AN UPDATE ON ROUNDUP READY ALFALFA

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INTRODUCTION

In February 2007 a Federal Court judge ruled that the USDA's environmental analysis of Roundup Ready Alfalfa was deficient in that it did not include a "hard look" at, 1) the potential impact on organic and other alfalfa growers that are producing for non-GE markets; and 2) a potential incremental effect that Roundup Ready Alfalfa commercialization may have on the generation of glyphosate resistant weeds. In June of 2007 the judge issued a permanent injunction that vacated the original deregulation decision pending the USDA/APHIS preparation of an Environmental Impact Statement (EIS). The ruling acknowledged the FDA's finding that Roundup Ready Alfalfa was safe for food and feed, and allowed the continued harvest of existing Roundup Ready Alfalfa forage and seed production fields. However the injunction prohibited any new planting of Roundup Ready Alfalfa until, and unless, a new deregulation decision was made by USDA/APHIS based on the EIS.

In this paper I will focus primarily on potential economic impact of RRA on organic and other GE-sensitive markets. On this topic the issues related to deregulation of Roundup Ready Alfalfa will be almost identical for other biotech traits in alfalfa. We believe that the key question is "how do we construct a stewardship program that makes it possible for growers of alfalfa with biotech traits to coexist with organic and other alfalfa growers that produce for export and other GE-sensitive markets?"

Corn, soybean and cotton growers have shown that coexistence is possible, with both biotech and organic acres increasing significantly over the last decade. These crops present a model for stewardship that enables co-existence, and that has allowed producers to capture increased farm income associated with improved weed and insect control from biotech traits. The National Center for Food and Agricultural Policy estimated that 123 million acres of biotech-derived crop varieties were planted in the U.S. in 2005 and that the associated biotech traits increased net return to growers by $2 billion (Sankula, 2006).

CURRENT U.S. MARKETS FOR ALFALFA HAY AND ALFALFA SEED

What do we know about the current markets for U.S. alfalfa hay and alfalfa seed? Data collected by the National Ag Statistics Service (NASS) and USDA Foreign Ag Service (FAS)[2] provide good information on the number of alfalfa acres harvested for hay and haylage, and the size of the export markets for alfalfa hay and seed.

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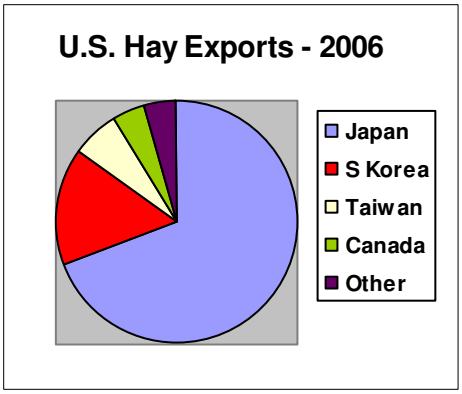
[2] The National Ag Statistics Service (NASS) collects and publishes data on planted and harvested acres of alfalfa hay, by state. The NASS data also includes an estimate of the % of all hay produced that is sold as organic. The USDA Foreign Ag Service (FAS) collects and publishes data on alfalfa hay and seed exports, by export country.

ALFALFA HAY MARKETS

In 2006, 21.4M acres of alfalfa hay and 3.3M acres of alfalfa haylage were harvested in the United States (NASS). Most of the alfalfa produced in the U.S. is consumed domestically. Approximately half of U.S. alfalfa hay production is consumed on the farm on which it was produced. Putnam (2005) estimates that 3-5% of U.S. alfalfa hay production might be sold to GE-sensitive markets; primarily organic hay and hay sold to export markets.

Organic hay. Organic milk production is one the fastest growing segments of organic agriculture in the U.S. Between 2000 and 2005 the number of certified organic milk cows on U.S. farms increased by an average of about 25 percent each year, from 38,000 to more than 87,000 (USDA, Economic Research Service). Organic alfalfa hay is a key component to many organic dairies, and acres of organic alfalfa hay are likely to increase to meet increased demand from an expanding organic dairy industry. Organic hay and alfalfa acres have increased steadily over the years, and in 2005 organic alfalfa hay made up 204,380 (0.9%) of the 22, 439,000 acres harvested in the US in 2005. National Organic Program (NOP) principles prohibit organic hay producers from planting GE-alfalfa and require a process-based production system designed to avoid "contamination" of the crop with various prohibited substances. There is currently negligible organic seed production of alfalfa varieties in the United States.

