground in March to its minimum in June and September.

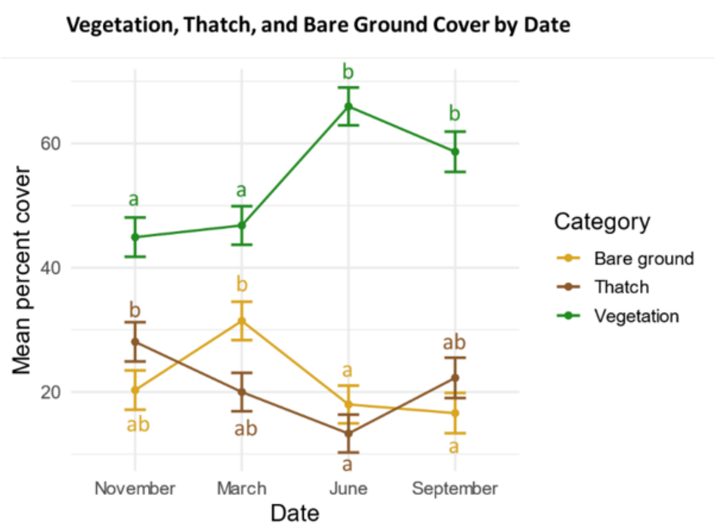


Figure 1. *Mean percent coverage of vegetation, thatch, and bare ground across sampling dates.*

Moderately invasive (Cal-IPC rating) plant species like mustards (*Hirschfeldia incana* and *Brassica nigra*), watercress (*Nasturtium officionale*), poison hemlock (*Conium maculatum*), and bermudagrass (*Cynodon dactylon*) were present in almost all the ditches throughout the sampling periods. Surveys showed a sharp increase in mustard and watercress coverage from March to June (Figure 2). There was also a steady increase in bermudagrass coverage starting from March and peaking in September. Surveys also revealed that poison hemlock coverage was low, with the species being absent in most ditches. However, when present, the mean percent coverage of poison hemlock was relatively high.

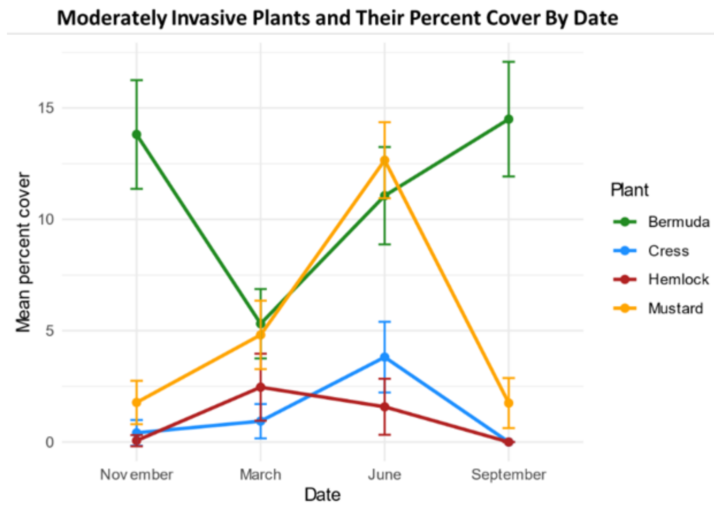


Figure 2. *Mean percent coverage of Cal IPC rated moderately invasive plants across date of sampling rounds. Despite having a mean coverage under 15%, these species dominated over others who averaged <2% each.*

Wind dispersed weeds species like horseweed (*Erigeron canadensis*), sowthistle (*Sonchus oleraceus*), prickly lettuce (*Lactuca serriola*), and italian thistle (*Carduus pycnocephalus*) were found at most ditch sites across the sample rounds. We found that horseweed and prickly lettuce were present for all sample rounds while sowthistle and italian thistle were present in three out of the four sample rounds, being absent only in September. Surveys also revealed that sowthistle was the most widespread wind dispersed weed with its presence being recorded at seven of the eight ditch sites. Horseweed was present at four of the eight sites, while italian thistle and prickly lettuce were recorded at one out of the eight sites.

Arthropod Collections:

Targeted pest populations, diamondback moth, lygus, and western flower thrips, followed similar patterns to the vegetation surveys with all three populations increasing in the period between March and June with population peaks in the June sample round (Figure 3). Diamondback Moth counts were significantly higher in June compared to March ($p=0.001$) and marginally significant compared to September ($p=0.07$). Diamondback moth was not found in any samples in November, even when brassicas were present. Lygus counts were also significantly higher in June compared to March, September, and November ($p<0.01$). Western Flower thrips also showed an increase in population from March to June, with June having significantly higher counts than the other sample rounds ($p<0.01$). Natural enemy populations, though present year-round, followed similar trends as the pests with significantly higher population counts in June compared to March (p=0.01) and November (p=0.0002). However, natural enemy counts in June were not significantly different compared to September (p>0.05).

