Final Project Report
California Alfalfa and Forage Research Foundation

Project Title: Reducing Weed Pressure During Stand Establishment Using Pre-Plant Weed Germination Followed by Mechanical or Chemical Control

Project Leaders:
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Total Funding: $5,000

Project Objectives: Evaluate the efficacy of pre-plant weed control in alfalfa using mechanical cultivation or Glyphosate spray.

Background: Good stand establishment is critical for alfalfa production and can impact crop productivity for years. Weed competition during stand establishment may be irreversible because it impedes root growth, results in thinner alfalfa stands, and can lower forage quality (Canevari et al., 2008). Although management recommendations are to pre-irrigate and then cultivate to promote weed germination and then control prior to alfalfa planting, there are barriers to adopting this practice. Results from this research will provide both organic and conventional growers with regionally relevant information about an integrated weed management tool for improved stand establishment.

Project Methods:

Table 1. Experimental treatments

Treatment number	Pre-plant treatment	In-season treatment	Herbicide rate(s)
1	None	None	N/A
2	Tillage	None	N/A
3	Glyphosate	None	3 pt/acre
4	None	Raptor	6 fl oz/acre
5	Tillage	Raptor	6 fl oz/acre
6	Glyphosate	Raptor	3 pt/acre + 6 fl oz/acre

Table 2. Plot layout

	Treatment number		
Block 1	1	2	3
	4	5	6
Block 2	1	3	2
	4	6	5
Block 3	3	1	2
	6	4	5

Each treatment was replicated three times in a split plot randomized complete block design (Table and Table 2). Main plots were pre-plant treatment (no pre-plant treatment, tillage, or Glyphosate) and sub-plots were in-season treatment (no treatment or Raptor application in-season). Sub-plots were not replicated within a block.

The original plan was to pre-irrigate up plots to germinate weeds for pre-plant weed control (mechanical cultivation or Glyphosate application). Pre-irrigation began on 11/6/2019. However, in between when pre-irrigation occurred and when weed control was implemented, there was rain fall in the area. The effect of pre-irrigation was negated.

The pre-plant Glyphosate was sprayed on plots on 1/31/20 at a rate of 3 pints Glyphosate/acre. The tank was not rinsed after a previous of Goal2XL so a minor amount of residual may have been in the tank mix. Mechanical cultivation (tillage treatments) were implemented on 2/11/20, once the soil was dry enough. This cultivation was very shallow, in the top few inches of the soil, to avoid bringing new weed seeds to the soil surface.

Alfalfa seed was flown on the field on 3/4/20 and the field was then ring-rolled to cover seed and get good seed to soil contact. Field was then irrigated up a week later.

In season weeds were controlled with a tank mix of Raptor (Imazamox Ammonium Salt) at 6 fl oz per acre and Buctril (Bromoxnil) on 4/25/20.

Data Collected:

Baseline weed counts were taken on 1/29/20 from all plots before treatment implementation but after weed germination. Individual broadleaf weeds and grasses + sedges were counted in three random 20x20 cm quadrats per plot (Table 3). Plants were counted on this date because weeds and alfalfa plants were small and percent cover would not have captured potential differences.

Weed counts were taken three times between planting and first cutting from all plots. In season weed counts were taken as percent cover, in which the area of the quadrat was broken up in percent covered with broadleaves, grasses + sedges, bare soil, and alfalfa. On 4/9/20 (Table 4, Table 5, and Table 6) and 5/14/20 weed counts were taken in three random 20x20 cm quadrats per plot (Table 7, Table 8, and Table 9) and on 6/8/20 percent cover was observed in 3 random square meter quadrats per plot (Table 10, Table 11, and Table 12). The larger quadrat was used for percent cover on 6/8/20 because alfalfa and weeds were tall at this time and the meter by meter square allowed for more accurate representation of each plot.

Plots were hand harvested on 6/8/20 prior to first cutting, which occurred on 6/10/20. Two square meter areas of each plot, which were representative of the larger plot, were cut. Yield biomass was separated into weeds and alfalfa, dried, weighed separately, and then converted up to a pounds dry matter/acre basis (Table 13).

Finally, on 6/23/20 following first cutting, alfalfa stand counts were taken in all plots by counting the number of alfalfa plants in three 20x20 cm quadrats (Table 14).

Results:

Baseline weed count (1/29/20) collected before treatment implementation.

Broadleaves: there were no significant differences by treatment but there were significantly more weeds in the side of the field with no in-season control compared to the side where Raptor was applied in-season.

