

# GMO Forages: Roundup Ready Alfalfa

Extension In-Service Training  
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# NMSU Resources

**Managing Roundup Ready<sup>1</sup> and Conventional or Organic Alfalfa Hay in Nearby Fields in New Mexico**

Guide A-336

Leonard Lauriault, Mark Marsalis, and Jamshid Ashigh<sup>2</sup>

Cooperative Extension Service • College of Agricultural, Consumer and Environmental Sciences

## 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](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](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.

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

<sup>2</sup>Respectively, 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.

To find more resources for your business, home, or family, visit the College of Agricultural, Consumer and Environmental Sciences on the World Wide Web at [aces.nmsu.edu](http://aces.nmsu.edu)

**Recommendations for Roundup Ready<sup>1</sup> Alfalfa Weed Management and Stand Removal in New Mexico**

Guide A-337

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## 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 (Table 1). 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). Roundup can be used on RRA at any growth stage (including establishment) for effective weed management with minimal restrictions on harvesting as hay or grazing (5 days) or crop rotations (30 days prior to planting the next crop).

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](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

**Table 1.** Effectiveness of Selected Post-Emergence Herbicides for Weed Control in Seedling (late summer seeded) and Established Roundup Ready Alfalfa<sup>a</sup>

Weed	Herbicide				
	Glyphosate	Bacitracin	Butyrac	Pursuit	Raptor
Weed Control Rating					
Common lambsquarters	9	9	9	8	8 <sub>a</sub>
Curly dock	9	N	6	8	8
Common chickweed	9 <sub>a</sub>	6	6	8 <sub>a</sub>	8 <sub>a</sub>
Shepherd's purse	9	9	9	8 <sub>a</sub>	9
Alfalfa Tolerance Rating					
	0	2+	1+	1	1
Weed Control Rating	Alfalfa Tolerance Rating				
10 = 95-100%	0 = No injury				
9 = 85-95%	1 = Rarely significant				
8 = 75-85%	2 = Damage evident				
7 = 65-75%	3 = Significant injury				
6 = 55-65%					
5 = 45-55%					

N = No control

<sup>a</sup>Source: Dillehay and Curran (2006).

seed production is only by contract with Forage Genetics International and Monsanto (<http://www.monsanto.com/ourcommitments/Pages/seed-patent-protection.aspx>).

## Availability and Selection of Roundup Ready Alfalfa Varieties in New Mexico

Similar to conventional varieties, the RRA varieties vary in their performance and levels of pest resistance and are available in a broad range of fall dormancy categories. Table 2 lists the varietal characteristics and relative performances of RRA varieties tested from

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<http://forages.nmsu.edu>



# Alfalfa Herbicide Options

## Roundup Ready Alfalfa

- Resistant to Glyphosate Herbicide
  - Broad-spectrum weed control
    - Grasses & broadleaves
    - Over-the-top at any growth stage
    - High quality hay / extend life of stand
  - Relatively low herbicide cost \$
    - **Can use generic glyphosate now**
  - Potentially fewer chemicals used
    - Glyphosate (low residual ; low toxicity)
    - Reduced environmental impact
  - Similar management to conventional

\* Always read and follow herbicide label for precautions and restrictions. Check supplemental labels.



# Roundup Ready Alfalfa

- Crops are made Roundup Ready (RR) by genetically inserting a single bacterial gene that modifies EPSP synthase
  - Enzyme essential for plant growth
  - Enhances this gene so that it is not disrupted by the mode-of-action of glyphosate
    - Aromatic amino acid synthesis (Group 9)
- Glyphosate can be sprayed at any growth stage of the alfalfa



# History of Roundup Ready Alfalfa

**1999** – Monsanto licensed the Roundup Ready gene to Forage Genetics International

**2003-04** – Monsanto filed petitions with APHIS for deregulation of Roundup Ready alfalfa. APHIS requested more information.

**2005** – APHIS and FDA gave approval for deregulation of Roundup Ready alfalfa.

**2006** – Lawsuit filed alleging that APHIS did not follow correct procedure in collecting information

[Environmental Impact Statement (EIS) instead of the Environmental Assessment (EA)].



# History of Roundup Ready Alfalfa

**2007** – Judge ordered APHIS to **regulate** RRA again

- Follow more intense procedure for collecting information
- Develop protocol to harvest, store, and transport of seed or forage
- Over 200,000 acres nationwide
- 20,000 acres in NM, CO, UT, WY, and MT, probably much less than 5,000 in NM due to the drought





# History of Roundup Ready Alfalfa

**June - December 2010 –**

US Supreme Court reverses lower court ruling

APHIS completed information collection and prepared EIS.

**January 2011 –**

APHIS **deregulated** Roundup Ready alfalfa with no restrictions.

Monsanto reported that Roundup Ready alfalfa seed would be available in Spring 2011.