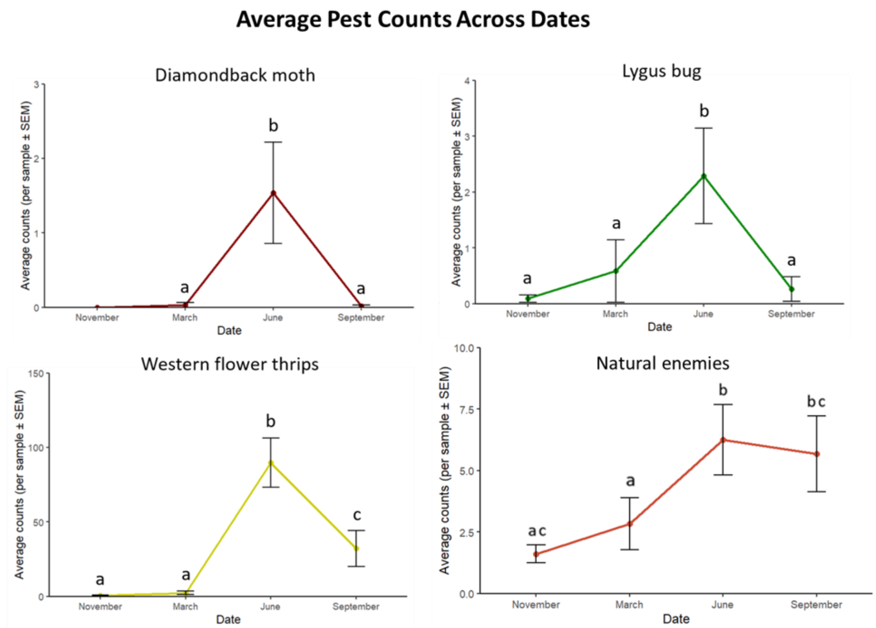


Figure 3. *Average counts of key pest species and their natural enemies across sample round dates. Diamondback moth, lygus, and western flower thrips counts were significantly higher in June compared to all other sample dates. Natural enemy counts were significantly higher in June compared to March but not significantly higher that counts in September.*

Plant preferences of each pest during the June sample round were investigated, revealing differences among the populations (Figure 4). Diamondback moth counts were found significantly higher on brassicas like mustards and watercress when compared to other broadleaves (p=0.001) and annual grasses (p=0.01), and marginally significantly higher compared to bermudagrass (p=0.07). Similar to diamondback moth, lygus had significantly higher counts in brassicas like mustard and watercress compared to other broadleaves (p=0.03) and annual grasses (p=0.04). Lygus counts in brassicas were not significantly different compared to bermudagrass (p=0.1). Western flower thrips were found to be utilizing a wider variety of plant types and families compared to the other pests, but counts were still significantly higher on brassicas compared to other broadleaves and annual grasses (p<0.01). However, western flower thrips counts on brassicas were not significantly different when compared to bermudagrass (p≥0.1). The lack of differences with bermudagrass for all three pest species, even diamondback moth, should be investigated further.

Over 4,000 parasitoid wasp individuals were collected, sorted, and counted in the arthropod samples. Identification of these individuals is still ongoing, but so far, over 21 different families have been identified including individuals from agriculturally important Braconidae, Ichneumonidae, Eulophidae, and Ecyrtidae families.