Table 3. Broadleaf weed counts between treatments before pre-plant weed control was implemented (# of broadleaf weeds per 20 cm^2) quadrat. Data reported as average count per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	6 ± .11	8 ± .40
Glyphosate pre-plant	6 ± 1.2	11 ± 2.7
Tillage pre-plant	6 ± 1.3	7 ± 1.7

Grasses + Sedges: Average count of zero for all treatments.

Weed counts:

4/9/20

Grasses + sedges: This is the average percent of the 20 cm^2 quadrat that is covered by grasses per treatment. There were not many grasses or sedges in the field.

Table 4. Percent cover of grasses & sedges between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	0 ± 0	0 ± 0
Glyphosate pre-plant	1 ± 0.58	0 ± 0.06
Tillage pre-plant	4 ± 3.9	0 ± 0.06

Broadleaves: This is the average percent of the 20 cm^2 quadrat that is covered by broadleaves by treatment. There were significantly more broadleaves in the plots that had no pre-plant weed control.

Table 5. Percent cover of broadleaves between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	100 ± 0	100 ± 0
Glyphosate pre-plant	11 ± 5.5	8 ± 1.9
Tillage pre-plant	6 ± 2.9	9 ± 1.1

Alfalfa: This is the average percent of the 20 cm^2 quadrat that is covered by alfalfa by treatment. Alfalfa plants were small at this counting date however, there were significant treatment differences with the pre-plant weed control treatments having more alfalfa than the control.

Table 6. Percent cover of alfalfa between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	0 ± 0	0 ± 0
Glyphosate pre-plant	3 ± .59	3 ± 0.20
Tillage pre-plant	3 ± .15	3 ± .15

5/14/20

Grasses + sedges: This is the average percent of the 20 cm^2 quadrat that is covered by grasses by treatment. There were not many grasses or sedges in the field.

Table 7. Percent cover of grasses + sedges between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	0 ± 0	0 ± 0
Glyphosate pre-plant	9 ± 3.4	1 ± 0.56
Tillage pre-plant	0 ± 0	3 ± 1.5

Broadleaves: This is the average percent of the 20 cm^2 quadrat that is covered by broadleaves by treatment. There were significantly less broadleaves in the plots that had pre-plant weed control (Glyphosate or tillage) and in the plots that had Raptor applied in-season.

Table 8. Percent cover of broadleaves between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	97 ± 1.5	99 ± .56
Glyphosate pre-plant	6 ± 0.56	51 ± 8.7
Tillage pre-plant	15 ± 7.6	51 ± 2.9

Alfalfa: This is the average percent of the 20 cm^2 quadrat that is covered by alfalfa by treatment. There was significantly more alfalfa in the plots that had pre-plant weed control (Glyphosate or tillage) and in the plots that had an in-season herbicide.

Table 9. Percent cover of alfalfa between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	0 ± 0	0 ± 0

Glyphosate pre-plant	61 ± 10.2	42 ± 9.2
Tillage pre-plant	58 ± 6.3	38 ± 2.4

6/8/20 (at first cutting):

Grasses + sedges: This is the average percent of the m^2 quadrat that is covered by grasses by treatment. There were not many grasses or sedges in the field and no significant differences by treatment. There were more grasses in the side of the field with no in-season herbicide application.

Table 10. Percent cover of grasses + sedges between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	0 ± 0	0 ± 0
Glyphosate pre-plant	1 ± .48	6 ± .48
Tillage pre-plant	0 ± 0	8 ± 4.0

Broadleaves: This is the average percent of the m^2 quadrat that is covered by broadleaves by treatment. There were significantly less broadleaves in the plots that had pre-plant weed control (Glyphosate or tillage) and in the plots that had Raptor applied in-season.

Table 11. Percent cover of broadleaves between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	94 ± 2.9	99 ± 1.3
Glyphosate pre-plant	5 ± 4.1	64 ± 10.6
Tillage pre-plant	4 ± .69	70 ± 6.8

Alfalfa: This is the average percent of the m^2 quadrat that is covered by alfalfa by treatment. There was significantly more alfalfa in the plots that had pre-plant weed control (Glyphosate or tillage) and in the plots that had an in-season herbicide.

Table 12. Percent cover of alfalfa between treatments. Data reported as average percent per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	2 ± 1.2	0 ± 0.22
Glyphosate pre-plant	94 ± 3.6	29 ± 10.8
Tillage pre-plant	96 ± .70	23 ± 7.0

Alfalfa Yield: Yields are reported in pounds per acre as 100% dry weight. This yield data is only for the first cutting of the stand, not for the full first year of production. There were significant differences in alfalfa yield between pre-plant treatments and plots that had no pre-plant weed

control. Both the Glyphosate and tillage pre-plant treatments increased yields. In addition, the in-season Raptor spray significantly increased yields compared to plots without in-season weed control.

