IS IT POSSIBLE FOR GENETICALLY-ENGINEERED (GE) AND NON-GE ALFALFA TO COEXIST?

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ABSTRACT

A key question with regards to the introduction (and later suspension) of Roundup Ready trait in alfalfa is whether this technology would permanently harm those growers who did not wish to adapt this technology. The key concern is the possibility of gene flow that would contaminate GE sensitive crops (primarily organic and export growers) to the point that it would no longer be possible to produce them. It is clear from technical viewpoint, that this is not inevitable, and that coexistence is certainly possible, if a few specific practices are followed. These are related primarily to the 1) distance between crops (isolation distances), 2) Understanding the factors which promote gene-flow and taking steps to reduce the risk from these factors. Hay-to-hay interactions consist of greater than 98% of the situations in fact, and the possibility of gene flow is very small due to the many practices which discourage gene flow. The seed industry is of particular importance, since gene flow risk is greater, and additional steps must be taken to ensure non-GE status. However, there are non-technical aspects that are equally important to ensure coexistence of GE- and GE-sensitive production including improved methods of communication and cooperation between parties and methods to develop tolerances, and assure markets for non-GE production. A method of certification of Non-GE status for hay or seed is proposed. In principle, we should develop the scientific and social infrastructure to ensure the production of any alfalfa product, using methods of the grower's choosing, for whatever the market demands (GE or non-GE), within a reasonable level of tolerance.

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Key Words: biotechnology, varieties, GM crops, organic alfalfa, gene flow, exports, organic hay, weed control, roundup-ready, economics, markets, genetic engineering.

BACKGROUND

The first genetically-engineered (GE) trait in alfalfa was commercialized in 2005, Roundup-Ready (RR) alfalfa, which enables growers to spray glyphosate (Roundup) safely over the crop to control weeds. Subsequently, it was been readily adapted by growers in California and the US. Current estimates are that over 80,000 acres have been planted in California and over 300,000 acres nationally. This planting took place within approximately a 21 month period from June, 2005 through March 2007, although realistically, it was closer to a 1 year planting window due to planting season and seed

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availability restrictions. This may constitute a 20-30% adaptation rate in California, somewhat surprising considering the high cost of the technology (e.g. 2x seed cost), legal requirements by Monsanto, and limitations in seed supply. On March 12 of this year, the 9th Circuit Court in San Francisco issued a preliminary decision, later made permanent on May 3, to vacate the decision to deregulate, thus disallowing further plantings past March, 2007. This was due to a lawsuit filed by the Center for Food Safety and others. Restrictions were placed on the acreage already planted. The USDA-Animal and Plant Health Inspection Service (APHIS) was charged with developing a more detailed Environmental Impact Statement before deregulation could occur (USDA-APHIS, 2007).

The key issues were: 1) The possibility that the introduction of RR would (irreversibly) contaminate organic or other conventional alfalfa varieties through accidental gene flow, thus 'harming the human environment' (the judge's language) by ruining organic or other non-GE production; 2) The possibility that increase in RR alfalfa would increase the level of Roundup-Resistant weeds. The latter is not highly relevant to the issue of coexistence (it is a broader technology issue), and thus this paper deals exclusively with the first issue, coexistence of GE-adapting and non-GE or GE-sensitive growers.

WHAT IS COEXISTENCE?

> *"Coexistence is a state in which two or more groups are living together while respecting their differences and resolving their conflicts nonviolently." (Wiener, 2000).*
>
> *"To exist together (in time or place) and to exist in mutual tolerance" (Oxford Dictionary)*

And, in the context of Genetically Engineered Crops:

> *"Coexistence refers to the economic consequences resulting from adventitious presence of material from one crop in another and is related to the principle that farmers should be able to cultivate freely the crops of their choice using the production system they prefer (GM, conventional, or organic). It is not, therefore a product/crop safety issue but relates solely to the production and marketing of crops approved for use. (Brooks, 2004).*

Khaminwa (2003) further defines 'Passive' and 'Active' coexistence as having either unequal power relationships (passive), or relationships based upon mutual respect, and recognition of diversity (active). The later status entails an active embrace of differences, equal access to opportunity, and greater equity between parties. Institutions in this environment are designed to ensure fairness and justice.