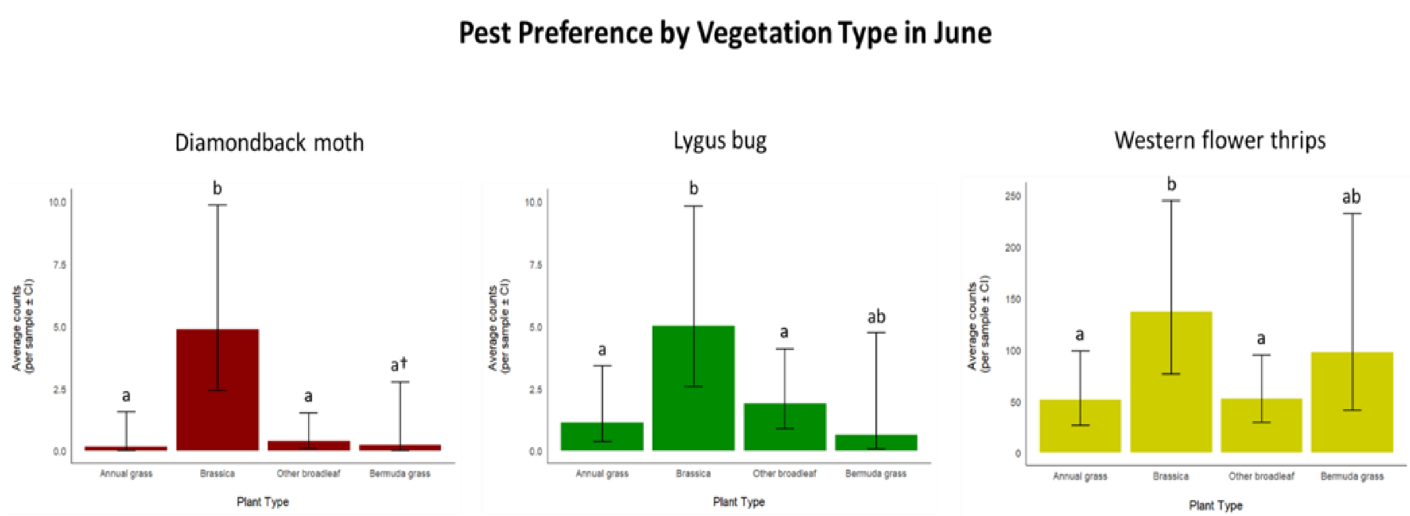


Figure 4. *Plant type utilized by key pest species during the June sample round. Diamondback moth counts were significantly higher on brassicas compared to other broadleaves and annual grasses while marginally significantly higher compared to bermudagrass. Lygus, and western flower thrips counts were significantly higher on brassicas compared to other broadleaves and annual grasses, but not bermudagrass.*

INSV Testing:

With the main vector of Impatiens Necrotic Spot Virus (INSV) from weeds to local crops being western flower thrips, we collected leaves from plant species that had higher counts of western flower thrips. The plant species tested for INSV were mustards, watercress, spurge (*Chamaesyce* spp.), sowthistle, prickly lettuce, primrose (*Oenothera elata*), mallow (*Malva parviflora*), poison hemlock, bermudagrass, and nettle (*Urtica dioica)*. All sampled plants tested negative for the virus except mallow for which the result was inconclusive.

Conclusions:

Results from the vegetation surveys revealed an increase in weedy vegetation cover in the ditches during March to June, peaking in June as the daylight temperatures rose to 65-75F. We also see that the vegetation cover remains high through September as the season shifts to a typical southern Californian fall with hotter, dryer weather with an average daylight temperature of 83F and an average 40% relative humidity. This vegetation cover is mostly made up of invasive species, including wind dispersed weeds. As the surveys revealed, these weeds increased in abundance in March, peaked in June, and remained high through September. This same trend is also reflected in the results of the arthropod collections. As weed populations increased from March to June, so did the populations of diamondback moth, lygus, and western flower thrips. Host plants such as mustards and watercress populations peaked in June, as did diamondback moth and lygus populations. Western flower thrips, being a native insect to California, was found to be utilizing a wide variety of plants, but higher counts were recorded on brassicas. As these weeds remain for long periods of time without management, they can act as parent plants and reservoirs for insect pests, aiding in the spread of pests, weeds, and disease into neighboring crops. With an increase in insect pest populations, we also observed an increase in natural enemy populations during the March to June period. However, natural enemies were present at every sampling round, indicating that these populations are resilient and possibly utilize vegetation as refuge for overwintering when other annual natural vegetation is mostly dry.

These results indicate a strong relationship between plant resources, arthropod abundance, and temperature. We can conclude from these results that effective and timely vegetation management can control pests and reduce the spread of weeds into adjacent farms, and, when done more selectively, enhance predator and parasitoids diversity.

Proposed Management Guidelines:

The results and conclusions above were used to create a comprehensive and practical set of recommendations and guidelines for managing agricultural drainage ditches. The following guidelines are meant to help promote a healthy ecosystem within these ditches and reduce the spread of weeds and insect pests into adjacent farms.