**Since January 2011 –** More lawsuits filed and dismissed.



# Roundup Ready Alfalfa

## Stewardship

- 1) Sign a Technology Use Agreement
- 2) RRA forage fields cannot be harvested for seed (contract only);
- 3) RRA forage should be harvested when or before it reaches 10% bloom (a very good hay management practice, anyway)
- 4) ~~RRA fields have to be identified by GPS coordinates~~ and be at least 5 miles from any non-RRA seed field
- 5) If export, labeled to prevent comingling with non-RRA
- 6) Not planted for wildlife food plots, sprouts, or on Federal Lands





# Roundup Ready Alfalfa

## Benefits

- Environmental Benefits
  - Water quality
    - Roundup could replace some herbicides that have greater potential for water contamination
    - Very low leaching ability
    - Very little evidence of off-site environmental impacts with glyphosate
  - Preventing spread of noxious weeds
    - More effective control limits spread of invasive weeds
    - Could aide in providing ‘weed-free’ alfalfa hay for forage
      - Animals can help the spread of weed seed as well...



# Roundup Ready Alfalfa

## Benefits

- Glyphosate
  - Roundup is the most widely used herbicide nationwide
    - **Inexpensive (can help reduce production costs)**
    - **No plantback restrictions**
    - Readily available (many generic formulations)
    - Low leaching potential or off-site impact
- Developed heavy reliance on glyphosate for weed control...





# Effective Persistence in Soil

Established Alfalfa

**Spring**

**In-Season**

Pre-emergent

Post-emergent

Follow-up

**PROWL<sup>®</sup> H<sub>2</sub>O**  
herbicide

**Pursuit<sup>®</sup>**  
Herbicide

**SELECTMAX<sup>®</sup>**  
herbicide  
www.selectmax.com

**Treflan<sup>®</sup>**  
TR-10<sup>®</sup>  
GRANULAR HERBICIDE



**Raptor<sup>®</sup>**  
herbicide



4 to 6 months

1 to 3 months

0 months

Rotation Restrictions

Up to 18 months

Up to 18 months

0 to 1 month

# Comparable Weed Control Options

Established Alfalfa

**Spring**

**In-Season**

Pre-emergent

Post-emergent

Follow-up

**PROWL<sup>H<sub>2</sub>O</sup>**  
herbicide

**Treflan<sup>®</sup>**  
TR-10<sup>®</sup>  
GRANULAR HERBICIDE



**Pursuit**  
Herbicide

**Raptor<sup>®</sup>**  
herbicide



**SELECTMAX<sup>®</sup>**  
herbicide

**Poast<sup>®</sup>**  
herbicide

**\$15-20/ac**

**\$15-23/ac**

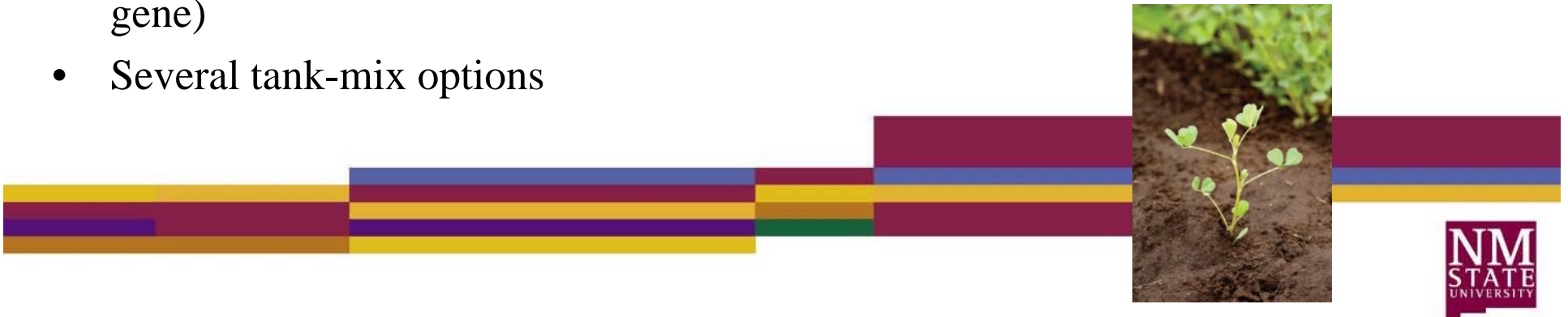
**\$13-15/ac**



# Roundup (PowerMax, 48.7%)

Generic Glyphosate (% a.i. may not be the same)

- Up to 44 oz./A per application, 5.3 quarts per year (4.1 quarts per year for in-season applications)
- Monsanto approves any generic glyphosate (as long as labeled for alfalfa) in lieu of Roundup (33-45% less cost per acre at same rate)
  - Roundup, \$12.50/A; Generic, \$7.50/A per 44 oz./A
- Better weed coverage while alfalfa is small/before regrowth
- **5 days pre-harvest interval**
- One application recommended for Roundup Ready alfalfa seedlings, 22 oz./A, **at or before** 4-trifoliate leaf stage to remove non-RR seedlings (low % without gene)
- Several tank-mix options