Several of these concepts might be quite useful here (particularly tolerance and active coexistence), as the alfalfa industry moves to ensure the viability of diverse approaches to agriculture, while adapting new technologies. The National Alfalfa and Forage Alliance

(NAFA) has promoted this process of coexistence, with the recognition that this process involves communication, respect, and working through specific issues between parties. A meeting was held in Denver, CO in August, 2007 to promote this process, with representation from USDA-APHIS (the biotech regulatory body), organic farmers, exporters, GE-adpating growers, scientists, and the businesses involved (Forage Genetics, Monsanto and competing seed and genetics companies). Documents from this event and subsequent discussions are in process.

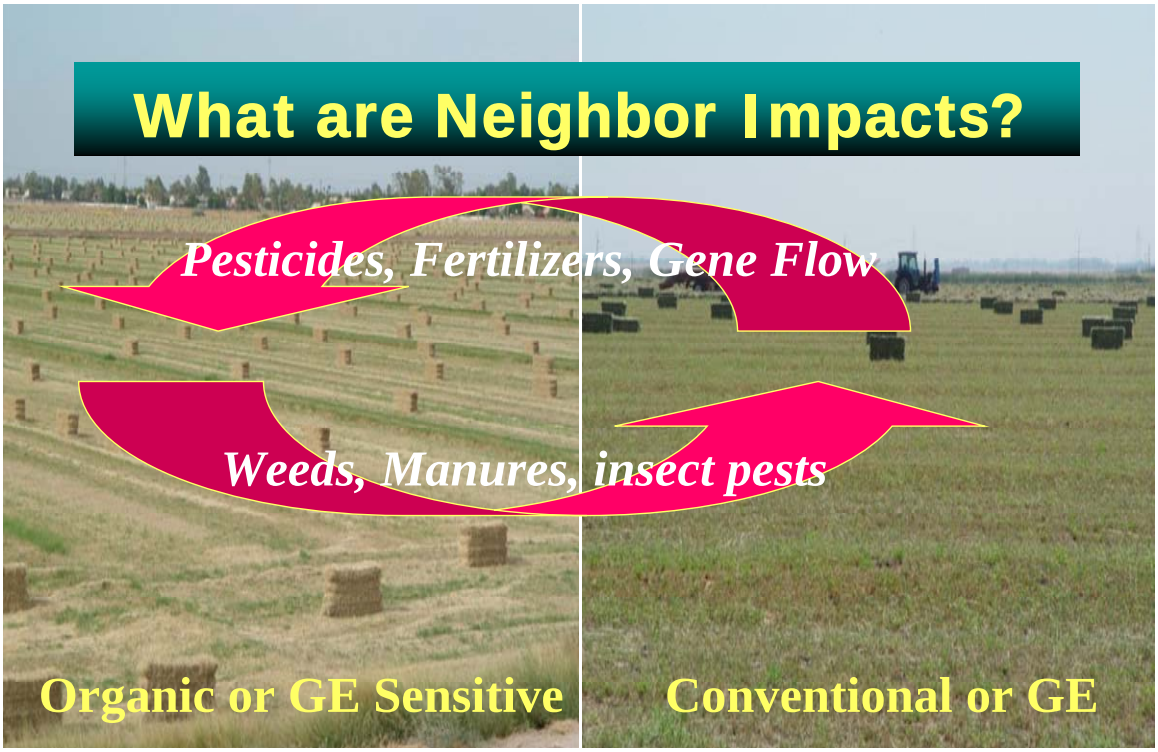

Figure 1. *Potential neighbor influences between organic or GE-sensitive alfalfa and conventional or GE-adapting production. Neighbor effects towards organic can be in the form of gene flow, fertilizers or pesticides. However, organic producers can also affect neighbors by allowing excessive insect populations, weed seed, or improper use of manures. A key question with gene flow from GE is whether this risk is any different in magnitude than other neighbor effects, or cannot be prevented.*