Hay export. In 2006 the NASS reported 24.7M acres of alfalfa hay and haylage harvested, producing 94.4M tons of hay/haylage. The FAS reported that almost 0.9M tons of hay was exported in 2006, valued at $165.1M. Although hay export represents approximately 1% of total U.S. hay production, it accounts for approximately 6% of hay produced in the Pacific Northwest and 20% of the hay produced in Washington (Shewmaker et al., 2005). Furthermore alfalfa hay sold in the export market generally brings a premium price to the grower, and helps stabilize hay prices for local domestic markets.



East Asia is the dominant export market for U.S. produced hay, with Japan accounting for almost 70% of all U.S. hay export in 2006 (FAS). Sales to Japan, South Korea, Taiwan and Canada represented >95% of total U.S. hay export in 2006. Although there are no regulatory barriers that prohibit export of Roundup Ready alfalfa to these countries[3], there may be market barriers for GE-alfalfa with specific customers in specific export markets. The fact that all of the key alfalfa export countries currently import U.S. produced corn and soybean feed grains containing the Roundup Ready trait, suggests that any market reluctance to Roundup Ready alfalfa may be short/medium term issue. However, alfalfa hay exporters need the tools to service non-GE alfalfa markets both now and in the long term. Widely available protein-based test strips have been proven effective and are now

[3] Regulatory approvals for Roundup Ready alfalfa feed and or other purposes have been granted by Japan, South Korea, Canada, Mexico, Philippines, Australia and New Zealand. There is currently no regulatory approval required for biotech feed in Taiwan.

routinely used to test hay sold to sensitive markets, confirming that adventitious presence of the Roundup Ready trait falls below the detection limits of the test (Woodward et al., 2006).

ALFALFA SEED MARKETS

According to NASS statistics for 2002 to 2006, 110 to 122 thousand acres were harvested for alfalfa seed annually and the total production was approximately 58 to 72 M pounds. Approximately 95% of the U.S. seed production of alfalfa seed is in seven western states: California (27%), Idaho (24%), Washington (21%), Nevada (8%), Oregon (7%), Wyoming (4%) and Montana (4%). There is virtually no alfalfa seed produced east of the Missouri River. Non-GE sensitive seed of conventional varieties produced for the domestic market conforms to seed company standards for adventitious presence, normally <1%. Based on Putnam (2005) the non-GE sensitive market is 95-97% of the total domestic alfalfa seed market. Approximately 1/3 of U.S. seed production is sold to export markets. There is negligible organic seed production of alfalfa varieties in the U.S.

Seed export. The vast majority of U.S. alfalfa seed export is non-dormant types produced in California. Since some of the key non-dormant seed export markets do not yet have regulatory approval, seed production isolation standards in California have been designed to manage adventitious presence of GE-traits in conventional seed to non-detect levels.

COEXISTENCE OF VARIOUS MARKETS

Alfalfa producers and academic experts agree co-existence is possible. In October 2007 about 70 stakeholders attended a meeting on "Peaceful Coexistence: Creating a Strategy for Harmony Among GM, Organic and Conventional Alfalfa Producers" sponsored by the National Alfalfa and Forage Alliance (NAFA). Speakers and attendees included growers, academic and industry stakeholders representing both domestic and export markets for conventional, Roundup Ready, and organic alfalfa hay and seed production. The overwhelming consensus of this group was that coexistence was possible if stewardship programs were in place to help insulate AP sensitive markets (e.g. seed export, hay export and organic hay). In addition to the stewardship efforts put forward by GE producers, the AP-sensitive producers must continue to apply their own market-specific production practices to ensure their product's differentiation (e.g., organic buffer zones, avoidance of prohibited practices, using certified planting seeds, lot segregation, official certification, testing of seed and/or hay lots for adventitious presence, etc.). NAFA will be publishing a consensus plan for coexistence based on this meeting. Putnam (2006) came to the same conclusion when he concluded that "simple methods to assure coexistence without disruption of sensitive (hay) markets should be effective under most conditions." Stakeholders at the NAFA meeting were in agreement that an AP tolerance greater than zero should be established.

GENE FLOW AND STEWARDSHIP

Managing gene flow from biotech to non-biotech alfalfa hay and/or seed is basis for any coexistence strategy. A critical first step is to understand potential gene flow between different sources.

Hay to Hay gene flow. Putnam (2006) describes and estimates the magnitude of the multiple biological barriers to gene flow from one hay field to another. He concludes that the risk of hay to hay gene flow is "infinitely small". This risk can be reduced to zero for hay growers producing for an organic or AP-sensitive export market by simply buying the right seed (non-GE) and harvesting the hay before the ripe seed stage.

Seed to Seed gene flow. Seed production is required for effective gene flow. Alfalfa seed production requires insect pollinators. These bee pollinators not only carry pollen from plant to plant within a seed production field, but can stray to neighboring seed production fields. In certified seed production this pollen-mediated gene flow is managed by requiring a minimum isolation distance between a certified alfalfa seed production field and a neighboring alfalfa seed (or hay) field. The isolation for certified seed has been deemed appropriate to meet the Federal standards of 99% varietal genetic purity.