1. Assess the ditch of concern. Understanding the vegetation composition and coverage can help provide insight for herbicide applications or deciding what type of management is best. We recommend a selective vegetation management style early in the year in order to control unwanted weeds before establishment occurs. Specifically targeting brassicas like mustards and watercress before they establish and flower can help reduce diamondback moth and lygus populations throughout the year. Targeting problematic weeds such as these, while still retaining some vegetation in the ditches may decrease pest populations while allowing natural enemy populations to remain through the year.
2. Aggressively control wind dispersed weeds. An aggressive management approach using herbicides like oxyfluorfen and flumioxazin before or after a rain event can prevent the germination of seeds and can control small seedlings. Herbicides like glyphosate should be used with more caution due to a growing resistance in some species of *Erigeron/Conyza* and survival after use should be monitored.[3] For managing weeds without the use of herbicides, mowing can be a great option especially for controlling already established weeds before seed production.
3. Semi-aquatic weeds and waterflow. To ensure the waterflow of the ditches is unobstructed, managing semi-aquatic weeds like watercress will be necessary.[5] Managing this weed can be a challenging task since it is hard to remove after establishment and can return quickly. Removal in early spring targeting the root system or the use of glyphosate,[7] when water is not flowing, are the best options for controlling this weed. Since this

weed is a popular host for lygus and diamondback moth, removal should be a priority in order to control these populations.

4. [Benefits of some vegetation](). Selectively managing the problematic plant species while retaining some vegetation in the ditches can have lasting benefits such as erosion prevention and refugia for predatory and parasitic insects. Bare ground in ditches also acts as disturbed sites that weeds can easily colonize, especially wind dispersed weeds. Retaining some vegetation may help to reduce these issues and ensure a healthy ditch.

For other recommendations or tools to help with ditch vegetation management, the UC IPM website is a great, free resource with up to date, reliable information from experts. UC IPM also provides herbicide susceptibility charts and more information on other weeds and insect pests. More information can be found on the UC IPM website https://ipm.ucanr.edu/ for weed control and pest management.

Acknowledgements:

Thelma Hansen Competitive Grant Program for funding this research. Ellen Dean, botanist with the California Native Plant Society, for her help with plant identification. Hamutahl Cohen, Julie Clark, and Ben Faber from UCCE Ventura County for their collaboration. Ian Grettenberger, Associate Professor of Cooperative Extension at UC Davis, for his help with the bug vacuum.

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Applications in California Dryland Perennial Grasses Improve Forage Yield and Crop Coverage

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Introduction:

Over the past few years, a host of studies have been published addressing the rejuvenation of perennial grass stands in unirrigated pastures through use of herbicide treatments (Alba et al 2024, Clark et al. 2019, Davies et al 2025). This is for good reason, as annual weeds can invade productive perennial grass ecosystems and reduce forage quality and decrease the life of a stand. Several residual herbicides like indaziflam, imazapic, and aminopyralid can rejuvenate perennial grass stands by limiting competition from annual weeds. In California's foothills the challenge is quite different than elsewhere in the western USA, as the perennial grasses here have almost entirely been replaced by annuals, so residual herbicides used to control annual grasses and broadleaf weeds may leave bare soil instead of a rejuvenated perennial grassland. Some exceptions exist, such as areas that have been planted back to perennial grass through the interventions of local ranchers, as has happened in parts of the northern Sacramento Valley. These grass stands can last for generations if fertility and grazing management if managed correctly. However, overgrazing, drought, or fertility issues can be difficult to avoid. The results can cause the thinning of stands leaving gaps for annual weeds to gain a foothold. The study discussed here was undertaken to identify whether residual herbicides can boost health of perennial grass plantings in Northern California, with the intention of prolonging the life of the stand.

Our article, published in Rangeland Ecology and Management (Davy et al. 2025), reported on rimsulfuron, indaziflam, and aminopyralid treatments applied to 7-year-old stands of wheatgrass (*Thinopyrum* and *Elytrigia* species), hardinggrass (*Phalaris aquatica*), tall fescue (*Schedonorus arundinaceus (Schreb.)*), and dryland orchardgrass (*Datylis glomerata*) in Tehama County (Figure 1). Treatments were applied in October, prior to the first germinating rain of the season. Plots were monitored for 18 months after treatment, with a focus on crop coverage, forage productivity, and weed species composition.

Results:

The data collected show that herbicide effects on weed species composition are highly dependent on the planted perennial grass species and in some cases this effect was dependent on the variety planted. All species reduced yellow starthistle (*Centaurea solstitialis* L.) coverage, while soft chess (*Bromus hordaeceus* L.) was controlled by every herbicide treatment tested. Medusahead (*Taeniatherum caput-medusae* [L.] Nevski) coverage was increased by rimsulfuron at 35 g ai ha^{-1} in four out of the nine varieties planted. The same effect was also caused by indaziflam at 73 g ai ha^{-1} in two out of nine varieties. Plots treated with a mix of indaziflam with rimsulfuron saw an increase in filaree coverage and plots treated with aminopyralid increased annual ryegrass coverage dramatically. Ryegrass and filaree are desirable annuals in California rangelands.

