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Roundup Ready® Alfalfa

A new technology for high plains hay producers

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A New Technology for High Plains Hay Producers

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Weed management in alfalfa involves two distinct phases: weed control during seedling establishment and weed control in established stands. Seedling establishment is the most critical time to control weeds in alfalfa. Infestations during alfalfa establishment increase weed seed reserves in the soil and reduce alfalfa vigor and density. This affects production for the life of the stand. After the crop is established, stands naturally thin over time, which makes the crop increasingly susceptible to weed invasion. Many weeds in established alfalfa have growth habits similar to alfalfa, often making control difficult. These weeds may reduce yield but, more importantly, they reduce forage quality (Miller et al., 2002), which affects animal performance. Weeds such as common lambsquarters, redroot pigweed, and kochia can accumulate toxic nitrate levels; others such as common groundsel, water hemlock, and those in the nightshade family are poisonous and have been known to harm or even kill animals.

Roundup Ready® technology has been successfully incorporated into alfalfa and is approved for use by growers in the United States. Roundup Ready® technology incorporates genetic resistance to glyphosate (N-[Phosphonomethyl]glycine) into alfalfa. This allows glyphosate (Roundup) to be applied over the entire crop to control a wide spectrum of annual and perennial weeds without crop injury. This trait has enabled the development of new weed-control strategies in alfalfa and was jointly developed by scientists at Monsanto Company and Forage Genetics International (Monsanto Company, 1998). Plans include linking the trait with several other important agronomic characteristics such as state-of-the-art pest resistance, forage yield potential, winter hardiness, and forage quality. The trait will eventually be broadly marketed by a range of seed companies.

Roundup Ready® crops have become an important part of many cropping systems.

In the United States in 2005, approximately 28 percent of corn, 91 percent



RR Alfalfa with no herbicide treatment. Alfalfa competes poorly with common lambsquarters and kochia during establishment.

of soybean, and 75 percent of cotton acreage was occupied by Roundup Ready® cultivars (Monsanto Company, 2005). Alfalfa is the nation's fourth most important crop with respect to area, occupying more than 22 million acres (U.S. Department of Agriculture (USDA), 2005). Alfalfa is the primary feed for dairy production and is commonly fed to beef cattle, sheep, and horses.

Roundup Ready® alfalfa offers Wyoming and Nebraska producers several potential benefits over existing technology and includes: 1) enhanced control of Canada thistle, common dandelion, dodder, nutsedge species, and quackgrass; 2) reduced early-season crop injury; 3) greater flexibility because of fewer restrictions on application timing, temperatures, and other environmental influences; 4) more reliable stand establishment, which could lead to improved forage yield and quality; 5) application of an environmentally friendly herbicide with a 30-year history of safe use; and 6) the ability to reduce the spread of noxious weeds in alfalfa hay. With any new technology there are always concerns and these include:





Roundup Ready alfalfa after two applications of Roundup UltraMax II at 22 oz/A.

1) development of herbicide resistance in weed populations because of continuous use of one herbicide; 2) shifts to weed species less susceptible to glyphosate; 3) gene flow from Roundup Ready® to feral alfalfa populations; and 4) potential for reduced market acceptance since this trait will result in the first transgenically enhanced alfalfa product in both domestic and foreign markets (Van Deynze et al., 2004).

University of Wyoming and University of Nebraska researchers began working with Roundup Ready® alfalfa in 2002 under both furrow and sprinkler irrigation. The work was closely monitored by several federal agencies including the USDA’s Animal and Plant Health Inspection Service and the U. S. Environmental Protection Agency. The studies evaluated the influence of Roundup rate and application timing on seedling alfalfa response and weed control and compared these results to several commercial

Table 1.
Roundup Ready® alfalfa response to several herbicide treatments the year of establishment.
 Values presented are the sum of two cuttings and are averaged over trials conducted in 2002 and 2003 at both sites.