# RRA Crop Safety

Yield in seeding year of Roundup Ready alfalfa managed in two weed control systems (Wisconsin, 2006). Source: Rankin, M. Is Roundup Ready Alfalfa Worth the Investment. Univ. Wis. Extension (<http://www.uwex.edu/ces/crops/RRAlfalfa07.htm>)

Variety	Marshfield		Lancaster	
	Glyphosate <sup>1</sup>	Conventional <sup>2</sup>	Glyphosate	Conventional
-----Tons/acre-----				
425RR	1.91	1.68		
4G18RR	2.00	1.76	4.79	4.08
6443RR	2.04	1.61	4.75	4.06
DK41-18RR	1.82	1.71		
Liberator RR	1.95	1.72		
WL355 RR	2.02	1.74		
MEAN <sup>3</sup>	1.93	1.70	4.77	4.07
Difference		0.25	0.77	

1 Roundup Weathermax applied at 44 oz/a at 4<sup>th</sup> trifoliolate

2 Raptor and Poast Plus applied at 6 oz/a and 24 oz/a respectively at 4<sup>th</sup> trifoliolate

3 Marshfield cut 2X, Lancaster cut 3X



# Alfalfa Establishment

## Historical Recommendation

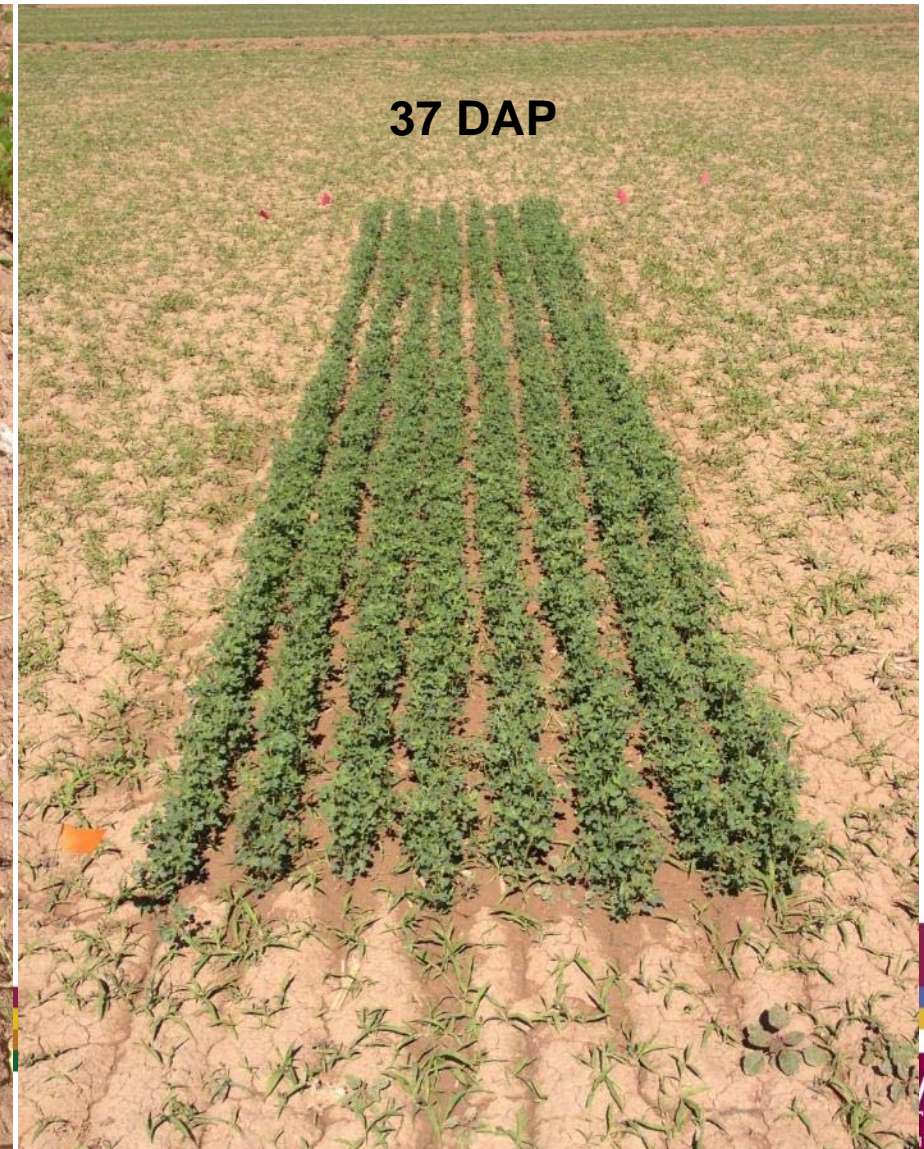
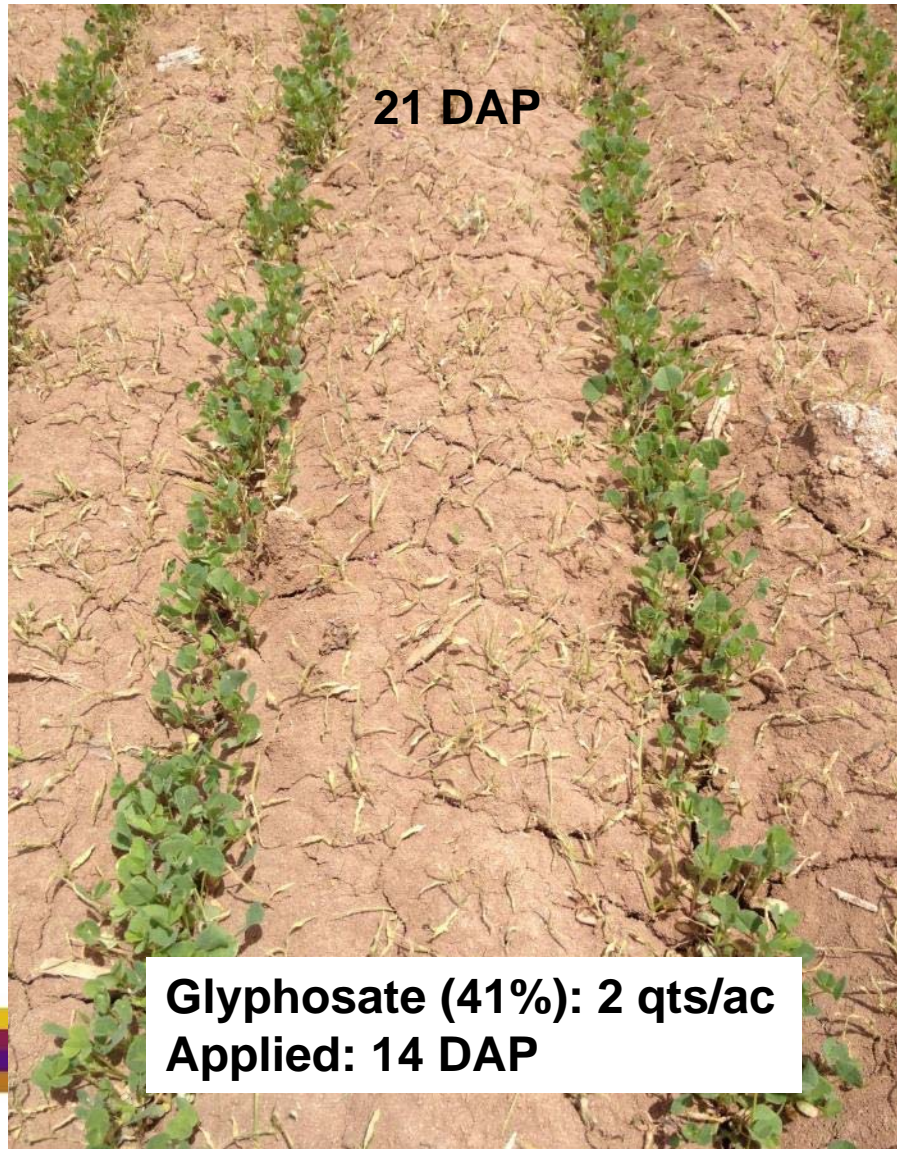
- Don't plant in spring: wrong time
  - Too many weeds and competition
  - Too hot/stressful; same irrigation as established stand
  - Lower 1<sup>st</sup> year total yield





# Alfalfa Planting Date Studies (RRA)

May 12





# Concerns about Roundup Ready Alfalfa

- Gene flow affecting non-Roundup Ready varieties, especially for seed production and the organic market.
- Higher seed cost due to the Tech Fee (\$125/bag).
- Possible yield drag; little independent yield data available due to previous regulated status.
- Stand replacement – how to destroy established Roundup Ready alfalfa.
- Potential to develop herbicide resistant weeds.



# Roundup Ready Alfalfa

## Concerns

- Gene flow to the environment
  - Can these RR genes (introduced through biotechnology) be passed to other plants in nature?
  - Affected by multiple factors
    - Sexual compatibility, flower characteristics, pollen viability, pollinator activities, proximity of neighboring plant, environmental conditions
  - Currently no sexually compatible wild relatives to alfalfa in US
    - Can cross with feral alfalfa





Is it easy to 'contaminate' this field with pollen from a nearby Roundup Ready alfalfa field?





# Concerns about Roundup Ready Alfalfa

- Gene flow affecting non-Roundup Ready varieties, especially for seed production and the organic market.



