Coexistence of Genetically-Engineered Alfalfa and Organic or GE-Sensitive Alfalfa Hay - Is it Possible?

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News Story (2002)

- Winter-applied alfalfa herbicides are measured in wells near Tracy, CA
- Concern expressed by residents and Dept. Pesticide Regulation
- State Implements ‘Groundwater Protection zones’ program to prevent contamination
- Many alfalfa herbicides affected
Coexistence of GE and Non-GE crops
News Story (2006):

- 60 Animals Killed in Poisoning incident in California
- Grower failed to control lambsquarters in the field
- Lambsquarters accumulate nitrate
- Nitrates Killed the animals
What’s the Issue at Hand?

- Risk! It’s is a part of farming (and life)
- RR technology could have prevented the first two incidents
- RR technology-new opportunities & new challenges
- Fundamental Principle: All technologies have both + and - features
  - ‘Conventional’ ‘Organic’ ‘GE Crops’
- How does one evaluate the risks of new technologies?
We should develop methods to allow successful production for any market or any production system:
- Organic
- Export
- GE Sensitive
- Conventional
- GE Adapting
- Dairy, beef, sheep, horse

Fundamentally, a new technology should not interfere with the ability of a grower to farm as they wish.
Coexistence of GE and Non-GE crops

Alfalfa:

- What are the Market Sensitivities?
- What can be done to prevent disruption of markets sensitive to biotech alfalfa?
  - Export
  - Organic

Coexistence of GE and Non-GE crops
### Where does Alfalfa Go?

#### Key Markets Approximate %

*California*

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<th>Market</th>
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<td>Dairy</td>
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<td>Beef</td>
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<td>Sheep/Goat</td>
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Domestic Dairy Usage is Clearly the Most Important Market for Alfalfa in the United States
Coexistence of GE and Non-GE crops

Considerations for Dairy Markets:

- Considered ‘wholesome’ food, “Motherhood”
- Predominance of quality requirements for hay (NO WEEDS!)
- Other health issues paramount (‘Mad Cow’, antibiotics)
- No Evidence of Biotech impact on milk (to date)
- Dairy has absorbed many GMO traits (>8)
  - BST (1980s)
  - RR Soybean, Corn, cotton
  - Bt Cotton seed, corn
  - Cheese (Biotech rennet)
- Organic Milk—about 1-2% but growing
- Majority will not likely be sensitive to Biotech hay.
Considerations-Horse Market

- >9 M horses in US..... and growing!
- Thousands of Individual Preferences
- Recreation/ Pets, not economic product
- Some Resistance to Biotech Likely-Personal Preference is important
- May work in Favor of RR alfalfa - each year horses are killed by poisonous weeds.
- Feed Store Decisions
Coexistence of GE and Non-GE crops


- Alfalfa Production: 18,478,311 MT
- Alfalfa Exports: 831,352 MT
  *(Journal of Commerce, hay and cubes)*
- Percent Exported (6 States): 4.54%
- Percent Exported (US): 1.10%
- California: approx 1%
- Washington State: v. high % exported
- Imperial Valley: high % exported
- Importers are sensitive to GE alfalfa
Estimate that <3-5% of US Alfalfa Production is ‘sensitive’ to Biotech trait
- Organic
- Export
- some horse markets
- Others

Important to respect market sensitivities in regions where different production systems must co-exist
Are Hay Markets Rational?

- Clear Evidence to the Contrary
  - Long Seed Heads on Timothy
  - Emphasis on Color
  - Arguments over 1/10% TDN, RFV
- Horse, Export particularly ‘subjective’
- Food/ feed safety is largely an issue of ‘trust’, which is built over time.
- ‘The customer is always right’ - hay growers must respond!

Coexistence of GE and Non-GE crops
Adventitious Presence (AP) in Alfalfa Hay

- There is a genuine concern by organic and export growers as to whether they will be ‘stuck’ with unwanted RR alfalfa in their field.
- This is the Key issue with judge’s decision
- What are the chances of this occurring?
Coexistence of GE and Non-GE crops

Gene Flow - What is it?

- “The incorporation of Genes into the gene pool of one population from one or more other populations” -- Futuyma, 1998, Ellstrand, 2003
  - Hybridization and introgression are subsets of gene flow.
  - Change in Population Frequency over time

Coexistence of GE and Non-GE crops
What is required for genes to move from one alfalfa hay field to another to cause Adventitious Presence?

Coexistence of GE and Non-GE crops
Process of Gene Flow in Hay Fields

Biotech Field

A. Probability of Flowering
B. Probability of Pollinators
C. Probability of Movement

Conventional Field

D. Probability of Flowering
E. Probability of Pollination
F. Probability of Seed Set
G. Probability of Stand Establishment
H. Adventitious Presence in Hay

Feral Alfalfa

Steps required

Coexistence of GE and Non-GE crops
Gene Flow Starting Point:

- Gene flow in Seed production
- (Worst Case Scenario for hay)
Gene Flow in Alfalfa

- **Fitzpatrick, et al., 2003:** Leafcutter Bees

  - Isolation at 1500 ft reduced gene flow to <0.2% in both years.
  - Isolation ≥ 900 ft reduced gene flow to <0.5% in both years.