Figure 1. *7 year-old stands of perennial forage grasses are shown here in spring, 18 months after treatment. 'Perla' koleagrass is in the foreground. 'Perla' was the variety that showed the best response to treatments.*

The highest yielding treatment in our study was "Perla" koleagrass (an American variety of hardinggrass' which are usually developed in Australia) treated with rimsulfuron at 70 g ai ha^{-1}. This treatment resulted in the highest biomass and crop coverage observed in the trial with 18,541 kg ha^{-1} yield and 82% crop coverage, though variability in production made it difficult to separate statistically. This represented a 70% increase in crop coverage and a 73% increase in productivity relative to the untreated plots (Table 1).

Table 1. *Crop coverage and biomass production of nine perennial grass plantings were evaluated following application of eight residual herbicide treatments.*

Treatment	Rate (g ai ha^{-1})	Crop coverage (%)		Biomass (kg ha^{-1})	Crop coverage (%)		Biomass (kg ha^{-1})	Crop coverage (%)		Biomass (kg ha^{-1})
		6 M	18 M	18 M	6 M	18 M	18 M	6 M	18 M	18 M
		'Advanced AT' hardinggrass			*'Alkar' tall wheatgrass*			*'Australian II' hardinggrass*		
UTC		31	34	7309	23	11	4584	23	16	4435
Indaziflam	73	33	35	3896	21	16	3942	8	31	4107
Indaz + Rim	73+35	26	30	3344	18	25 *	2794	20	33	2855
Indaziflam	102	43	41	4435	25	22	2877	35	30	2426
Indaz + Rim	102+70	29	39	4219	30	31 *	3700	32	33	3195
Rimsulfuron	35	34	36	6341	29	18	4435	20	25	4996
Rimsulfuron	70	32	50	5300	33	20	2830	28	40	5461
Aminopyralid	123	50	29	6802	35	21	4458	45	30	5629
Aminopyralid	245	44	62	11093	28	8	4716	14 *	12	7265
		'Berber' orchardgrass			*'Flecha' tall fescue*			*'Holdfast' hardinggrass*		
UTC		39	34	4584	48	28	4304	33	59	9245
Indaziflam	73	27	34	4107	45	44	5022	37	56	6802
Indaz + Rim	73+35	35	51	5022	35	30	2572	29	53	7770
Indaziflam	102	41	49	3699	50	35	2679	49	46	5805
Indaz + Rim	102+70	44	55	4336	44	36	3527	24	26 *	2141*
Rimsulfuron	35	30	25	4584	36	31	4716	29	42	6802
Rimsulfuron	70	55	58	4716	57	42	4219	36	69	12914
Aminopyralid	123	53	39	5186	58	29	4458	55 *	57	9581
Aminopyralid	245	39	13	5630	45	23	5630	61 *	67	11961
		'Luna' pubescent wheatgrass			*'Perla' Koleagrass*			*'Rush' intermediate wheatgrass*		
UTC		6	4	4219	60	48	10689	16	8	3943
Indaziflam	73	5	16	3351	65	70	16386	13	16	3725
Indaz + Rim	73+35	20	13	1696*	46	57	17068	24	16	2295*
Indaziflam	102	26 *	25 *	2624	64	63	8922	31	14	2040*
Indaz + Rim	102+70	17	10	1643*	42	58	18084	41 *	28 *	3051
Rimsulfuron	35	10	5	3272	45	64	15114	19	10	4107
Rimsulfuron	70	30 *	28 *	3527	48	82 *	18541	32	16	3272

Abbreviations: M, months after treatment; UTC, untreated control; Indaz, indaziflam; Rim, rimsulfuron
"*" indicates mean separation between treatment and control, based on Dunnett's test with a $p<0.05$ threshold.

The greatest biomass production in every other species (except "Perla") was associated with the 245 g ai ha^{-1} aminopyralid treatment. This was due to the increase in annual ryegrass coverage. In "Advanced AT" hardinggrass this treatment was associated with a 62% increase in crop coverage and a 51% increase in productivity relative to the untreated control (Table 1).

Aminopyralid treatments induced 10–20% injury at the 245 g ai ha^{-1} rate in "Alkar" tall wheatgrass and "Berber" orchardgrass resulting in low coverage at 18 months after treatment. "Australian II" hardinggrass also showed reduced coverage resulting from the 245 g ai ha^{-1} aminopyralid treatment. Though crop coverage was reduced, the overall productivity in these aminopyralid plots was still the highest numerically overall, due to high ryegrass populations (Table 1).