Table 13. Alfalfa dry matter yield. Data reported in lb/acre per treatment ± standard error.		
Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	53 ± 38.1	10 ± 2.4
Glyphosate pre-plant	3845 ± 163.6	1956 ± 332.3
Tillage pre-plant	3258 ± 233.4	1457 ± 388.9

Biomass was separated into alfalfa (above) and weeds after plots were hand-harvested. Then alfalfa and weeds were weighed separately by plot. There were significantly more weeds, by weight, in the side of the field that did not get the herbicide spray in season compared to the side that did get an herbicide spray. However, within one side of the field (Raptor or not), there were not significant differences by pre-plant treatment. In other words, even though there was more alfalfa in the plots with pre-plant weed control, there were also more weeds. The photos below, taken at harvest show how heavy the weed pressure was even in plots with Glyphosate and tillage pre-plant that did not have in season herbicide application.

Left: close up of a plot with Glyphosate pre-plant plus in-season Raptor.
Right: close up of a plot with Glyphosate pre-plant but no in-season herbicide.

Below are broad views of the same plots.

Alfalfa Stand After 1st cutting:

This is the number of alfalfa plants in a 20cm^2 quadrant after first cutting. There were significant differences in the alfalfa stand after first cutting. With regard to pre-plant treatments, both Glyphosate spray and tillage pre-plant significantly increased alfalfa stand compared to the plots with no pre-plant treatment.

When comparing plots with the same pre-plant treatments with or without in-season herbicide spray, plots that were tilled pre-plant did not have significantly different stand counts regardless of in-season herbicide treatment. However, within the plots that were sprayed with Glyphosate pre-plant, those that also were sprayed with Raptor in-season had significantly higher alfalfa stand counts than those that without in-season control.

Table 14. Alfalfa plants/quadrat Data reported per treatment ± standard error.

Treatment	*Raptor In-season*	*No In-season control*
No pre-plant treatment	1 ± .22	0 ± .22
Glyphosate pre-plant	18 ± 1.7	12 ± 3.5
Tillage pre-plant	14 ± 2.0	11 ± 2.0

Example of count data taken after first cutting.

Summary:

The data shows that controlling weeds prior to planting, either with shallow tillage or an herbicide spray (Glyphosate) will reduce weed pressure, increase yields, and lead to a stronger alfalfa stand after first cutting. There were also differences between plots that got an in-season herbicide and those that did not. Yields were highest in plots that had both pre-plant weed control and an in-season herbicide. The plots with the highest stand counts after first cutting were also the plots that had both pre-plant and in-season weed control. However, the stand in the pre-plant treatment plots that did not have in-season herbicide application still had relatively high alfalfa stand counts after first cutting. This means that the alfalfa stand may be more robust for future cuttings, even if weed pressure was high initially. As shown in photos above, the alfalfa was robust in the understory of the canopy, even when broadleaf weeds

were very large. By first cutting many broad leaf weeds had gone to flower so likely would not return after first cutting.

Ideally, both pre-plant and in-season weed control would be implemented to get highest yields, quality, and ensure animal safety. However, growers (particularly organic) may be able to do a pre-plant tillage to control weeds and establish a good alfalfa stand, have yield reduction and additional weed pressure leading up to first cutting, and then have a strong alfalfa stand for subsequent cuttings.

Project Challenges:

- Project could not be implemented in Fall of 2018 as originally anticipated due to farm management challenges. In brief, there were significant delays in installing irrigation in the field prior to alfalfa planting. These delays made it burdensome to continue with the on-farm research project as there was a need to plant the alfalfa in a timely manner and thus not delay by setting up the pre-plant treatments. Thus, project was put into the field in Fall of 2019 instead (no-cost extension approved by Jane Townsend).
- Mariano Galla left UC Cooperative Extension in January 2019 thus project was only implemented at one farm site in Colusa County.
- Treatments were modified. The organic herbicide Scythe was removed as a pre-plant treatment, but Glyphosate and tillage were included (conventional and organic option). In addition, treatment areas were split into two, with half receiving in-season weed control using Raptor herbicide (standard grower practice) and half without (pre-plant treatments only). Thus, we were able to evaluate the impact of pre-plant weed control with and without the in-season control.
- Project end date was extended to Fall 2020 to allow for taking yield data before first cutting as well as final weed counts, and alfalfa stand counts, after first cutting.
- Due to COVID-19 restrictions, no field day was held this spring. Project findings will be disseminated via other UCCE methods instead.
- It rained prior to treatment implementation so there was no effect of pre-irrigation but pre-plant treatments were implemented following rain, before alfalfa planting.

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