# Roundup Ready Alfalfa

## Concerns

- Market acceptance of RR hay
  - Genetically enhanced product that is marketed commercially
  - Forage for beef and dairy industry
    - Largest animal consumers of forage crops
    - Depends on market for organic hay
    - Resistance to GMO (e.g., horse market)
  - Possibility for ‘weed-free’ forage may help market acceptance



- Test kits available online
  - Simple, easy-to-use
  - Qualitative visual (5 minutes)
  - Specific to alfalfa hay
    - Protein detection (CP4 EPSPS)
    - 0.1% level (w/w basis)
    - \$4-5 per sample





# Alfalfa Seed Cost

Alfalfa seed prices (per lb.) from selected companies in 2012.

Seed class	Non-organic	Organic	Cost 20 lb/ac
RR Cultivar	\$7.00 - \$8.30	-----	\$153
Conventional cultivar	\$2.90 - \$6.00	\$4.76	\$90
Conventional VNS	\$3.60	\$3.80	\$74

Average varietal yield differences (tons/acre) in New Mexico and value of the difference per year at the average 2012 price of \$271/ton in NM.

Location	Average of top yielders	Average of bottom yielders	Yield difference	Value of difference (2012)
Farmington, 08-11	9.40	8.72	0.68	\$184.28
Los Lunas, 08-11	7.34	6.78	0.56	\$151.76



# Roundup Ready Alfalfa

## Concerns

- More Variety Testing Needed
  - None of the current Roundup Ready varieties has been broadly tested in New Mexico.
  - Yield advantage? Quality advantage?
  - Stand longevity?
  - NMSU: 80-110% of test average (yield)



## Performance of Roundup Ready alfalfa varieties across years and tests in New Mexico.

Variety	Proprietor	Artesia						Tucumcari						Los Lunas	Mora	Farmington		
								2005			2012 <sup>1</sup>							
		2006				2013	2014				Std <sup>3</sup>		RR <sup>4</sup>		2013	2013	2012	
		07 <sup>2</sup>	08	09	10	14	14	06	07	08	13	14	13	14	14	14	12	13
DKA41-18RR	Monsanto																	
ALF6R100	Eureka Seeds		*															
R65BD277	Forage Genetics Int'l	*	*		*													
R65BD278	Forage Genetics Int'l	*	*		*													
R65BD279	Forage Genetics Int'l	*	*		*													
R65BD280	Forage Genetics Int'l	*	*															
WL550RR	W-L Research		*															
54QR04	Pioneer HiBred Int'l											*		*				
54VR03	Pioneer HiBred Int'l															*		
55VR05	Pioneer HiBred Int'l						*								*			
Transition 6.10RR	Croplan Genetics													*				
WL454HQ.RR	W-L Research											*		*				
R57A136	Forage Genetics Int.												*	*				
R57K138	Forage Genetics Int.													*				
R57OK216	Forage Genetics Int.													*				
R57OK217	Forage Genetics Int.													*				
R57W213	Forage Genetics Int.													*				
R58HG236	Forage Genetics Int.													*				
R65BD277	Forage Genetics Int.													*				
R65BD278	Forage Genetics Int.												*	*				
R65BD279	Forage Genetics Int.													*				
R66BX311	Forage Genetics Int.													*				
RR57K337	Forage Genetics Int.												*	*				

<sup>1</sup> Establishment year.

<sup>2</sup> Harvest year.

Shaded boxes indicate that the variety was not in the test.

\*\* Highest yielding variety in the test for that year.

\* Not significantly different from the highest yielding variety in the test for that year.

