

Introduction

Effective weed management in alfalfa is critical not only for the production of high-quality, weed-free forage but also for enhancing stand establishment and persistence by eliminating weed competition. The development of Roundup Ready alfalfa (RRA) provides a significant option for effective weed control with no measurable damage to the alfalfa (see Guide A-337, *Recommendations for Roundup Ready Alfalfa Weed Management and Stand Removal in New Mexico*, http://aces.nmsu.edu/pubs/_a/A337.pdf). Glyphosate, the active ingredient in many commercially available herbicides such as Roundup, is the world's most widely used herbicide due to its cost-effective, broad-spectrum weed control and environmental safety (it readily breaks down in the soil leaving no residues).

Nonetheless, RRA is a genetically modified crop, and without proper management, gene flow (the movement of pollen from plant to plant) from RRA could contaminate organic or conventional non-RRA alfalfa hay, with possible legal ramifications. Additionally, RRA seed and seed grown for organic production could become commingled during processing prior to sale. To allay concerns about gene flow from RRA and to promote coexistence, the Council for Agricultural Science and Technology has prepared a publication based on scientific research entitled *Gene Flow in Alfalfa: Biology, Mitigation, and Potential Impact on Production* (can be purchased at http://www.cast-science.org/publications/?gene_flow_in_alfalfa_biology_mitigation_and_potential_impact_on_production&show=product&productID=2940).

The Mechanism of Gene Flow

Genes do not move from plant to plant like a contagious disease. Gene flow in alfalfa mostly occurs when an insect “trips” the flower, thus releasing pollen grains (Figure 1) that adhere to the insect. When the insect flies to other alfalfa flowers, pollen grains become



Figure 1. Untripped alfalfa flower (a), pollinator on alfalfa flower (b), and tripped alfalfa flower (c). Photos (a) and (c) courtesy of Plant and Soil Sciences Department, Oklahoma State University. Photo (b) courtesy of USDA Agricultural Research Service.

¹Roundup and Roundup Ready are registered trademarks of Monsanto Technology LLC. Roundup Ready alfalfa varieties are proprietary to Forage Genetics International.

²Respectively, Forage Agronomist, Agricultural Science Center at Tucumcari; Extension Agronomist, Agricultural Science Center at Clovis; and Extension Weed Specialist, Department of Extension Plant Sciences, New Mexico State University.

dislodged, fertilizing that flower and initiating seed production. Insects (generally a few species of bees) are an integral part of alfalfa seed production, which constitutes only about 1% of the US alfalfa acreage and is concentrated in California and the Pacific Northwest. Despite this limited acreage, gene flow has always been a significant issue to maintain varietal purity in alfalfa seed production. Therefore, seed certification standards have been developed by the Association of Official Seed Certifying Agencies (AOSCA; <http://www.aosca.org>), and isolation has long been required to maintain seed purity. A coalition that includes Forage Genetics International, who contracts producers for RRA seed production, has developed a publication entitled *Best Management Practices for Roundup Ready Alfalfa Seed Production* (<http://www.alfalfa.org/pdf/CSBMPForRRA.pdf>) that requires increased isolation distances based on how far particular species of bees can fly. Other guidelines in that publication include instructions to prevent comingling of harvested seed. Furthermore, there are only a limited number of RRA seed producers, and none are located in New Mexico. Additionally, the possibility of comingling seed is further limited because these producers are different than the companies that handle only organically certified seed.

Recommendations for Managing Roundup Ready and Conventional or Organic Alfalfa Hay in Nearby Fields in New Mexico

Preventing gene transfer between alfalfa hay fields, which account for 99% of the US alfalfa acreage, is simpler than preventing gene transfer between alfalfa seed fields and is to the hay grower's advantage. Whether RRA or conventional or organic alfalfa is grown, the hay nutritive value declines with plant maturity (the onset of flowering and seed production), greatly reducing the dollar value of the hay. Therefore, harvesting the alfalfa before it blooms not only decreases the likelihood of gene flow but also maintains the higher nutritive value of the alfalfa and, therefore, its monetary value.

Licensing Requirements

Monsanto, the company that developed the Roundup Ready technology, requires RRA hay producers to sign their Technology Use Agreement and follow the requirements in their Technology Use Guide (https://www.genuity.com/stewardship/Documents/2011_TUG.pdf). Those requirements include (a) planting RRA in wildlife food plots is forbidden; (b) all RRA field locations must be identified with GPS coordinates; (c) forage from RRA fields must be harvested before 10%

bloom, labeled to prevent comingling with non-RRA forage if it is to be exported out of the US, and not sold in countries where the importation of genetically modified crops is prohibited (labeling requirements do not apply to forage to be used in the US); and (d) RRA hay fields are not to be harvested for seed (RRA seed production is only by contract with Forage Genetics International and Monsanto [<http://www.monsanto.com/ourcommitments/Pages/seed-patent-protection.aspx>]).