Are current isolation standards for certified seed adequate for managing pollen-mediated gene flow in Roundup Ready alfalfa seed production? Beginning in 2001, scientists at FGI and UC Davis began a series of experiments using the Roundup Ready gene as a marker to measure pollen-mediated gene flow for leafcutter bee and honeybee pollinators (Fitzpatrick, et al., 2003; Teuber et al, 2005 and 2007). These gene flow data have been used to design Roundup Ready alfalfa isolation distances required to appropriately manage AP. In the Pacific Northwest, where the overwhelming majority of seed production is for domestic markets and leafcutter bees are used as primary pollinators, a 900 ft isolation distance between Roundup Ready and conventional alfalfa seed production is being used to manage AP to $\leq$0.5%, a common industry standard for AP tolerance in conventional seed of other crop species. The 900 ft isolation was a science-based determination and is greater than 5 times the standard isolation requirement for conventional Certified seed, and coincidentally, the same isolation requirement for Foundation class seed. In California, where over 50% of the seed production is for AP sensitive export markets and honeybees are used as primary pollinators, a 3 mile isolation distance is being used to manage AP to a non-detect level, a common industry standard for seed destined for export markets where there is no regulatory approval of the trait (e.g. Saudi Arabia). This isolation standard is greater than 95 times the standard isolation requirement for conventional Certified seed. This isolation distance was adopted by consensus of a California seed industry stakeholder group convened by the UC Seed Biotech Center in 2005 (UCSBC, 2005), is science-based, and recognizes the importance and sensitivity of the alfalfa seed export market in the state. The common ground here is an effective RRA seed production stewardship (i.e. coexistence) strategy needs to be: 1) science-based; 2) market sensitive; and 3) pollinator specific. We believe current isolation standards and seed field location reporting for RRA seed production meet these requirements and that AP-sensitive seed producers have effective quality assurance methods available to them (Fitzpatrick et al., 2007).

Hay to Seed gene flow. Just as the Roundup Ready trait was used to effectively measure pollen-mediated seed-to-seed gene flow, separate experiments were conducted by UC Davis and FGI to measure potential forage to seed pollen-mediated gene flow when RRA forage production fields were allowed to bloom, during the peak pollination period, in proximity to conventional seed production fields. Current isolation requirements for Certified seed production of conventional varieties requires 165 ft isolation from all alfalfa (seed, forage or feral) of a different variety. With both honeybee and leafcutter bee pollinators, $\geq$165ft isolation between RRA forage (20 to 50% bloom) and conventional seed production reduced seed AP to <0.3% (Teuber and Fitzpatrick, 2007). This data suggests that current Certified seed isolation standards are adequate to manage potential hay to seed AP.

Gene flow from Feral alfalfa. Feral plants are crop plants that have escaped cultivation. Feral alfalfa plants can sometimes be found on road edges, in fence lines and in abandoned fields. In a 2001/2002 multi-state survey, feral plants were found within 2000 meters of cultivated alfalfa at 22% of the survey sites (Kendrick et al., 2005). Although we expect that with time some Roundup Ready plants could become part of the feral alfalfa population, there is no reason to believe they will become a disproportionate part of the the feral population, since the trait provides no fitness advantage over the conventional-type.

Given that feral Roundup Ready alfalfa has no advantage over wild-types, the question then is will feral Roundup Ready alfalfa plants become a significant source of potential gene flow to conventional alfalfa hay or seed? No, many of the biological filters limiting hay-to-hay gene flow also exist for feral-to-hay gene flow. This risk is very low and by simply cutting the hay field before the ripe seed stage the risk can be reduced to zero. Most hay is cut at late bud to early flower stage, six weeks before the ripe seed stage. Virtually all of the alfalfa seed production in the western states is irrigated, and seed production fields are sprayed regularly to control Lygus and other insect pests. Feral plants have neither the benefit of irrigation or insect control and have poor fitness compared to their cultivated cousins. Furthermore amount of pollen from sparse feral plants will be negligible compared to the pollen produced within the seed production field itself – where plants are at a much higher density and being managed specifically for seed production. Potential feral-to-seed pollen mediated gene flow is very low based on the relative fitness and the relative low abundance of pollen from feral plants (Hammon et al., 2006).

Summary. Although understanding and managing gene flow is a foundation for effective stewardship, there are multiple other important components, including: best practices for seed production, seed harvesting and seed processing to minimize potential seed mixing of biotech and conventional varieties; and trait licensure of seed and hay growers with required adoption of best practices for stewardship.