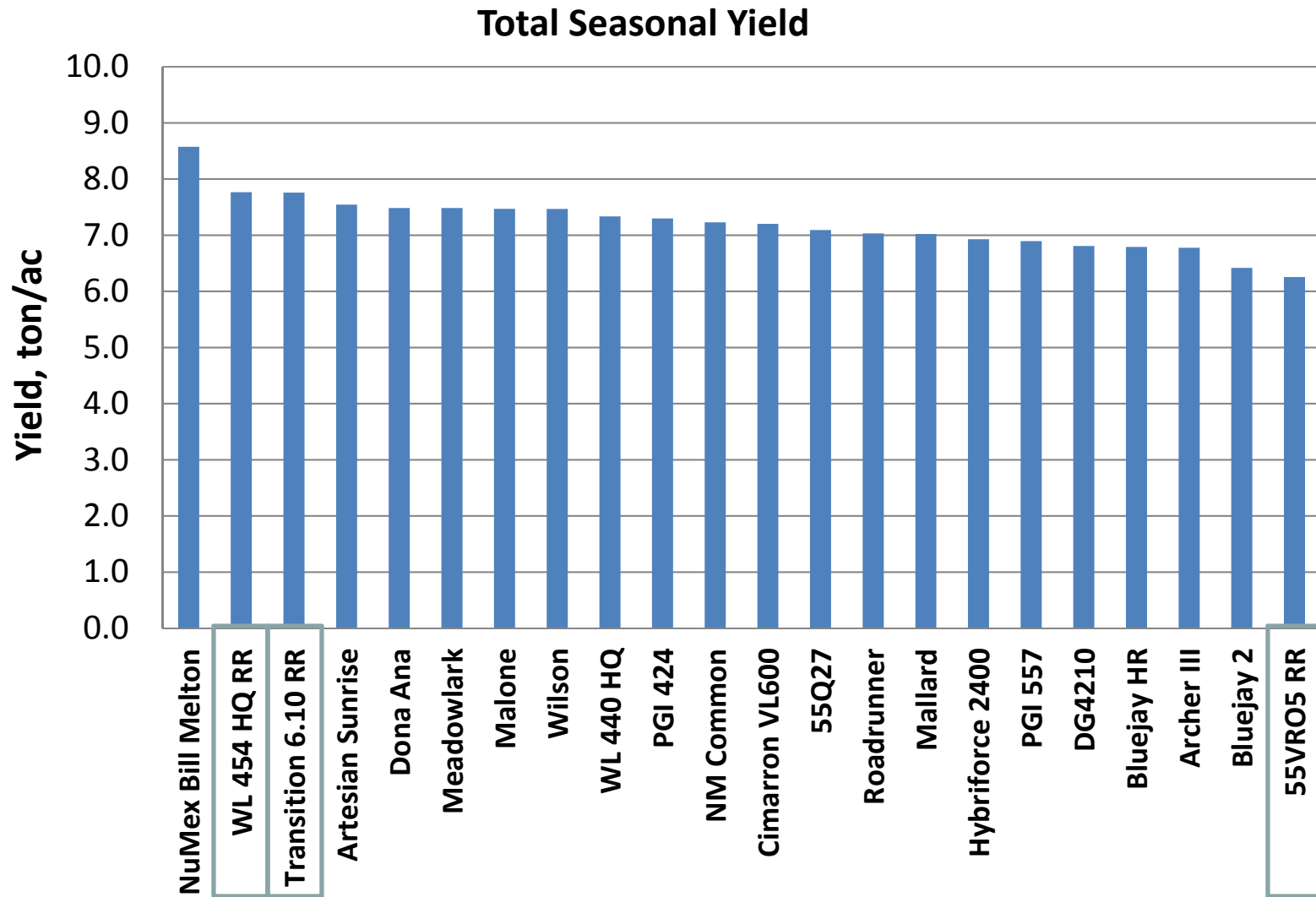
Leonard Lauriault, Ian Ray, Chris Pierce, Owen Burney, Robert Flynn, Mark Marsalis, Mick O'Neill, and Curtis Owen





# Alfalfa Variety Trial (2 yrs)

ASC at Los Lunas



# NAFA Leaflet Guide (2015)

Varieties/Hybrids that are RR

Alfalfa FD	RR	Non-RR
4	16	62
5	9	19
6	5	13
7	2	5
8	5	12
9	5	14
10	1	4
	43	129



# Roundup Ready Alfalfa

## Stand Removal





**Table 3. Roundup Ready alfalfa stand removal prior to no-till corn<sup>1</sup>** (From: Dillehay, B.L., and W.S. Curran. 2006 Guidelines for weed management in Roundup Ready alfalfa. Agronomy Facts 65. Crop and Soil Sci., Penn. State Univ. (<http://cropsoil.psu.edu/extension/facts/agronomy-facts-65>)).

Herbicide(s) <sup>2</sup>	Rate	Alfalfa
2,4-D LV4	1 pt/A	7+
dicamba	1 pt/A	8
2,4-D LV4 + dicamba	1 + 1 pt/A	9
2,4-D LV4 + dicamba	1 + 0.5 pt/A	8+
2,4-D LV4 + dicamba	0.5 + 1 pt/A	8
2,4-D LV4 + dicamba	0.5 + 0.5 pt/A	8
Clopyralid (Stinger)	8 oz/A	9

<sup>1</sup> Follow label guidelines.

<sup>2</sup> Herbicide should be applied to alfalfa with at least 10 inches of spring growth or after 6 inches of alfalfa regrowth.

#### Alfalfa Control Rating

10 = 95-100%

9 = 85-95%

8 = 75-85%

7 = 75-65%

6 = 65-55%

5 = 55-45%



Declining alfalfa stand prior to the last cutting, and to be removed from the crop rotation. A late summer to early fall preharvest treatment can provide better stand removal than a treatment applied after harvest.







