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2017 Western Alfalfa and Forage Symposium

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RECENT DEVELOPMENTS IN ALFALFA WEED CONTROL: GLYPHOSATE-INDUCED INJURY IN RR ALFALFA AND SHARPEN HERBICIDE

Steve Orloff and Rob Wilson[1]

ABSTRACT

Roundup Ready (RR) alfalfa has become a popular weed management strategy for alfalfa producers in western states. Considerable research was conducted before and shortly after its commercial release to evaluate its value in terms of weed control and crop safety. The research showed properly timed applications of glyphosate provided excellent weed control with essentially no perceptible crop injury, which was further confirmed by grower experience in commercial fields. However, during the spring of 2014 and 2015, we observed significant crop injury in RR alfalfa fields in the Scott Valley (Intermountain area of Northern California). Logical causes for the poor growth such as spray-tank contamination, a bad batch of glyphosate, or non-herbicide related management practices were systematically ruled out, and the theory was developed that cold temperatures after an application of glyphosate was the cause. Field experiments were conducted in spring and fall of 2015 to evaluate this theory. Research results and field observations to date suggests that the injury is related to the degree and number of frosts after application, the height of the alfalfa (taller alfalfa being more prone to injury), and stand age (no injury has been observed in seedling alfalfa and less injury on recently established alfalfa compared with fields established for over a year). Research is ongoing and will be expanded to better understand the conditions that lead to injury so that it can be avoided in the future and to understand the biochemical mechanism responsible for cell injury.

Sharpen (saflufenacil) recently received federal registration and is close to registration in alfalfa in California. It is a postemergence broadleaf herbicide that causes rapid and thorough burn down of foliage. Sharpen is very effective on some difficult to control broadleaf weeds including common groundsel and some weeds difficult to control with Roundup such as cheeseweed and wild buckwheat. Producers should heed label restrictions regarding application timing (90 or 75 days before harvest depending on the area) to avoid excessive crop injury.

Key Words: Herbicides, herbicide registration, phytotoxicity, transgenic alfalfa

GLYPHOSATE-INDUCED INJURY TO ROUNDUP READY ALFALFA

Roundup Ready (RR) alfalfa has had a significant impact on the alfalfa industry, now comprising a significant percentage of the alfalfa acreage in the West. The main advantages are improved weed control, ease-of-use, and avoidance of crop injury. Considerable research was conducted prior to the commercial release of RR alfalfa to evaluate its value in terms of weed control and

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crop safety. In addition, the technology has now been used extensively in commercial fields since it was first released in 2005 and then rereleased in 2011. In a grower survey conducted by Putnam and Orloff, most grower respondents indicated a high level of satisfaction with RR alfalfa—75% indicating that they were very pleased or that the technology far exceeded expectations. A reduction in crop injury compared with conventional herbicides, especially in seedling alfalfa, has been considered a significant advantage of this technology.

The author is unaware of any published reports or studies showing glyphosate injury to alfalfa. Previous research conducted at the Intermountain Research and Extension Center (IREC) in Tulelake, CA and other areas prior to the commercialization of RR alfalfa demonstrated good safety of glyphosate to RR alfalfa. In one trial, glyphosate was applied over a broad range of rates up to 10 gallons per acre over the season (obviously many fold over the labeled rate and common use rates). It was applied at 50 percent regrowth before and after each cutting in an attempt to maximize the potential for crop injury. Only at the highest rate with the maximum number of applications was any injury observed (a few narrow strapped leaves at the top of the canopy), and this injury was only transitory and short-lived. No injury whatsoever was observed with more moderate use rates (including rates still well above label rates).

However, during the spring of 2014 we observed significant crop injury in some commercial RR alfalfa fields in the Scott Valley, Siskiyou County, CA. The cause was unknown but untreated areas of the field (such as where wheel-lines were anchored for the winter) had significantly more growth than treated areas and necrotic shoots were observed as an understory in the treated area. Potential causes for the poor growth such as spray-tank contamination, a bad batch of glyphosate, or other non-herbicide related management practices were systematically ruled out. A test plot was established in the field in the untreated strip to evaluate whether the injury was the result of the batch of Roundup PowerMAX the grower used, the rate, or the adjuvant added to Roundup. No injury was observed with any of the Roundup treatments applied to this strip and we were essentially unable to duplicate the injury that had occurred in the field. A year passed and the cause for the injury was never determined. Then in 2015 the same situation occurred in several commercial RR alfalfa fields in the Scott Valley. Untreated areas were significantly more vigorous than treated areas, and again shoot dieback was observed in glyphosate treated areas.

