

ROUNDUP-READY ALFALFA: The Long and Winding Road

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INTRODUCTION

Alfalfa is the fourth largest crop in both acreage and economic importance in the United States, with over 20 million acres of alfalfa hay grown nationwide (USDA-NASS data). It is principally grown for consumption by dairy animals, but a portion is used by horses, beef cows, sheep and goats. Western states, from Colorado west, account for about 42%, Midwest states 50%, and Eastern states 8% of US alfalfa hay production. Alfalfa is California's largest acreage crop, and alfalfa hay production is greater in CA than in any other state.

Genetic engineering (GE) has had a major impact on the major US-grown field crops, particularly corn, soybean, and cotton, which have had very high rates of adoption of both Glyphosate-Tolerant (GT), and *Bacillus thuringiensis* (BT) traits. GT-Tolerant alfalfa, also known as Roundup-Ready Alfalfa (RRA) has had a major effect on herbicide options for alfalfa growers during the past 6 years, but has also had a checkered legal and regulatory history. This paper reviews the history and the issues surrounding the introduction of Glyphosate-Tolerant (also known as Roundup-Ready) Alfalfa (RRA) through early 2011.

INTEREST BY THE INDUSTRY

There have been some claims that a small minority (7%) of US alfalfa fields receive herbicides (USDA-NASS data, Center for Food Safety statements on website), and thus there is little need for this technology. However, this is certainly not true of California alfalfa fields. California alfalfa fields had 1.4 million acres with herbicides applied in 2009 (CA-DPR, Pesticide Use Reporting) – this alone is 7% of the US alfalfa acreage, indicating that the 7% figure on a national basis is highly suspect. I estimate that a minimum of 90% of California alfalfa fields have herbicides at some point during their lifetime, importantly for stand establishment. Current herbicide strategies have been effective in many environments, but have limitations in terms of crop injury, restrictions due to rainfall, temperature and growth stage, and groups of weeds that are controlled, as well as environmental impacts on water quality. Thus there has been considerable interest among alfalfa growers in this technology. Interest in RRA has been keenest by growers who have had difficulty in controlling weeds such as nutsedge, dodder, common groundsel and dandelion which are not easily controlled by other methods.

ROUNDUP-READY ALFALFA SAGA-Regulation, Lawsuits, and Science

The introduction of GT alfalfa began with the transformation of the first GT lines in 1997 (Table 1). The first RRA varieties were released by Forage Genetics International in 2005 after USDA-APHIS deregulation, but production was halted in 2007 due to a lawsuit that stopped

further plantings (APHIS, 2007). The risks of unwanted pollen-mediated gene flow as well as the possibility of Roundup resistant weeds were the key legal and regulatory issues raised in the lawsuit and addressed by APHIS during their subsequent regulatory reviews. These controversies have remained even after USDA-APHIS re-deregulated the trait in 2011, with the issuance of its final Environmental Impact Statement (EIS) in January of 2011 (see USDA-APHIS documents), and will very likely be subject of further lawsuits.

THE TECHNOLOGY

The GT-Tolerant alfalfa technology, or Roundup-Ready Alfalfa (RRA), which enables the use of glyphosate safely on RRA varieties, has been more extensively reviewed in other publications. In brief, Van Dynze et al. (2004) and others (Canevari et al., 2007) reviewed the pros and cons of this technology, and found a range of positive traits for RRA, including its broad spectrum efficacy, high flexibility in application timing, lack of plant-back restrictions, lack of crop injury, economic benefits, benefits for animal feed safety, water quality, and the prevention of spread of noxious weeds. Potential problems of this technology were recognized to be the potential for herbicide resistance, weed shifts to weeds not controlled by Roundup, market acceptance of the hay by GE-sensitive growers and buyers, notably export and organic, and gene flow which might infect neighboring growers during seed production. As it turned out, the possibility of excessive gene flow contamination of neighbors, and the possibility of rampant herbicide resistance were the key subjects of the lawsuit and subsequent APHIS EIS.

THE GENE FLOW ISSUE

Alfalfa is a cross-pollinated crop. Therefore, in seed production, gene flow is a necessary phenomenon and promoted by seed growers since pollinators are required for maximum seed production. However, in production systems, unwanted gene flow from field to field can create contamination (also known as Adventitious Presence or Low Level Presence) of an unwanted gene in a neighboring field. For hay production, a range of barriers to gene flow can prevent inadvertent gene flow (Figure 1). A

Figure 1. Steps necessary for gene flow to occur between alfalfa forage production fields sufficient to cause adventitious presence (AP) in hay.