For more information, please refer to our publication, available open access from Rangeland Ecology and Management (Davy et al 2025).

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Control of Mexican Sprangletop (*Leptochloa fusca* ssp. *fascicularis*) in Citrus

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Introduction:

Weed control is very important during the early years of tree establishment in citrus orchards. Weeds compete with young trees for water and nutrients, which can reduce tree vigor and delay growth. One of the methods of managing weeds in citrus is through the use of preemergence and postemergence herbicides. Because most citrus orchards are irrigated with microsprinklers, multiple flushes of summer and winter annual weeds can emerge within a single growing season. Applying preemergence herbicides in late winter or early spring can provide effective weed control for several months. There are several preemergence herbicides that are currently registered for use in citrus orchards in California.

Mexican sprangletop (*Leptochloa fusca* ssp. *fascicularis*) has become an increasing concern in citrus orchards (Figure 1). This summer annual grass produces seeds that can germinate within the same growing season. If Mexican sprangletop is allowed to set seed, multiple flushes can occur during a single growing season. Several postemergence herbicides are commonly used in citrus orchards for the control of Mexican sprangletop, including glyphosate, glufosinate, sethoxydim, clethodim, and fluazifop-p-butyl. However, escapes following glyphosate applications have been reported. Although glyphosate-resistant Mexican sprangletop has not been confirmed in California, growers often make multiple postemergence herbicide applications throughout the season to maintain acceptable control. To reduce the risk of selecting for herbicide-resistant populations, the use of preemergence herbicides and tank-mixing herbicides with different modes of action is important. Although several preemergence herbicides have demonstrated activity on sprangletop species, their effectiveness specifically against Mexican sprangletop has not been well documented.

The primary objective of this study was to evaluate the weed control efficacy of several preemergence herbicides registered for use in young citrus trees (less than three years old). The secondary objective was to determine whether these herbicides effectively control Mexican sprangletop. The third objective was to compare the efficacy of pyroxasulfone to that of other preemergence herbicides currently registered for use in citrus.

Figure 1. *Mexican sprangletop in young citrus orchard in Fresno County.*

Materials and Methods:

A study was conducted at Lindcove Research and Extension Center in March 19, 2025. The herbicide treatments (Table 1) included indaziflam, indaziflam + rimsulfuron, rimsulfuron, pendimethalin, flumioxazin, oxyfluorfen, trifluralin, pyroxasulfone, and a tank-mix combination of pyroxasulfone + pendimethalin, applied at application label rates appropriate for young citrus trees established for less than three years. Glyphosate (Roundup PowerMax 3) at 40 oz/acre and a non-ionic surfactant (R-11) at 0.25% (v/v) were added to all treatments at the time of application to burndown existing weeds. All herbicide treatments were applied at a volume carrier rate of 20 gallons per acre (GPA). The plots were set up in a young citrus orchard (Tango mandarins) that was planted in 2022. The plot sizes were 10 feet wide by 22 feet long with four replications. In each treated tree row, a 5-foot strip on both sides of the berm was treated. The experimental design was a randomized complete block design. The treatments were applied with CO2- pressurized backpack sprayer and a 5ft spray hand boom with TeeJet 8003XR flat fan nozzles.

Table 1. *Treatment list and rates.*

TRT #	Treatments	A.I.	Rate (oz/acre)	lb ai/acre
1	Untreated		0	
2	Alion	Indaziflam	5 oz	0.065
3	Centrus	Indaziflam + Rimsulfuron	4.3 oz	0.065 + 0.045
4	Matrix	Rimsulfuron	4 oz	0.0625
5	Prowl H_2O	Pendimethalin	134.4 oz	4
6	Chateau SW	Flumioxazin	6 oz	0.188
7	Goal 2XL	Oxyfluorfen	192 oz	1.50
8	Treflan	Trifluralin	64 oz	2
9	Pyroxasulfone	Pyroxasulfone	8 oz	0.261
10	Pyroxasuflone + Prowl H_2O	Pyroxasulfone + Pendimethalin	8 oz + 67.2 oz	0.261 + 2

*Glyphosate (Roundup Powermax 3) and non-ionic surfactant (R-11) at rates of 40 oz/acre and 0.25%(v/v) were added to all treatments at the time of application.