After considerable deliberation, the theory was developed that cold temperatures after application were needed for glyphosate-induced injury to occur, likely explaining why we didn't see injury when we tried to duplicate the injury in 2014 (it was late enough in the season that cold temperatures did not follow the application). We observed that commercial applications made early in the season when alfalfa was dormant did not show injury, and similarly extremely late applications did not show injury symptoms. The fields where injury was observed had approximately 6-8 inches of growth at the time of application. A plausible explanation for this observation was that early-treated fields lacked sufficient alfalfa growth to take up the glyphosate and in the case of the fields treated very late, temperatures after application were not sufficiently cold to cause injury.

A replicated trial was established in the spring of 2015 in Tulelake, CA to see if the observations from producer fields could be duplicated. Tulelake is a colder area than Scott Valley so alfalfa growth is delayed and freezing temperatures occur later into the season. A trial was established

and treated on 5/4/15. Roundup PowerMAX alone was applied at 22 and 44 ounces of product per acre at a spray volume of 20 gallons per acre to 6-8 inch tall alfalfa. Ammonium sulfate was also added to a 22 ounce rate at 8.5 lbs/100 gallons to see if it had a different effect than 22 ounces of glyphosate alone. Nighttime temperatures after application were relatively mild compared with normal, but lows of 29 and 30^{o} F were recorded 2 and 3 days after application, respectively (recorded at a nearby CIMIS weather station; field temperatures may have been lower). Within 2 weeks after application, wilting and drooping of the end of scattered stems was observed in the treated plots. As time progressed, the wilted shoots turned necrotic (burned back). First and second cutting yield was monitored (Table 1.) First cutting yield was lower for the Roundup treated plots than the untreated control. The addition of ammonium sulfate did not appear to change the effect. There was no significant carry-over effect on second cutting.

Table 1. Effect of Roundup PowerMAX rate on alfalfa height at first cutting and the yield of 1st and 2nd cutting. IREC. Tulelake, 2015

Treatment	Rate	Height	1st Cut 6/4/15	2nd Cut 7/6/15
		(in)	------Tons/A------	
Untreated	-	20.2	1.83	2.22
Roundup	22 oz	19.7	1.51	2.39
Roundup + AMS1	22 oz	18.2	1.58	2.31
Roundup	44 oz	18.4	1.41	2.37
LSD 0.05		1.5	0.20	ns

Alfalfa yield was also monitored in three commercial alfalfa fields in Scott Valley by harvesting three treated and untreated areas in RR alfalfa fields with a plot harvester and averaging the yield. The yield reduction on first cutting was more severe (up to 0.8 tons/acre) than that observed in the replicated Tulelake study, perhaps due to more frost events and colder temperatures after the commercial Roundup applications were made.

An additional field trial was conducted during the summer of 2015 in one of the commercial fields that had injury in the spring. The same treatments used in the spring trial in Tulelake were applied after 1st cutting to 6-8 inch tall alfalfa. The plots were carefully inspected after the application and no injury symptoms were ever observed on the alfalfa and there was no difference in alfalfa yield with any of the treatments, again suggesting that cold weather after application was required for injury to occur.

Four trials (two at IREC and two in commercial fields in Scott Valley) were conducted in the fall of 2015 to further evaluate the theory that glyphosate injury may occur when cold temperatures (near freezing or below) follow an application. Roundup PowerMAX was applied at 22 and 44 ounces per acre on weekly intervals from mid-September through October. While this was not a common time of year to apply glyphosate to RR alfalfa, it did allow us to address in a research setting whether cold weather following an application of glyphosate could cause injury, as frosts after application were essentially guaranteed as the fall progressed. Within a week after treatment, the same injury symptoms that were observed in the spring were found in some of the fall trials. The tips of affected shoots drooped in a typical "shepherd's crook". A week later

these shoots turned neurotic (dead tissue light brown in color). These symptoms were only observed on some plants—often a single shoot, sometimes multiple shoots per plant, and sometimes all the shoots on a plant. Later as the temperatures dropped further, some of the plants in treated plots turned chlorotic. This symptom was far more common in fall than was observed in spring.