Coexistence is Nothing New. It should be pointed out that coexistence in the agricultural context is not new. While the introduction of GE crops raises new technical questions about gene flow and market tolerance, these issues have been raised before. When sweet corn is grown in proximity to field corn, pollen flow may change the genetic nature of either crop through cross-pollination, affecting markets. Cross-pollination of commercial hybrids may affect the genetic makeup of landraces and other varieties, or visa-versa. The production of *Brassica* species with specific fatty acid profiles (canola and rapeseed) requires understanding of cross pollination effects on commercial production of either crop, and the importance of crop handling and identification controls. The introduction of cotton into the Sacramento Valley in the 1990s created 'neighbor effects' with the use of pesticides that had to be worked out (and they were). Organic

farmers in particular have had considerable experience considering neighbor effects to protect their crop from unwanted influence of pesticides or fertilizers from neighbors.

Thus, although the introduction of GE-technology presents new technical considerations, in principle it is no different than these examples. The key question is whether this specific technology is either 1) unduly intrusive, or 2) its effects cannot be mitigated using ordinary means.

IS COEXISTENCE A ONE-WAY STREET?

The answer is clearly no. Although the questions raised by this lawsuit specifically target GE-alfalfa (RR alfalfa) and its potential affects on organic growers, this implies that influences can only be one-way. However, organic growers can themselves have unwanted influences on neighbors as well (Fig. 1). For example manures, if not properly handled, can run off of fields and contaminate surfaces streams or rivers, or even drinking wells through leaching. Organic growers sometimes have difficulty controlling weeds and insects – and these can move en mass (seeds or insects) to neighbor fields, causing economic harm. These are not exceptional or unusual events – they are usually tolerated between neighbors or steps are taken to prevent them. Farming is a complex operation, and good organic growers know how to prevent or reduce the risk of these events, but their probability is not zero. All growers need to consider the influences of their practices on neighbors, whether conventional or organic. The two-way street aspect of this question is important, since a level of tolerance for many types of farming practices must somehow be determined.

GENE FLOW AND ITS IMPORTANCE

At the heart of the coexistence issue is gene flow, and its potential impact. Since RR alfalfa is primarily at issue because it is GE, this discussion is broadly relevant to any potential GE alfalfa that might be commercialized in the future, not just RR. Thus I will refer to RR as GE alfalfa, even though RR alfalfa is the only trait in question at this time, and the only GE alfalfa currently commercialized.

What is Gene Flow? Gene flow is described as "the incorporation of genes into the gene pool of one population from one or more other populations". It is the change in population frequency over time. It is a neutral concept; gene flow may be considered positive or negative (or neutral), depending upon the perspective. Since alfalfa is a cross-pollinated crop, genetic exchange between individuals is important for maintaining a population, and necessary for commercial seed production. Alfalfa is insect-pollinated, which facilitates genetic exchange between plants, seed set, and gene flow. Thus in this case, if genetic exchange occurs between a GE crop and a conventional (non-GE) crop sufficient to change the population, gene flow has occurred.

Description of Gene Flow in Alfalfa. In commercial hay or seed fields, it is possible for genes to move from crop to crop, resulting in low level presence, also called adventitious presence to occur. This will be considered contamination by some, a nuisance, or a non-

issue by others depending upon their production system and impacts upon their markets. This is an important point, since the vast majority of uses and markets for alfalfa are NOT sensitive to the presence of GE, whether as whole hay lots or as low level adventitious presence in conventional forage (see below discussion of demographics).

It is absolutely vital that we differentiate between the different scenarios for gene flow, which include seed-to-seed gene flow with different types of pollinators (honeybees or leafcutter bees), hay-to-seed, and hay-to-hay (Figure 2). The potential for gene flow in alfalfa differs significantly between these scenarios.

