Genetic Crop Improvement

- The ‘old-fashioned’ way to achieve genetic improvement in corn and soy was through traditional sexual acts among consenting, or sometimes not consenting, plants of the same species.

'Natural' Corn Plant Sex

- Gravity, wind or human intervention allows the pollen to fertilize the ovules.
- Pollen produced in the tassel anthers contains the male genetic material.
- Ovules produced on the ears contain the female genetic material.
- This ‘natural’ sex has been going on for thousands of years!
Results of ‘Natural’ Crop Sex

- Domestication of crops.
- Improved crop traits for enhanced yield and/or grain quality.
- Genetic modification (GM) of crop species by:
  - Rearrangement of genes within a species via natural or directed-pollination
  - Incorporation of genes from “wild” or “close” relatives via natural cross-pollination

‘Natural’ GM of Crops Works!

- Indiana corn grain yields have increased by 1.6 bushels per acre per year for the last 70 years.
- Primarily due to ‘natural’ genetic modification (GM) and improved crop production technologies.

But, some worry...

- The annual yield gain (1.6 bu/ac/yr) as a percent of the yield potential of the corn crop has been decreasing for the past 70 years.

Nagging Question:
Can we keep up with the increasing global need for food?
Limits to Crop Breeding?

- Slow process to develop new varieties.
  - Not uncommon for 8 – 10 years from start to finish using traditional breeding techniques.
- Desired new or improved traits not always present in crop species.
  - Disease or insect resistance
  - Physiological improvements
  - Stress tolerance
  - Grain or plant composition

Thus, Genetic Engineering

- Allows for faster variety development.
  - Tissue culture, recombinant DNA, etc.
- Allows for transferring heretofore unavailable genetic traits into a crop variety from unrelated species.
  - e.g., transgenic traits such as Bt insect resistance originating from soil bacteria.

Transgenic Example: Bt

- Bt genes originate from the soil bacteria, *Bacillus thuringiensis*
  - Researchers can identify and isolate the genes.
  - “Blasted” into corn DNA using gold particle gene guns
  - Bt genes that successfully incorporate into corn DNA express the insecticidal Bt protein in corn plant grown by farmer.

Image Source: Univ. of Nebraska
http://www.agbiosafety.unl.edu/education/summary.htm
Genes vs. Events

- Different versions of a gene may exist.
  - Cry1a(b), Cry1a(c), Cry9c, etc. for Bt genes.
  - Thus, different varieties marketed.
- The combination of exact gene version and its eventual location within the corn genome is termed an ‘event’.
  - Two companies may use the same Bt gene, but located in different DNA positions; thus two different ‘events’.

So, what about StarLink™?

- StarLink™ corn hybrids contained the Cry9C insecticidal gene from *Bacillus thuringiensis*
  - Technically, is a different version of the Bt gene, but has the same mode of action as other Bt genes
  - However, the protein has different binding site in the insect gut than that from other Bt versions, which made it attractive for combating insect resistance to Bt.

Common consumer concerns?

- Fears of unidentified food safety risks from transgenic modifications
  - Toxins
  - Carcinogens
  - Dietary preferences
    - Not a risk, but a matter of choice
  - Allergens
    - Soybean & Brazil nut genes
    - Kraft™ taco shell recall & StarLink™ Bt corn
So, what about StarLink™?

- Stability of protein to heat and gastric digestion are greater than those of other Bt genes
  - Was the reason for allergen uncertainty on the behalf of EPA regulators
  - Was the reason for non-approval of StarLink™ corn for human food use.

Common consumer concerns?

- Fears of unidentified environmental risks from transgenic modifications
  - Off-target injury or death to nonpests
  - Monarch butterflies & Bt corn pollen
  - Genetic selection pressure for resistance to transgenic trait or herbicide used with transgenic trait
  - Glyphosate (Roundup™) & ryegrass in Australia
  - Gene escapes (cross-pollination) to weedy relatives of crops
    - Canada (rapeseed) & weedy mustards in Canada
    - Corn & wild relatives in Mexico

Common consumer concerns?

- Fears of corporate monopolies in agricultural production
  - Control of global food supply
  - Elimination of small farmers

Top 7 Agrochemical Co’s
Marketplace response?

- Grain importers, buyers & processors have responded to consumer concerns by limiting which transgenic varieties they will purchase.
- European Union has an accepted list
  - Includes Roundup Ready® soy & most Bt corn, but not Roundup Ready® corn or StarLink™ Bt corn
- Acceptance by processors & public is less certain for the immediate future
  - Frito-Lay, Gerber, Staley, McDonalds, National Starch
  - Kraft (taco shell recall)

Transgenic Crops in Indiana

- Herbicide tolerant varieties
  - Glyphosate resistant soy & corn
    - Roundup Ready®
  - Glufosinate-ammonium resistant corn
    - Liberty Link®
- Insect resistant varieties
  - Bt corn
    - Primarily European corn borer control
    - Several Bt genes and events marketed

Transgenic Corn in U.S.