The occurrence of symptoms varied greatly among trials, which may provide some insight as to the conditions under which injury is most likely to occur. The most severe symptoms were observed in a Scott Valley field where the alfalfa was relatively tall when the field was treated (average plant height was 10 inches at the time the first plots were treated). The next most severe symptoms were noted in one of the test plots in Tulelake. This was an older alfalfa field (planted in 2011) and the alfalfa overall was shorter than the Scott Valley field (averaging 9 inches in one replication and 4.5 inches in the other three replications). The taller replication had significantly more injury than the other replications. The second alfalfa test plot field in Scott Valley showed less symptoms and they were slower to develop. This field was shorter than the other fields when the first application was made (average height was 5 inches) and temperatures in this field were milder than Tulelake temperatures. Almost no symptoms were observed in the second plot in Tulelake despite the fact that this field was the tallest when treated (13 inches at the first application). This field was newly established, planted the previous June and only cut one time before treatments were applied. The lack of injury in this field may be due to the fact that newly-planted fields are typically more cold-tolerant. They oftentimes remain green the entire winter; whereas, older established fields usually turn completely brown over the dormant period in the intermountain area.

These preliminary results demonstrated that alfalfa injury was in fact associated with glyphosate applications preceding cold temperatures, and the greatest injury occurred in taller alfalfa and in older fields than fields recently established. Research is ongoing to better understand conditions that may lead to injury and to understand the biochemical mechanism responsible for cell injury. This result does not question the value of the RR technology in cold climates, but instead demonstrates the need for further research to identify management practices (such as application timing) that should be employed to avoid damage in the future.

A NEW HERBICIDE ON THE HORIZON?

After a drought of over a decade without any new active ingredient herbicide registrations, there is some interest in the commercialization of new herbicides for alfalfa. The herbicides I am aware of that are being evaluated for weed control in alfalfa are not new herbicide chemistry, but rather relatively new herbicides that are registered in other crops that may have a fit in alfalfa production systems. The research on some of these herbicides are so recent and preliminary that it would be premature to mention trade names. However, one herbicide, Sharpen (saflufenacil), has been evaluated in alfalfa for several years and is close to registration in alfalfa in California (currently under review California Department of Pesticide Regulation). Sharpen already has a Federal EPA registration for use in dormant alfalfa. At the rates Sharpen would be used in alfalfa, it is primarily a postemergence herbicide. It inhibits chlorophyll biosynthesis that causes a buildup of reactive oxygen compounds that cause cell membranes to lose their integrity leading eventually death of the weeds. The herbicide is absorbed by plant roots, shoots and leaves.

The visual plant symptoms associated with an application of Sharpen is a rapid and thorough burn down of the foliage. Most alfalfa producers are very familiar with the symptoms on the alfalfa and the weeds following an application of Gramoxone. An application of Sharpen typically results in a significantly more extensive and longer-lasting burndown of foliage than that which occurs with Gramoxone.

While Gramoxone and Sharpen are both post-emergence herbicides, there are key differences. Sharpen is a broadleaf herbicide and does not control grasses. And, unlike Gramoxone, Sharpen does have some limited pre-emergence control of some weeds. Sharpen is very effective on some difficult to control broadleaf weeds that in many areas have been increasingly troublesome. Perhaps the main one is common groundsel, which in many cases is escaping Gramoxone and sometimes Velpar applications in California's Central Valley. Sharpen is very effective for common groundsel control (Figure 1). It also controls a broad spectrum of other broadleaf weeds including many mustard species. Sharpen controls some weeds that are difficult to control with Roundup such as cheeseweed and wild buckwheat and therefore may be an effective herbicide to rotate with Roundup in RR alfalfa systems.