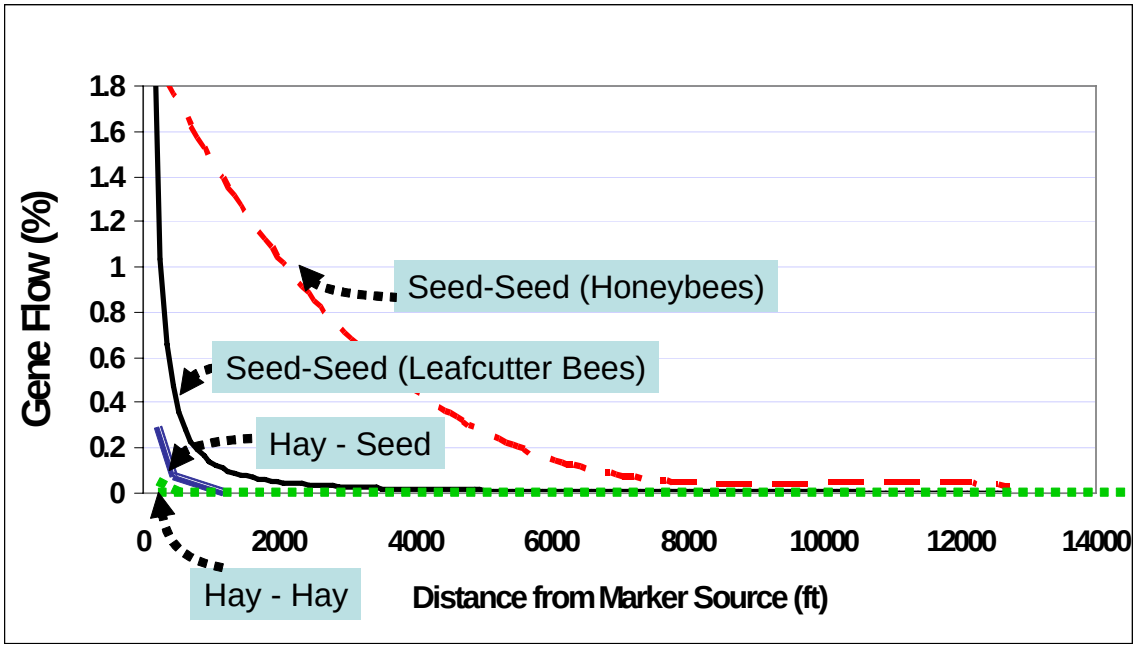

Figure 2. Gene flow likelihood for neighboring fields for seed-seed, hay-seed, and hay to hay, dependent upon distance and pollinator. Derived from data from Teuber (Honeybees and hay-seed), and S. Fitspztrick (Leafcutter bees). Hay to hay estimates are projections from seed-seed and hay-seed data (Putnam, 2006).

The potential for gene flow is clearly dependent upon several key factors:

- Distance between Fields
- Pollinator type and density
- Production management system (hay or seed)

DEMOGRAPHICS: HAY-TO-HAY COEXISTENCE IS MOST IMPORTANT.

In terms of demographics of the alfalfa crop in the United States, hay-to-hay coexistence is clearly the most important, making up over 98% of the potential situations (of neighbors affecting neighbors). Over 22 million acres of alfalfa are produced in the US. Of this, less than 200,000 acres are devoted to seed, or less than 1%. These seed fields are not scattered uniformly throughout the country. The key states are California, Idaho,

Oregon, Washington, and several other western states. Even within these states, the production regions for seed are typically concentrated; for example there is approximately 20,000 acres of alfalfa seed within California, but the vast majority of those fields are in Imperial County and Fresno County. In terms of neighbor effects, although California is the nation's #1 seed producer, the hay-seed or seed-to-seed interaction is likely to affect less than 5% of our acreage in practice. The exceptions are these two counties, where coexistence becomes more important issue between seed fields.

Who are the GE-Sensitive Growers? We should also be realistic about the demographics of GE-sensitive growers. It is estimated that less than 1 % (probably closer to ½%) of all alfalfa hay growers are organic, a small but growing number, since organic dairies are expanding significantly. Previously, I have estimated the total GE-sensitive growers to be 3-5%, and have net seen any data yet that would cause me to change this estimate.