The temperature during application was 65°F, average wind speed was about 1.4 mph, and relative humidity was 59%. The cloud cover was 20%. All plant debris was removed from the berms in each treated row using a leaf blower. Ratings of 0 – 100% weed control were taken in each plot by individual weed species and overall weed control. Evaluations were taken at 28, 60, 90, and 123 days after treatment (DAT). Data was analyzed in SAS at a level of 0.05 level and means were separated using the Fisher's Least Significant Difference test.

Results and Discussion:

All herbicide treatments provided excellent weed control at 60 days after treatment (DAT), with minimal differences among treatments. Mexican sprangletop was one of the only grasses that emerged in the untreated plots, and all herbicide treatments achieved over 90% control at 60 DAT (Table 3).

At 90 DAT, all treatments provided ≥86% control of Mexican sprangletop with minor differences between treatments (Table 2). Overall weed control at 90 DAT was high across all treatments, with most achieving over 81%, except Trifluralin 4EC (79%) (Table 2).

By 123 DAT, differences among treatments became more apparent as herbicides residual control declined. Most treatments still provided good control of Mexican sprangletop (≥79%), except flumioxazin, oxyfluorfen, and rimsulfuron, which had ≤69% control (Table 3). Indaziflam, pendimethalin, and pyroxasulfone treatments provided the best visual weed control of Mexican sprangletop and overall weeds (Fig 2).

Table 2. *Weed Control of Overall Weeds (expressed as percent from 0 – 100).*

Overall Weed Control					
Treatments	Rate (oz/acre)	28 DAT	60 DAT	90 DAT	123 DAT
Untreated	0	0 b	0 b	0 d	0 d
Alion	5	99 a	94 a	90 abc	80 ab
Centrus	4.3	98 a	96 a	91 ab	91 a
Matrix	4	99 a	95 a	89 abc	60 c
Prowl H_2O	134.4	100 a	95 a	91 ab	64 c
Chateau	6	99 a	93 a	85 abc	64 c
Goal 2XL	96	98 a	95 a	81 bc	73 bc
Trifluralin 4EC	64	98 a	94 a	79 c	63 c
Pyroxasulfone	8	99 a	95 a	91 ab	79 ab
Pyroxasulfone + Prowl H_2O	8 + 67.2	98 a	95 a	94 a	81 ab
P-Value		0.0001	0.0001	0.0001	0.0001
Coefficient of Var		2.62	3.91	10.31	15.73

* Means followed by the same letter are not significantly different according to the Fisher's LSD test at 0.05 level of significance

Table 3. *Weed Control of Mexican Sprangletop (expressed as percent from 0 – 100).*

Mexican Sprangletop (*Leptochloa uninervia*)					
Treatments	Rate (oz/acre)	28 DAT	60 DAT	90 DAT	123 DAT
Untreated	0	0 b	0 b	0 b	0 e
Alion	5	100 a	95 a	95 a	91 ab
Centrus	4.3	98 a	96 a	98 a	96 a
Matrix	4	99 a	95 a	86 a	50 d
Prowl H_2O	134.4	100 a	98 a	95 a	81 ab
Chateau	6	99 a	91 a	88 a	61 cd
Goal 2XL	96	99 a	96 a	88 a	69 bcd
Trifluralin 4EC	64	99 a	97 a	95 a	79 abc
Pyroxasulfone	8	99 a	99 a	95 a	88 ab
Pyroxasulfone + Prowl H_2O	8 + 67.2	100 a	98 a	94 a	86 ab
P-Value		0.0001	0.0001	0.0001	0.0001
Coefficient of Var		2.12	6.75	11.03	26.5

* Means followed by the same letter are not significantly different according to the Fisher's LSD test at 0.05 level of significance

In summary, all herbicide treatments maintained excellent control up to 90 DAT. By 123 DAT, residual activity had declined for most herbicide treatments, leading to reduced efficacy and greater variation among treatments. The herbicides with the most consistent control across broadleaf and grass species were indaziflam, indaziflam + rimsulfuron, pyroxasulfone, and pyroxasulfone + pendimethalin (Graph 1).

These treatments also provided the best control of Mexican sprangletop. Based on the weed control efficacy of this study, pyroxasulfone, can provide good weed control compared to other pre-emergence herbicides registered for citrus in California.