*Coexistence of GE and Non-GE crops*
Gene Flow in Alfalfa

Under Honey bee pollination

Gene flow % = \(-1E-12x^3 + 5E-08x^2 - 0.0005x + 1.9908\)

\(R^2 = 0.9688\)

LSD \(0.05 = 0.13\)

CV (%) = 45.5

Coexistence of GE and Non-GE crops

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Gene Flow in Alfalfa

Under Honey bee pollination

Predicted Gene flow with “isolation” distances between 165’ and 5000’

Gene Flow (%) = -0.0003x + 1.8529

\[ r^2 = 0.9827 \]
Gene Flow in Alfalfa

- Extent of Gene flow from hay to seed fields

Hay: contains marker (RR)

Seed: conventional cultivar

Normal management

Total area of seed and hay equal – range finding study

[Diagram showing the extent of gene flow from hay to seed fields with specific areas marked and distances indicated.]
Coexistence of GE and Non-GE crops

\[ y = -0.1844 \ln(x) + 1.1778 \]

\[ R^2 = 0.7199 \]
How to Estimate gene flow in hay:

Estimate Gene Flow in Seed Crops (e.g. .25% to 1.5% - distance dependent)

*Environmental Barriers in hay production:*

- X Probability of simultaneous flowering
- X Probability of pollinators for movement
- X Probability of seed produced
- X Probability of germination, survival

= Probability of Adventitious Presence in Hay
Example (1):

1.5% Upper Limit

X Probability of:

Simultaneous Flowering (10%) = 0.15%
Sufficient Pollenators (10%) = 0.015%
Maturation of seed in hay (10%) = 0.0015
Seed Remains, germinates, survives (10%) = 0.00015

= Probability of Permanent Gene flow (Adventitious Presence) in Hay crops
Example (2):

0.25% Upper Limit (hay to seed Teuber data)

X Probability of:

Simultaneous Flowering (100%) = 0.25%

Sufficient Pollinators (100%) = 0.25%

How many flowers would be pollinated? (likely 1/1,000 or 1/10,000) (0.01% or 0.001%)

Maturation of seed in hay (0.01%) = 0.0025

Seed Remains, germinates, survives (e.g. 1%) = 0.00025
Gene Flow Potential in Hay Crops

- A series of ‘Environmental Barriers’ based upon management
- Is it zero?
- Is it Low?

Coexistence of GE and Non-GE crops
In general, the potential for gene flow in alfalfa hay crops is no different in magnitude from the possibility of other impacts between neighbors (weed seeds, insects, pesticides, fertilizers).

- Probability of gene flow very low
- There are steps that can be taken to reduce
What are Neighbor Impacts?

- Pesticides, Fertilizers, Gene Flow
- Weeds, Manures, insect pests

Coexistence of GE and Non-GE crops

Organic or GE Sensitive

Conventional or GE
Methods to enable co-existence of Biotech and non-biotech alfalfa

- Plant non-GE seed when growing for sensitive markets
  - This is the most important step!
- Understand Potential for Gene Flow in hay crops
  - (0.5 to 2% in seed fields)

Coexistence of GE and Non-GE crops

Methods to enable co-existence (continued)

- Understand **Limits** to Gene Flow in hay
  - ‘Environmental Filters’ of harvest, removal, poor stand establishment in existing crops

- Reduce Conditions which enable gene flow
  - Flowering, pollinators, seed production

- Control Feral Alfalfa
  - Refuge, movement of genes
Methods to enable co-existence (continued)

- Identify GE and non-GE alfalfa
  - (Prevent lot mixing, mislabeling)
- Testing to Verify
  - Test Strips for field, stacks, and lab
- What are Tolerance Limits?
  - Japan requires labeling >5% for hay
Coexistence of GE and Non-GE crops

Field Study

Meridian, Idaho

TEN %
FIVE %
ONE %
ZERO %
Coexistence of GE and Non-GE crops

SAMPLING PROTOCOL

1. Identify a single lot of hay
2. Randomly sample 20 cores from hay lot
3. Combine samples and mix
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Coexistence of GE and Non-GE crops
**TEST STRIP RESULTS GROUND SAMPLES**

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Coexistence of GE and Non-GE crops
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Using Test Strips
Coexistence of GE and Non-GE crops

Limits of Detection - Test Strips

Results - RR Desktop Study
UC Davis

- Coexistence of GE and Non-GE crops

- Graph showing the percentage positive against treatment percentage for Envirologix and SDI.
What is our tolerance?

- In this case - tolerance is not a toxicology issue - but market defined.
- Zero Tolerance?
  - Raises many questions about methods
  - Does not really exist in most industries
- Tolerate Low level of Adventitious presence?
- Do we tolerate other unwanted neighbor effects currently?
Coexistence of GE and Non-GE crops

Conclusions:

- Small Component of market will be ‘sensitive’ to RR alfalfa (3-5% nationwide)
- Hay-seed and seed-seed- special challenges
- Coexistence of GE and non-GE is possible
- The risks of GE impacts upon neighbors in hay production are similar to other technologies (fertilizers, pesticides, pests, weeds) that impact neighbors.
- A ‘Good Neighbor’ approach should be effective in most cases.
- There are steps that can be taken to enable successful coexistence
Coexistence—is it Possible?

Coexistence of GE and Non-GE crops
California Alfalfa & Forage Symposium
Monterey, CA
December 17-19th, 2007
See http://alfalfa.ucdavis.edu

Coexistence of GE and Non-GE crops
Coexistence of GE and Non-GE crops

Process of Gene Flow in Hay Fields

Steps required to move genes from one alfalfa hay field to another to cause Adventitious Presence
Coexistence of GE and Non-GE crops
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