Additionally the demographics of those interested in trying the RR trait in alfalfa are clearly in favor of the trait. If one were to poll the alfalfa growers in California, for example, I would speculate that between 40-60% of growers have tried the RR trait (pro) or intend to do so if it's degregulated (based upon adaptation rates in the first few years), 20-30% are conventional growers who may be interested at some point but may not immediately try it (neutral or fence-sitters), and small percentage (perhaps 10%) are conventional growers probably won't be interested for various reasons, and a smaller percentage (3-5%) are actively against the technology for various reasons or are producing for GE-sensitive markets. Polls such as this have not been done to my knowledge (in the public sphere), and it might be useful to do so.

Of the GE-sensitive growers, export growers are clearly more important in volume than organic growers. It is estimated that approximately 4.5% of the production of western states goes for export (Putnam, 2006), but this number is closer to 1% nationwide. Again, exporters are concentrated in specific areas, for example the Columbia basin of Washington and Oregon, and the Imperial Valley of California.

Protection of Minority Viewpoints and Production Systems. Nevertheless, regardless of the minority status of the GE-sensitive growers, it is nevertheless very important to assure production systems for these markets (primarily organic and export). This is an important principle of coexistence.

HOW MAY COEXISTENCE OCCUR?

The Importance of Seed. Although hay is the more important interaction between diverse systems demographically in the US, successful coexistence begins with the seed industry. Preventing contamination of seed is the most important coexistence principle for GE-sensitive growers—thus assuring a supply of non-GE alfalfa seed is an important aspect of coexistence for alfalfa hay growers. The alfalfa seed industry has a long history of assuring seed production methods which both assure origin of the genetic material, and provide seed production practices which assure the purity of these lines, within a given

level of tolerance. This method of certification can be used to also assure non-GE status of the seed. The seed industry met in 2007 (NAFA Denver meeting), and have discussed more stringent isolation distances, and are developing mapping tools to further assure isolation distances which will keep adventitious presence to low levels. Organic growers have especially been concerned about the supply of non-GE alfalfa seed. The seed companies (the big 4: Dairyland, Forage Genetics, Cal West, and Pioneer) have made a public commitment to assure the continued production of non-GE seed, and are currently working to develop and implement improved practices to assure these markets.

Hay-to-Hay Coexistence is Feasible. For alfalfa hay, methods to assure production of non-GE alfalfa and to protect this alfalfa hay from unwanted gene flow have been published elsewhere (Putnam, 2006). I have provided this publication in its entirety at the end of this article for readers of this symposium, since some may not have seen it. It is clear to alfalfa hay growers that methods exist to assure integrity of non-GE production, should growers wish to do so. Testing of lots to provide further market assurance is a method which may be used in addition to production practices (see Putnam, 2006).

PREMISE & PRINCIPLES

There are several premises here which derive from this discussion, and might be useful as we move forward. Since this issue of coexistence contains both scientific/technical aspects and social or community aspects, both of these are critical components of coexistence principles.

- **Ensure Viable Viability of Organic or other GE-sensitive producers.** It is important, in principle that growers should be able to farm successfully using techniques of their choosing for whichever market they wish. We should develop the scientific and social infrastructure to enable and ensure the production of any alfalfa product using diverse methods of grower's choosing for whatever the market demands. This especially includes organic markets, but also for export or horse markets or other GE-sensitive markets – or someone who simply does not want the trait. However, this is also true for the introduction of GE traits—those growers should be able to successfully adapt those technologies.

- **Prevent Undue Influence.** As a corollary to the above principle, a technology adapted by one farmer should not have undue influence upon a neighbor's ability to farm in the fashion that they see fit, within a given level of tolerance for neighbor influences that commonly occur in agriculture. Methods should be put into place which reduce the possibilities of these influences to very low levels, so that they do not unduly impact neighbor's ability to farm. Additionally, the choice of production method (GE or Organic) should not strategically prevent the ability of a neighbor to utilize a production system of their choosing.

- **Tolerance is Determined Largely by Markets**. Brooks (2004) points out that if there is no distinct non-GE demand, the coexistence issue does not arise. There are GE-sensitive markets, but in the case of a GE-product which has been found

to be safe, tolerance is largely a market-determined quality, not derived from toxicology. This is not the case for toxins or health-based contaminants, where tolerance can scientifically-derived. For example the acceptable level of nitrate in a forage crop (from either organic or conventional forage) has a toxicology-derived value; the same is not true for a trait that can be safely fed up to 100% of the diet (the RR trait in alfalfa).