POTENTIAL BENEFITS FROM BIOTECH TRAITS

The history of wide adoption of biotech traits by American farmers is primarily based on one thing – improved net farm income. In a recent nationwide survey of Roundup Ready alfalfa growers, more than 98% expressed satisfaction with variety and trait performance. Growers reported higher yields and improved forage quality with Roundup Ready alfalfa and estimated an

increase of approximately $50 net income per acre compared with conventional types. Several growers also reported a significant benefit related to human safety in handling Roundup herbicides compared to those used in conventional alfalfa production systems.

There many environmental benefits associated with biotech traits. Sangula (2006) estimated that in 2005 the adoption of biotech traits by U.S. farmers reduced pesticide use by 69.7M pounds. Roundup Ready crops are also widely credited for an increase in no-till planting, thereby decreasing energy use, greenhouse gas emission and soil erosion. Putnam (2005) projected that the adoption of Roundup Ready alfalfa would result in the replacement of many currently-used herbicides in fields planted with RR alfalfa. Therefore, he did not believe that the introduction of this GE crop would increase herbicide useage in total, but where adopted, will cause a shift of herbicide use to glyphosate. He further finds that where glyphosate (Roundup) replaces other herbicides that are more highly soluble and subject to runoff, the introduction of this technology may reduce the overall impact of herbicides on the environment. Several winter-applied herbicides currently used in California have been detected in wells in the Central Valley and are of strong concern to regulators. Growers who use these herbicides are subject to severe restrictions for use based upon soil type and groundwater characteristics. It is anticipated that glyphosate presents a lower risk to the environment compared with some of these herbicides (DPR website, State of California).

New traits. The Consortium for Alfalfa Improvement[4] (CAI) is a is a cross-institutional collaboration focusing on using biotech tools for improving alfalfa for dairy and biofuels feedstock. Lignin reduction to increase fiber digestibility has been a key CAI research focus. Reduced lignin transgenic plants have been in field testing since 2001, and have consistently shown lower lignin content and a 10 to 15% increase in fiber digestibility. In 2007, two reduced lignin genotypes were used in "proof of concept" feeding studies conducted with both young lambs and dairy cows. The U.S. Dairy Forage Research Center (USDFRC) predicts that a 10% increase in fiber digestibility could increase milk and beef production by $350 million/year and reduce manure production by 2.8 M tons/year. A second CAI research project on improving the efficiency of alfalfa protein utilization shows promising progress. Tannin-expressing alfalfa which would increase the proportion of alfalfa protein that bypasses the rumen (RUP), could significantly decrease the cost of protein supplements for high producing dairy cows and decrease nitrogen losses on dairy farms. The USDFRC estimates that tannin alfalfa could result in a 12% increase in net return for the dairy operation and decrease on-farm nitrogen losses by 25%.

In the last several years there has been an explosion in genomics-based research for discovery of new genes that add value to crops. Industry alone is probably investing close to $1 billion/yr in these activities. Alfalfa is poised to take advantage of the fruits from this research investment. Other new biotech traits currently in various stages of development include drought tolerance/ improved water use efficiency, improved salt tolerance, increased biomass/forage yield and delayed flowering.

[4] The Consortium for Alfalfa Improvement member organizations are Forage Genetics Intl., The Samuel Roberts Noble Foundation, Pioneer HiBred Intl., and the U.S. Dairy Forage Research Center.

SUMMARY

Understanding potential gene flow in alfalfa allows the design of stewardship programs that mitigate potential gene flow in the production of GE-sensitive alfalfa hay or seed crops. Under NAFA's leadership, scientific consensus on gene flow and industry consensus on proper stewardship practices are being developed. These stewardship programs are a primary mechanism for developing strategies for coexistence of various markets. Market coexistence is the only path for insuring farmer choice and keeping alfalfa competitive with other major crops.

Roundup Ready is the first of several new biotech traits that will increase yield and/or quality of the crop. Agriculture is on the cusp of what is being called the "Second Green Revolution", driven in large part by increases in productivity and crop value associated with current and future biotech traits. Strategies for coexistence of alfalfa markets will help ensure alfalfa is part of this significant advancement in science and technology.

Let me close with two quotes from Dr. Norman Borlaug, 1970 winner of the Nobel Peace Prize, father of the first "Green Revolution", esteemed scientist and plant breeder.

"Genetic modification of crops is not some kind of witchcraft; rather, it is the progressive harnessing of the forces of nature to the benefit of feeding the human race."

'Genetically engineered crops are playing an increasingly important role in world agriculture, enabling scientists to reach across genera for useful genes to enhance tolerance to drought, heat, cold, and waterlogging, all likely consequences of global warming. I believe biotechnology will be essential to meeting future food, feed, fiber, and biofuel demand."

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