Harvest Timing

Everyone should keep in mind that protecting the integrity of alfalfa hay is the responsibility of both RRA and conventional or organic growers. Proper management that optimizes forage yield and quality by harvesting at bud or first flower is the simplest means of protecting crop integrity for all alfalfa growers. Harvesting all RRA and conventional or organic alfalfa fields for hay before the alfalfa reaches 10% bloom will minimize pollen production and the presence of natural pollinators and considerably reduce the possibility of RRA pollen flow into fields where it is unwanted. It also is important to prevent pollen flow to or from any volunteer alfalfa plants in the area, whether or not they have the Roundup Ready genetics, to lessen the possibility of uncontrolled RRA seed production.

To determine the harvesting time of alfalfa, monitor the growth stage of the plants regularly by gently pinching the tips of a few stems. When a 1/10-inch diameter ball (BB-sized) is felt at the stem tip, the alfalfa is in pre-bud stage and will soon be at the bud stage. As soon as the alfalfa reaches the bud stage (Figure 2) or the first flower is visible, it can be harvested to optimize forage yield and nutritive value. Root carbohydrates at that time also will be sufficient to promote rapid alfalfa regrowth and stand persistence.

Delayed Harvest and "Contaminated Crops"

It should be a very rare occasion that harvest is delayed for 4 to 6 weeks after flowering (which can allow for production of viable seed) in either an RRA or a conventional or organic alfalfa field. Nonetheless, any seed that might be produced and dropped in the alfalfa field would likely die upon germination because established alfalfa releases compounds into the soil that are toxic to alfalfa seedlings. Additionally, any "contamination" is removed as soon as the topgrowth of the alfalfa is removed because gene flow only takes place through fertilization and seed production and does not move into other plant parts. The stand itself remains unaffected and the next regrowth starts out without any contamination. An example from livestock breeding genetics may help make the point: A farmer has purebred Black Angus cows and

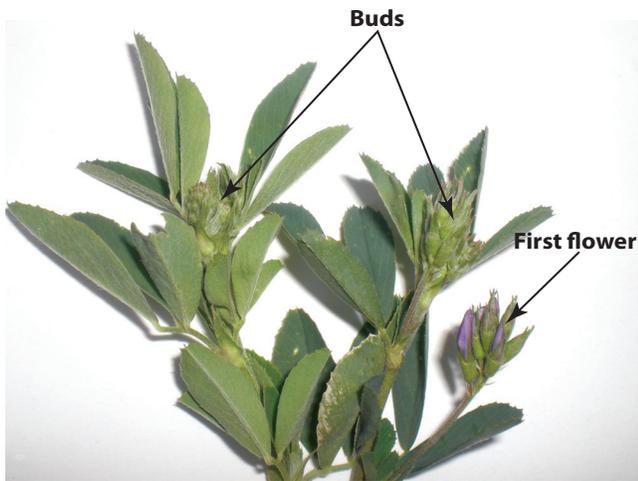


Figure 2. The near-optimum time for alfalfa harvest, the bud to first flower stage.

a purebred Hereford bull. Their offspring will be black with white faces, but the mother cows' faces don't turn white, and if they are bred the next time to a purebred Black Angus bull, the calves will all be purebred Black Angus. Hence, the mother (likened to the original, non-RRA plant) is not genetically altered by having the crossbred calves.

Final Thoughts for Management

Good stewardship should be used by everyone involved—those wanting to use RRA as well as those not wanting it to affect their operation—so that the two can be grown in nearby fields. The use of RRA and Roundup can provide effective weed control with lower toxicity to applicators as well as reduced use of potentially environmentally damaging herbicides, but only when label advisories and directions for use are followed. Con-

sequently, Monsanto discourages the use of Roundup Ready technology by growers who will not or cannot commit to EPA restrictions and practices that prevent gene flow and the development of herbicide-resistant weeds. Key components of coexistence include talking across the fence, understanding your neighbors' goals, following best alfalfa management practices in your area (regardless of the alfalfa variety), and coming to an agreement on what is best for all parties involved.

The deregulation of Roundup Ready alfalfa by USDA does not preclude restrictions at the local level. While there are currently no such restrictions in New Mexico, Forage Genetics International, with assistance from the National Alfalfa and Forage Alliance (<http://www.alfalfa.org/pdf/GOZseed.pdf>), has worked with at least one grower group in southern California to develop regulatory agreements (<http://hayandforage.com/hay/alfalfa/no-rr-alfalfa-in-imperial-valley-0209/>).

For more specific information about managing RRA, see Guide A-337, *Recommendations for Roundup Ready Alfalfa Weed Management and Stand Removal in New Mexico* (http://aces.nmsu.edu/pubs/_a/A337.pdf). This and other publications about management of alfalfa and other forages can be found at the resources page of NMSU's forage website (<http://forages.nmsu.edu/resources.html>) or your county Cooperative Extension Service office.



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