- **Zero Tolerance is not Acceptable.** Since all agricultural practices involve potential neighbor influences, the promotion of zero tolerance of neighbor's practices is not realistic. In a world where there is a (low) tolerance for poisons or contaminants (e.g. rodent parts in cereals or tolerance for boron or selenium in drinking water), it makes no sense to promote zero tolerance for non-poisonous neighbor effects. Tolerances are of two types: food safety (toxicology) and product/market purity. Tolerance in the GE-context is clearly of the second sort. Although the quantity varies by crop and by use, these thresholds typically range from1% to 5% (for example, inert material, weed seeds, off-types). For reference, the EU's labeling requirements for GM crops is 0.9%, and the Japanese require labeling if a food product is over 5%.

- **Cooperation is Required** to Promote Stewardship and Coexistence between neighbors. A 'good neighbor' approach will be effective in most cases, but there are broader institutional approaches which may be useful. These should be based upon communication, respect, cooperation, and willingness to promote coexistence principles. These principles of coexistence (elucidated by Brooks, 2004) may be as follows:

    - **Context.** Coexistence methods should be based upon the demographics, acreage, economic value, biological realities and probability of impact.
    - **Consistency.** To assure the integrity/crop purity of organic and other systems, there should be a consistency which considers GE presence in line with other product purity issues. Organic producers currently have tolerances for small amounts of non-organic components for certification.
    - **Proportionality.** All coexistence measures should be proportionate to the need and to the demographic realities.
    - **Equity-Fairness.** Coexistence should not be one-sided. No one technology or viewpoint should be given the power to veto the other (active coexistence, as described above).
    - **Practicality.** Steps towards coexistence should be based upon practical, scientifically determined realities and growers should be able to accomplish these under real-life situations.

- **Non-GE Certification?** There is a clear need to provide both information and methodologies to assure production of non-GE crops in a GE-adapting world. For those who produce for non-GE markets (primarily export and organic), methods to assure integrity of production and products are needed. Here, I would

propose a method of non-GE self-certification to assure markets of the production integrity of non-GE products. This might have the following elements:

- **Web-based Mechanism.** Documents describing generally-accepted methodologies to prevent or reduce the probabilities of unwanted gene-flow or other neighbor effects on non-GE production would be provided. This would include a protocol for production of seed and hay for GE-sensitive markets. An on-line learning exam would be provided to assure that the reader understands the materials.
- **Hay and Seed.** Protocols for hay and seed could both be developed.
- **Sponsorship.** This certification could be sponsored by hay grower groups, organic certification groups, state departments of agriculture, or other bodies, and endorsed by others. University scientists could provide peer-review for the technical aspects.
- **Free and Simple.** This mechanism could be provided, with a modest investment, free of charge to those who wish to provide non-GE alfalfa products. Growers, with a modest investment in time, could use this to assure markets of the non-GE status of their crops.
- **Certification.** Growers could use this mechanism to self-certify the integrity of their products, assuring their customers that their product has been produced according to a given protocol. Alternatively, certifying agencies could use this mechanism to provide additional product assurance, along with organic certification.
- **Process-based Certification.** As is the case with organic certification, this is a process-based concept: The grower will have taken every reasonable step to assure the non-GE status of their crop.

SUMMARY

Coexistence between GE (Roundup Ready) alfalfa and non-GE or GE-sensitive production is certainly technically feasible. However, the implementation of coexistence in real life production systems will depend upon the adaptation of the principles of respect for different viewpoints (especially minority viewpoints), cooperation between parties, fairness, and recognition of the development of market-based tolerances for low-level neighbor effects which are commonplace in agriculture. There is a need to further develop the scientific and social infrastructure to ensure the continued production of alfalfa for whatever markets using whatever methods of the growers choosing, whether organic, export, GE-adapting, or GE-sensitive. This may include continued dialog between parties, and a proposed development of an on-line Non-GE certification program among other steps.

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