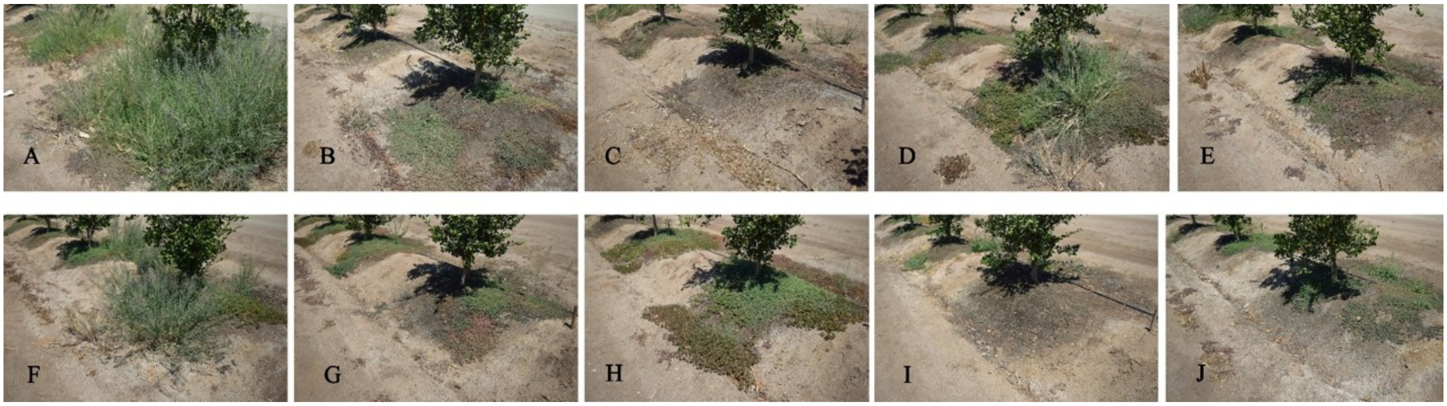
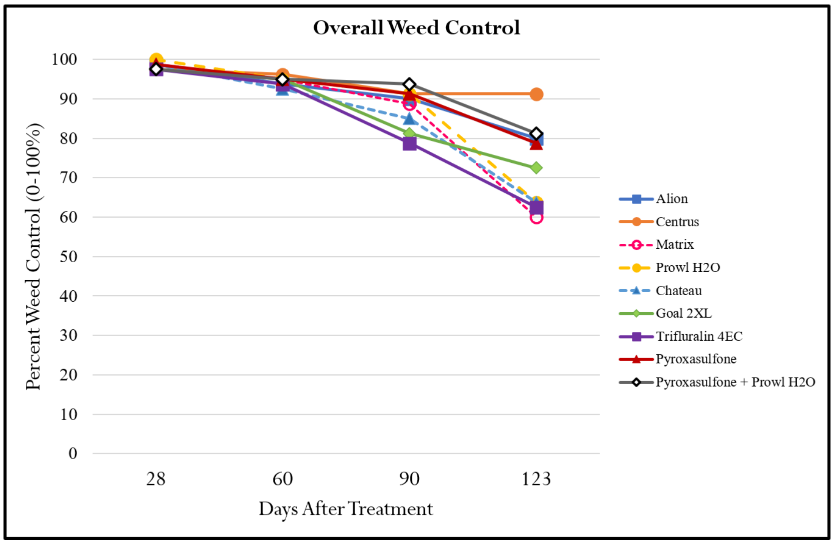


Figure 2. *Treatments at 123 DAT. A) Untreated, B) Alion, C) Centrus, D) Matrix, E) Prowl H_2O, F) Chateau, G) Goal 2XL, H) Trifluralin 4EC, I) Pyroxasulfone, J) Pyroxasulfone + Prowl H_2O.*



Graph 1. *Percent Weed Control of Overall Weeds.*

Limitations:

The citrus orchard where the herbicide trial was conducted was heavily infested with spotted spurge and Mexican sprangletop. As a result, the overall weed control data primarily reflect these two species. Other weeds such as hairy fleabane, puncturevine, little mallow, and lambsquarters germinated sporadically in some plots but were not evaluated due to their low populations or absence in the untreated control plots.

The herbicide application rates were selected based on the young age of the citrus trees. It is possible that higher rates, which are typically used in more established orchards, would have provided longer residual weed control. Because the orchard was irrigated with micro-sprinklers, the amount and distribution of surface water likely influenced herbicide residual activity and may have contributed to the heavy germination of spotted spurge and Mexican sprangletop. These two species rapidly covered the berms, likely suppressing the emergence of other weed species.

In some treatment plots, sprangletop weeds were cut back because their height interfered with the water distribution of the micro-sprinklers. Additionally, sprangletop weeds that germinated early in the study produced seed within the first two months, leading to a secondary flush of seedlings. This secondary emergence may have reduced the apparent efficacy of some treatment plots and introduced variability among replicates at 90 and 123 DAT.

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