Herbicide ¹	Rate	Application timing	Alfalfa			
			Torrington, WY		Scottsbluff, NE	
			Injury	Yield	Injury	Yield
	Oz/A		%	T/A	%	T/A
Roundup	26	cotyledon	0	4.3	0	4.2
Roundup	52	cotyledon	0	4.3	0	4.5
Roundup ²	26+26	cotyledon + 3 wk	0	4.4	1	4.6
Roundup	26	2-leaf	0	4.3	0	4.4
Roundup	52	2-leaf	0	4.3	5	4.1
Roundup ²	26+26	2-leaf + 3 wk	0	4.3	2	4.3
Roundup	26	4-leaf	0	4.0	0	3.9
Roundup	52	4-leaf	0	4.0	0	3.8
Pursuit + Select	4+8	2-leaf	6	3.5	6	4.0
Raptor	4	2-leaf	3	3.6	9	3.7
Weedy Check	---	----	0	2.1	0	1.3

¹The Roundup formulation used was UltraMax. Ammonium sulfate was included at 1.7-pounds per acre with all treatments and X-77 (a non-ionic surfactant) at 0.25 percent with Pursuit or Raptor. ²Treatments applied only in 2003 at Scottsbluff.

Table 2.

Weed control results in Roundup Ready® alfalfa with several herbicides applied the year of establishment. Values presented are averaged over trials conducted in 2002 and 2003 at both sites.

Herbicide ¹	Rate <u>Oz/A</u>	Application timing	Weed control		
			<u>Torrington, WY</u>		<u>Scottsbluff, NE</u>
			Grass	Broadleaf	Broadleaf
			----- % -----		
Roundup	26	cotyledon	94	91	81
Roundup	52	cotyledon	95	93	80
Roundup ²	26+26	cotyledon + 3 wk	100	100	90
Roundup	26	2-leaf	96	96	86
Roundup	52	2-leaf	98	98	83
Roundup ²	26+26	2-leaf + 3 wk	100	100	91
Roundup	26	4-leaf	96	96	74
Roundup	52	4-leaf	99	99	89
Pursuit + Select	4+8	2-leaf	96	80	59
Raptor	4	2-leaf	86	84	79
Weedy Check	---	----	0	0	0

¹The Roundup formulation used was UltraMax. Ammonium sulfate was included at 1.7 pounds per acre with all treatments and X-77 (a non-ionic surfactant) at 0.25 percent with Pursuit or Raptor. Treatments applied only in 2003 at Scottsbluff.

standards. Once these alfalfa stands had been established for 12 to 15 months, the effectiveness of several herbicide treatments to kill Roundup Ready® alfalfa was also evaluated.

Herbicide Efficacy Trials

Regardless of application timing, Roundup treatments caused no injury at the Torrington, Wyoming, site and only slight injury at the Scottsbluff, Nebraska, site (Table 1). A slight yellowing of the leaves occurred at Scottsbluff several days after treatment when air temperatures were near freezing. The symptoms disappeared within four to seven days following application. Raptor® and Pursuit® herbicide treatments resulted in higher injury ratings than glyphosate treatments at both locations; however, crop injury was rated as minor.

Weed control with Roundup in seedling alfalfa was influenced by application timing and rate



Many conventional herbicides labeled for use in alfalfa are ALS-inhibitors. This photo shows ALS-resistant kochia infesting alfalfa after treatment with Raptor at 4 oz/A.





If herbicide treatment is delayed until the 4th trifoliolate stage of alfalfa, weed control can still be achieved with Roundup UltraMax II at 44 oz/A. However, alfalfa stand and vigor has been dramatically reduced from the early-season weed competition. This will result in reduced yield, quality, and stand life.

and differed between locations (Table 2). Weed control was better at Torrington compared to Scottsbluff and was related to weed spectra present. Predominant weeds at Torrington included kochia, redroot pigweed, hairy nightshade, common lambsquarters, longspine sandbur, and green foxtail; the predominant weed species at Scottsbluff was common lambsquarters. Previous research indicated common lambsquarters is one of the more difficult annual weeds to control in Roundup Ready® crops.

Application timing and rate were less important at Torrington compared to Scottsbluff, most likely due to different weed species at the two locations. When Roundup was applied at the cotyledon and two-leaf stage of alfalfa, weed control was improved with a follow-up application three weeks later at both locations (Table 2). At Torrington, this application after the cotyledon or two-leaf stage provided 100-percent weed control. Using a 52-

ounce per acre rate of Roundup UltraMax® did not improve weed control compared to 26 ounces per acre when alfalfa and weeds were small. As weeds became larger and alfalfa progressed to the four-trifoliolate stage of growth, increasing the Roundup UltraMax rate to 52 ounces per acre improved weed control. Weed control with Roundup was equal to or greater than conventional treatments of Raptor, Pursuit, or tank mixes of the two with Buctril® or Butyrac 200® (data not shown). Although weed control was similar, alfalfa injury was usually greater from conventional treatments compared to Roundup.