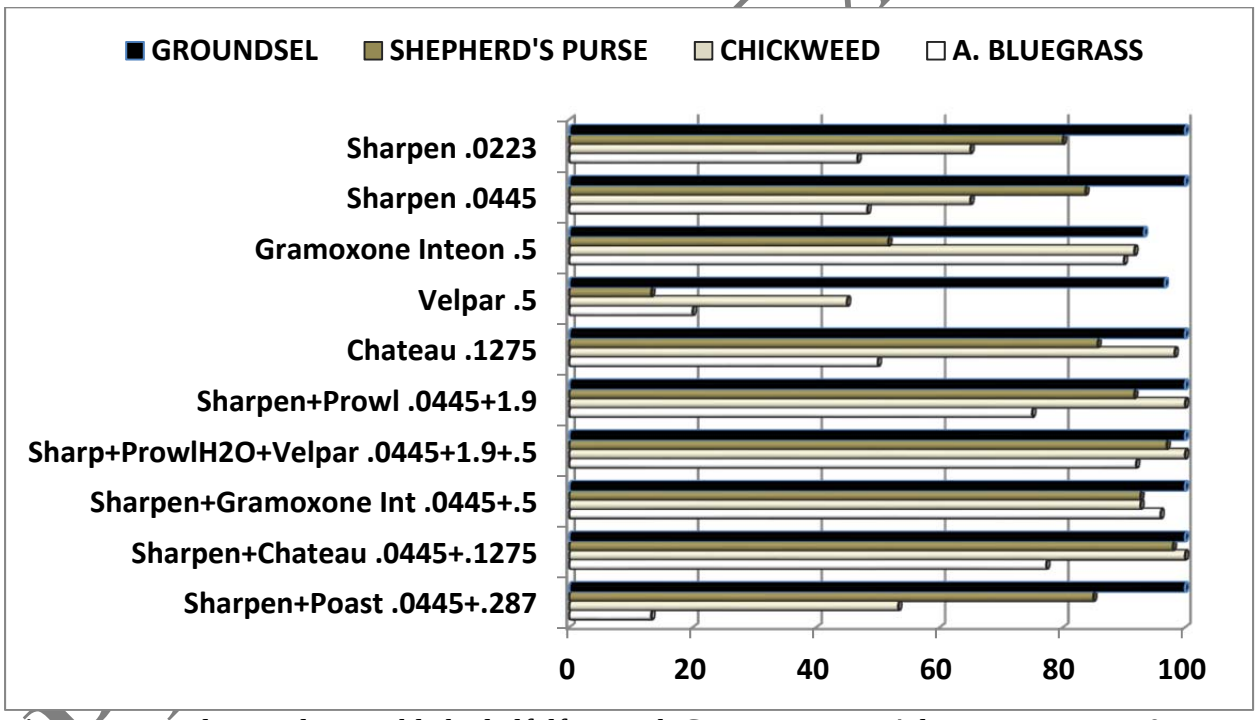

Figure 1. Weed control in established alfalfa. Mick Canevari, Farm Advisor Emeritus. 2014.

One of the concerns with Sharpen may be the degree of initial crop burndown. As mentioned above, the burndown exceeds that of Gramoxone. Therefore, it will be important for growers and crop consultants to follow the label closely and apply in the fall when alfalfa is not actively growing or during the winter dormant period. The timing of the application during the dormant season depends on the growing area. In the northern tier of states (Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming, and in the California counties of Del Norte, Lassen, Plumas, Modoc, Nevada, Shasta,

Sierra, and Siskiyou) Sharpen must be applied at least 90 days before harvest or yield reductions in the first cutting may occur. In the more southern states (Arizona, New Mexico, Oklahoma, and the remaining counties of California) Sharpen should be applied at least 75 days before the first cutting or yield reduction may occur. Sharpen is also registered for use in mixed stands of alfalfa and perennial cool-season grasses. There are very few herbicides registered for this use, and this could be a very important niche for this herbicide.

CONCLUSION

Weed management is an ongoing challenge for alfalfa producers. Researchers, growers and field consultants have fine-tuned weed management practices over the last decade but, other than the Roundup Ready system of weed management, there have been few changes. However, a new herbicide to alfalfa growers, Sharpen (recently registered at the federal level and pending registration in California), shows promise for broadleaf control in established alfalfa and alfalfa/grass mixtures. Another new development in alfalfa weed control is the discovery of glyphosate injury to RR alfalfa when applications are made to relatively tall alfalfa (6 or more inches in height) and cold temperatures follow. Research is ongoing to further quantify conditions that lead to injury so that it can be avoided in the future.

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