# Roundup Ready Alfalfa

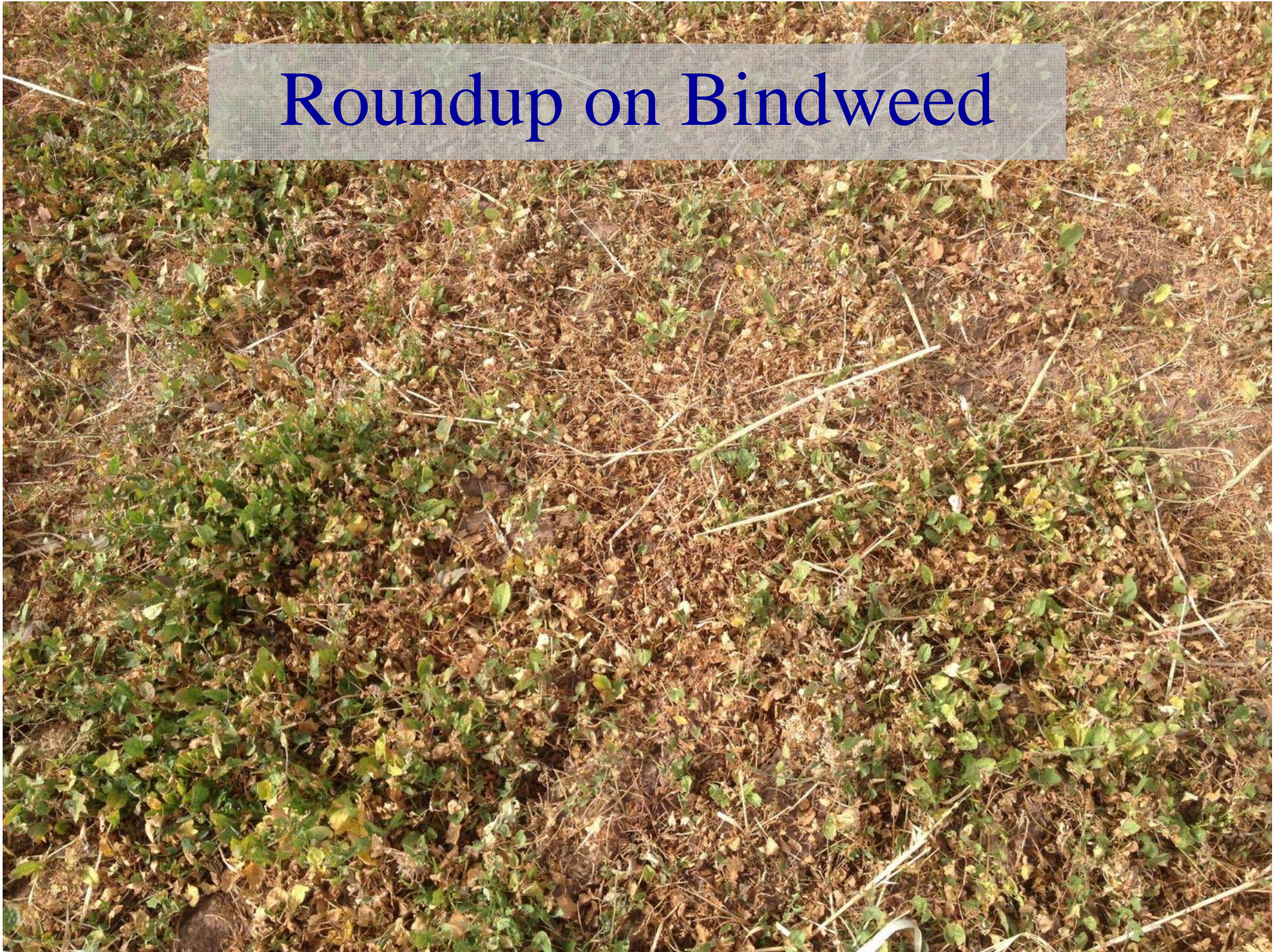
## Concerns

- Weed control limitations
  - Though broad spectrum, glyphosate does not effectively control all weeds in all situations
    - Common mallow, morningglory, horsenettle, milkweed, fillaree, burclover, marestail, groundcherry, dandelion, white and red clover, bindweed, nutsedge, some mustards, kochia, Russian thistle, etc.





# Roundup on Bindweed





# Plantain –

*[Plantago spp.]*

- Perennial weed
  - Buckhorn & Broadleaf species
  - Dense crown, strong taproot
  - Difficult to control (Rotations)
    - Tillage can be effective (deep)
  - Dry conditions favor plantain
- Options (alfalfa)
  - Crop Rotation
    - Cereal crops (wheat)
    - Plow + 2,4-D (multiple applications; fall)
  - Chemical Control
    - **Post-: Roundup (Fair to Good): RRA only**
    - Pre-: Velpar: Dormant season treatments



\* Always read and follow herbicide label for precautions and restrictions. Check supplemental labels.