Alfalfa yields the year of establishment were excellent at both locations and were higher in all herbicide treatments compared to the untreated controls (Table 1). Yield increases in herbicide-treated areas ranged from 1.4 to 3.3 tons per acre (T/A) and were related to both time and level of weed control. Alfalfa yields were highest in Roundup plots where weeds were removed at the two-trifoliolate leaf stage of alfalfa or earlier. Delaying Roundup applications to the four-trifoliolate leaf stage reduced alfalfa yields 0.3 to 0.8 T/A. Alfalfa yields were 0.1 T/A lower to 0.9 T/A higher in Roundup-treated plots compared to conventionally treated plots depending on application timing and herbicide.

Roundup Ready® Alfalfa Removal

Eventually, an alfalfa stand must be removed when production falls to a level the field is not profitable or returns would be greater with a different crop. In some situations, Roundup has been used to remove depleted alfalfa stands; however, it could not be used for this purpose in a field of Roundup Ready® alfalfa. If it could not be adequately removed, unwanted Roundup Ready® alfalfa in subsequent crops could be a potential limitation of this technology. Research conducted at Torrington and Scottsbluff indicates there are several effective methods available to kill Roundup Ready® alfalfa. The methods must be adapted to the specific crop rotation planned.





Table 3.
Roundup Ready® alfalfa control two months following treatment with herbicides alone or in combination with tillage. Values presented are averaged over trials conducted in 2003 and 2004 at Torrington, WY.

Herbicide ¹	Rate Oz/A	Alfalfa Control ²		
		No-tillage	Plow	Chisel plow
Stinger	3	84	100	96
Stinger	4	91	100	99
Stinger	6	93	100	100
Curtail	40	93	100	100
Clarity	4	32	90	85
Clarity	8	37	91	89
Distinct	4	25	88	82
Distinct	8	34	90	87
Clarity + 2,4-D	4+16	76	98	93
Clarity + 2,4-D	8+16	82	100	96
2,4-D	32	88	100	98
Tordon	8	98	100	100
Tordon + 2,4-D	4+16	100	100	100
None	---	0	75	50

¹Herbicide treatments were applied to 6-inch alfalfa regrowth following first or second cutting. The 2,4-D formulation used in the study was the isoctyl ester.

²Tillage treatments were performed one month following herbicide application.

Herbicides are most often used in combination with tillage (plow, offset disk, or chisel plow) for removal of thinned stands. Alfalfa control with several herbicides alone or in combination with tillage is presented in Table 3. Control with the various herbicide treatments without tillage ranged from 25 to 100 percent and was greatest with Tordon® plus 2,4-D and lowest with Clarity® and Distinct®. Treatments containing 2,4-D, Tordon, Curtail®, or Stinger® provided 83-percent or higher alfalfa control without tillage, 100-percent control when plowed, and 96- to 100-percent control when chisel plowed. They should provide acceptable removal of Roundup Ready® alfalfa in nearly any situation.

The important point to remember with both Stinger and Tordon is the rotational restrictions.

Pea, lentil, potato, and dry bean cannot be planted until 18 months following application of Stinger or Curtail. Tordon at 4 or 8 ounces per acre will carryover for more than one year. Only grass crops can be planted the year following application. Sunflower, dry bean, and potato are especially sensitive to Tordon and probably should not be planted for several years following application. Clarity and Distinct were the least effective treatments in removing Roundup Ready® alfalfa stands; however, control was greatly improved by adding tillage and should provide acceptable control in a competitive cropping system involving small grains. An application of 2,4-D followed three to four weeks later by tillage will likely provide adequate alfalfa removal while resulting in the least potential for carryover.



Summary

Roundup Ready® alfalfa received regulatory approval in July 2005. This technology combines the insertion of a gene conferring resistance to glyphosate in alfalfa varieties with over-the-top application of this broad spectrum herbicide for weed control. It is likely to expand weed-control options available for alfalfa growers potentially enhancing yield, forage quality, and profitability. Economic benefits will be determined by pricing structure for this technology. There are potential environmental benefits compared to current registered herbicides, since glyphosate is short-lived in the soil, has negligible soil activity, and a low mammalian toxicity. The major concerns associated with this technology include potential shifts in the weed spectrum to more tolerant species, weed resistance, and gene flow to feral alfalfa during seed production. Roundup Ready® alfalfa is being extensively evaluated by public and private researchers to develop management protocols and address environmental concerns. This technology provides an additional management tool for growers with the principle features being its ease of use, flexibility, and broad spectrum weed control.

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