Transgenic Soy in U.S.

- 78%
- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%

NE IA IL IN OH U.S.

2001 Crop Year


Issues for Indiana Farmers

- Seed cost of TG crops?
  - Typically more expensive than non-TGs
- Agronomic benefits of TG crops?
  - Sometimes questionable
- Agronomic disadvantages of TG crops?
  - Sometimes ignored
- Market uncertainties of TG crops?
  - Sometimes dramatic
- TG consequence for non-TG crops?
  - Can be costly

Grow TG crops or not?

- Must determine the balance between agronomic costs, agronomic or economic benefits and market uncertainties

For example:
- High cost + little benefit + uncertain market = substantial economic risk
- High cost + some benefit + feed own livestock = little economic risk
Nielsen’s Opinion:
- Insect-resistant or herbicide-tolerant varieties are NOT CRITICAL for the successful production of corn & soybean in Indiana!

In other words, growing non-TGs will not result in economic ruin for most Indiana farmers!

Example: Bt corn
- An “insurance” trait
  - The Bt gene or trait, by itself, does not increase yield
  - Only useful when pest occurs
  - Little payback in years when European corn borer (ECB) infestations are minor
  - For example, 1998 & 1999 in Indiana
  - ECB damage in 2000 and 2001 more severe, but damage still questionable economically.

Our position on Bt corn …
- Bt corn is not economical for the average Indiana corn field due to low historical frequencies and severities of ECB outbreaks relative to “tech fees” of hybrids (Purdue Extension Publication ID-219)

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By average, 2001

Image Source: USDA, Image Number K2634-8
http://www.ars.usda.gov/is/graphics/photos/
So, what about RR soy?

- Why so popular?
  - Good weed control
  - Lower herbicide cost
  - For many farmers
  - More time flexibility
  - Less crop injury
  - Less mgmt. effort

- Any disadvantages?
  - Higher seed cost
  - Appl’n timing
  - Some wait too long to apply herbicide and consequently suffer yield loss to early weed pressure
  - Market acceptance?
    - Sometimes an issue
    - Genetic yield diff.?

TG Consequences for non-TG

- Because some grain buyers will not accept TG grain, some farmers need to take extra precautions to avoid TG contamination of their non-TG grain.

  - TRANSLATION: Extra costs and headaches placed on farmers and the grain buying industry.

Costs of non-TG production

- Ensuring seeding purity
  - Seed source certification for non-TG
  - Prior crop in the field
  - Planting operation
- Avoiding cross-pollination w/ TGs (corn)
  - TGs or not in adjacent fields
  - Buffer rows around edges of field
  - Tinkering w/ planting date to manipulate timing of pollination of corn relative to adj. fields
Costs of non-TG production

- Ensuring harvesting purity
  - Super cleanout of harvester prior to harvest of non-TG field
  - Harvest non-TG fields before TG fields
- Avoiding grain commingling
  - Super cleanout of storage facilities
  - Store TG separate from non-TG
  - Super cleanout of transport equipment
  - Consider selling or delivering grain directly from field harvest

StarLink™ lessons for future

Biotech firms should not be allowed to market a biotech variety until:

- The variety has been approved by regulatory agencies and accepted by the grain industry for all end uses, including feed, industrial, food and pharmaceutical;
- Reliable and inexpensive testing technology is available for use at the first point of sale (such as strip-test kits for elevator use);

Case in Point:
Roundup Ready® corn, 2001 harvest season, test kits available (as of 10/8/01) for new NK603 event (lesser acreage) but not older GA21 event (greater acreage).
Transgenic Crops in Indiana

StarLink™ lessons for future

- Biotech firms **should not be allowed** to market a biotech variety until:
  - The variety has been approved by regulatory agencies and accepted by the grain industry for all end uses, including feed, industrial, food and pharmaceuticals.
  - Reliable and inexpensive testing technology is available for use at the first point of sale (such as strip-test kits for elevator use); and
  - Tolerance levels based on detectable limits have been established in order to give the U.S. grain handling, exporting and processing industry the ability to meet customer demands with respect to the presence of approved but undesired transgenic crop traits in their end-products.

Bottom Line …

- The “GMO” debate will continue into the near future.
- Current TGs are not critical for the agronomic success of most Indiana corn/soy operations.
- Farmer’s choice to grow or not depends primarily on his/her perception of the agronomic benefits of the TG, the market uncertainties for TGs in the coming crop year & seed availability of non-TG varieties.

References