# Nutsedge –

[*Cyperus spp.*]

- Perennial weed
  - Difficult to control (Rotations)
  - Excessive irrigation
  - Lack of competition
- Chemical Options (alfalfa)
  - Pre-emergence
    - Eptam (EPTC)
    - Zorial (Norflurazon)
  - Post-emergence (suppression)
    - Pursuit/Raptor (BL + Grasses)
    - **Roundup (RR Alfalfa Only)**
      - Control ??



\* Always read and follow herbicide label for precautions and restrictions. Check supplemental labels.



# Roundup Ready Alfalfa





# Roundup Ready Alfalfa





# Roundup Ready Alfalfa

## Concerns

- Caution!
  - Herbicide resistance is on the increase
  - Palmer amaranth and others
  - Rotate herbicide 'mode of actions'
    - Break out of the glyphosate cycle on occasion
  - Inspect fields regularly
    - Mechanically remove any survivors



# Roundup Ready Alfalfa

**Table 3. Mode of Action Groups for Herbicides Labeled for Alfalfa in New Mexico\***

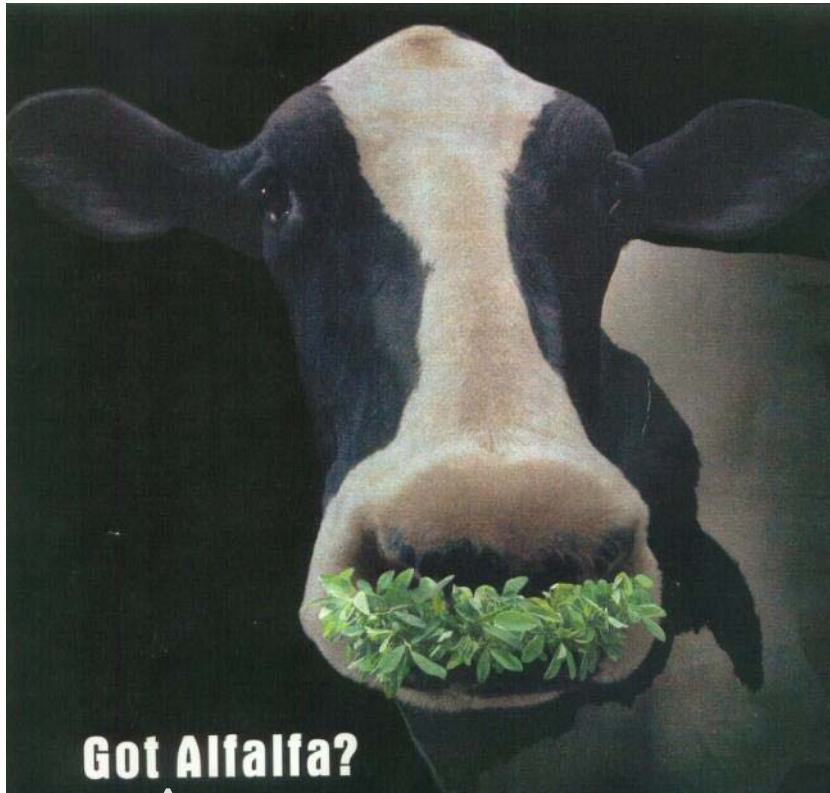
Mode of Action Group	Herbicides
1 ACCase grasskillers	Clethodim, Poast, Poast Plus, Select 2E, Select Max
2 ALS/AHAS inhibitors	Pursuit, Raptor, Sandea
3 Microtubule assembly inhibitors	Balan DF, Prowl H <sub>2</sub> O, Treflan 4EC, Treflan 4L, Treflan HFP, Treflan TR-10, Kerb 50W
4 Synthetic auxins	Butoxone 200, Butoxone 7500, Butyrac 200, MCPA amine 4
5 Photosynthetic inhibitors – triazines	Lexone 75DE, Sencor 4E, Sencor 75DE, Sinbar, Velpar
6 Photosynthetic inhibitors – nitriles/benzothiadiazoles	Buctril, Buctril 4EC
7 Photosynthetic inhibitors – ureas/amides	Karmex DF
8 Lipid synthesis inhibitors	Eptam 7E
9 EPSP synthase inhibitors	Roundup and other glyphosate products
12 Carotenoid biosynthesis inhibitors	Solicam DF
14 PPO inhibitors	Chateau, ET Herbicide
22 Photosystem I inhibitors	Gramoxone Extra
27 Unknown	K-PAM HL, Metam CLR 42%, Scythe



\*Adapted from Weed Science Society of America, *Weeds Resistance Education and Action Program* (<http://wssa.net/Weeds/Resistance/WREAP.pdf>). New herbicides do not necessarily have a unique mode of action and may fall within the groups listed in the charts. Herbicides that have the same mode of action may not control the same weed spectrum. Other trade names with the same active ingredient may be available on the market.



# Got Questions?



**Got Alfalfa?**  
^  
Roundup  
Ready

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