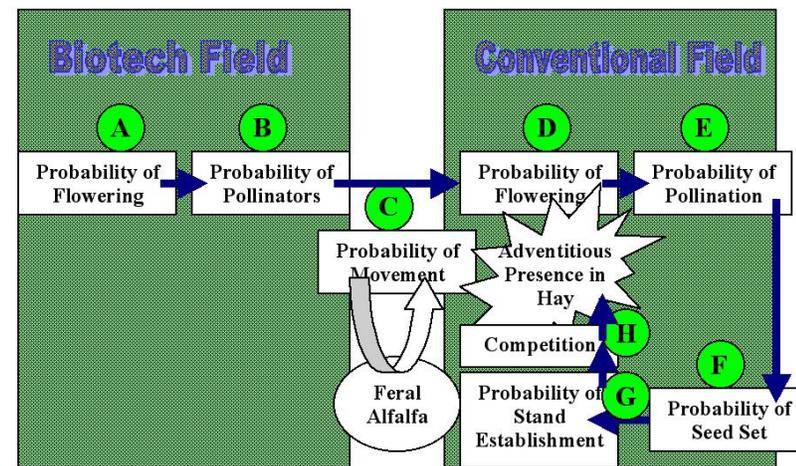


Figure 1. Steps necessary for gene flow to occur between alfalfa forage production fields sufficient to cause adventitious presence (AP) in hay.

series of probabilities for separate events are required, and these probabilities are much lower than with seed. The question of market tolerance threshold is a key aspect of this issue- that is whether markets will tolerate small amounts (e.g. less than 0.1%) AP, or whether markets will demand zero levels. It is anticipated that export hay is likely to tolerate somewhat higher AP whereas organic may be lower, levels that will be largely determined by markets.

THE ROUNDUP RESISTANT WEED ISSUE

The excessive development of roundup-resistant weeds as a consequence of the one more GT crops (in addition to corn, soy, cotton) were listed during the lawsuit and de-regulation process as a risk to be considered. A more complete analysis of this issue, and methods to prevent weed resistance, can be found in Orloff et al., 2009.

While it is yet undetermined whether RRA presents a higher risk of resistance than with annual crops (it is my view that the risk is lower), there is no dispute that greater repeated applications of the same herbicide over large acreage increase the risk of both weed shifts and weed resistance. A few key points about this issue: 1) Weed shifts (to weeds not normally controlled by Roundup) are clearly a more important than weed resistance, which requires selection pressure over years. 2) Genetic resistance to an herbicide results from the application of any herbicide, not just glyphosate, and is not necessarily linked to GE crops. 3) Diverse strategies of cultural practices, diverse herbicides are required to prevent resistance or shifts in any system, not just GT cropping systems. 4) There are readily available and well –understood methods to prevent either weed shifts or weed resistance in alfalfa (Orloff et al., 2009). 5) The development of resistance to glyphosate is primarily a technological issue – negating the usefulness of the herbicide. It is a practical problem for farmers, not necessarily an environmental problem. 6) It is important for growers to adapt resistance strategies from the outset, not just wait for weed resistance to occur and then try to address it later.

THE CONCEPT OF CO-EXISTENCE and NEED TO PREVENT RESISTANCE

The de-regulation of Roundup-Ready alfalfa in January of 2011 has determined that GE (genetically-engineered) crops are very likely going to be a part of the future of alfalfa production. RRA is really only the first of several proposed GE traits in alfalfa, with low lignin, higher quality, salt tolerant and other traits proposed. Thus it is abundantly clear that the alfalfa industry must discover methods that GE-adapting and GE-rejecting growers can continue to farm in the method of their choice. This requires coexistence strategies involving better knowledge of gene flow and crop contamination risks, human factors such as communication and willingness to work with neighbors, and awareness of the need to respect and protect differing production systems. Additionally, strategies to prevent the excessive development of Roundup-resistant weeds are required.

Table 1. Important landmarks in the history of Glyphosate-Tolerant (Roundup-Ready) alfalfa.	
1997	First GT-Tolerant Events (Montana State University)
1998-2011	Variety Development (ongoing)-Forage Genetics
2003	Petition for deregulation submitted (contained Environmental Assessment)
2005	USDA-APHIS comes to a FONSI (Finding of No Significant impact), OK's release of RRA.
2005-2007	>300,000 acres planted in US
2006	Lawsuit filed by Center for Food Safety alleging important environmental effects of 'gene flow' and resistant weeds not addressed by APHIS.
2007, January	Legal Decision by 9 th Circuit Judge stopping further plantings, requiring APHIS to do a more involved Environmental Impact Statement (EIS)
2007, March	No Further Plantings allowed; Current plantings were allowed to be harvested, with restrictions.
2007-2009	EIS under development by USDA-APHIS
2009, Dec.	Draft EIS issued by APHIS for public comment. Tens of thousands received.
2010, June	Alfalfa Case reaches Supreme Court. Court decides in Favor of Monsanto, that 9 th Circuit should not have forced the ban, and that the decision should have been under the control of APHIS.
2010, December	Final EIS issued by APHIS. Additional public comment allowed. Proposed 3 solutions. Two potential de-regulations were presented, one with restrictions, one without.
December-January	More than 16,000 comments received by APHIS. Majority of public comments were against GT alfalfa, as a symbol of GMOs in the food system, comments solicited by activist groups. Majority from farming community were in favor.
2011 January	Aphis makes final determination of non-regulated status for GT-alfalfa, rejecting partial de-regulation (restrictions on planting in seed growing areas)
February, 2011	First opportunities for planting GT-alfalfa after 4 year ban.

REFERENCES - please see: <http://alfalfa.ucdavis.edu> biotechnology link.