Genetically Engineered Crops and Herbicide Resistance: Common Pool Resource Economics in Action

Dept. of Economics Seminar
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Why should we care about GE crops?
What are the potential benefits and risks? (NRC study)
Common pool resource management challenges with herbicide resistance (HR)
Economic ramifications of community-based approaches for HR management
Agriculture is:
- key to global food and biofuel production
- largest global land use ~ 38%
- largest consumptive use of freshwater
- largest source of U.S. water pollution
Why Should We Care?

- Key threat to biodiversity
  “…freeze the footprint of food by….productivity, efficiency and sustainable intensification” (WWF 2014)
- Food system, including production, emits one third of greenhouse gases (CIGAR 2012)
- Conundrum: GE crops have the potential to increase food and biofuel production and lessen each environmental impact but also pose risks.
Popular perception of GE Crops?
GE Corn
GE Soybeans
GE Cotton
GE Sugar Beets
GE Rainbow Papaya
GE Golden Rice (Vitamin A fortified)
The Impact of Genetically Engineered Crops on Farm Sustainability in the United States

Study Committee

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Purpose of the Study

• Funded by NRC to take holistic perspective
• Interdisciplinary investigation of economic, environmental, and social impacts of GE crops (in U.S.) using peer-reviewed evidence
• Retrospective examination (1996-2009)
• Identify gaps and future applications of genetic engineering technology
What are GE crops?

- Advances in molecular & cellular biology allow “desirable” traits from other species to be inserted into crop plants via GE methods.
- IR Crops: common GE trait allows plants to produce their own insecticide, e.g., Bt, to reduce crop losses from insect damage.
- HR Crops: another common form resists certain herbicides (e.g., Roundup) so herbicides can kill many types of weeds without harming the crop plants.
GE Crops Analyzed

- Soybeans
  - Herbicide resistance, e.g., Roundup-Ready
- Corn
  - Herbicide resistance
  - Insect resistance, e.g., Bt
- Cotton
  - Herbicide resistance
  - Insect resistance, e.g., Bt
GE Crop Growth in the U.S.

U.S. acreage of GE soybean, corn, and cotton as a percentage of all acreage of these crops

Environmental Effects

Evaluation

- Examined soil, water and biodiversity
- Compared GE v. non-GE crops managed with herbicides and insecticides (baseline)

Main Conclusions

- Generally found fewer adverse effects than conventional production practices due to fewer and less toxic pesticides and less tillage
- However, GE crop management practices were likely to cause a return to more environmentally damaging practices.
Pest Resistance

- Weed resistance to Roundup increasing at fast rate
- 12+ weed species resistant in the U.S. including Palmer Amaranth, Common Water Hemp, Giant Ragweed, and Horseweed
- Alternative controls include more toxic compounds, more tillage, or both.
- Insect resistance not yet present in the U.S., but some early signs in developing countries.
GE crop adopters have benefited from:

- Cost-effective weed control
- Reduced yield losses from insect pests
- Reduced expenditures on pesticides and fuel
- Increased worker safety
- Greater flexibility in farm management
- Lower risk of yield variability
- All are short-run effects.
Conclusions

#1: Weed problems in fields of HR crops will become more common as weeds evolve resistance to glyphosate.

Recommendation: Multi-stakeholder group needed to document emerging weed-resistance problems and develop cost-effect practices to increase longevity of HR technology.
THE PROBLEM
Harvesting ragweeds and corn!
Palmer amaranth changes agriculture forever

Photo credit: Stanley Culpepper, U. Georgia
2000-2005: 17% of growers hand-weeded 5% cotton acres at $2.40/A

2006-2010: 92% of growers hand-weeded 52% cotton acres at $23.70/A
Diverse demand drivers for HR crops

• Strong crop prices
• Cost/lower efficacy of alternative herbicides
• Opportunity cost of time for non-herbicide pracs
• Company herbicide use promotions
• Farm Bill program provisions, e.g., conservation compliance, that preclude tillage on some land
• Community social network (peer pressure)
• Operator preferences for health and safety
• Expectation that substitute technologies will bail them out.
The problem is increasing!
Multiple SOA resistance is rising!
Herbicide resistance occurs due to selective ecological pressure on weeds (Darwin)

Weed resistance mobility occurs from natural processes, e.g., pollen drift, and machinery

Hence the genetic pool of weeds susceptible to control by certain herbicides is a common pool resource shared across farms and the community landscape.
Common Pool Resource Challenges

- Grower actions affect other growers via weed gene movement (*nonexcludable externality*)
- If farmers feel their control actions will not be matched by their neighbors, they have less incentive to manage HR on their lands.
- It’s an assurance problem! (Individual decisions depend on those of the group.)
- Because of mobility, strategies to control HR farmer by farmer will not optimize welfare.
- Some form of collective action is necessary.
Potential Solution Approaches

1. Voluntary education and tech assistance for individual farmers aren’t working.

2. Top-down prescriptive regulation, but……
   • Lack of flexibility increases control expense
   • Prescriptive practices often stymie innovation
   • High monitoring and enforcement costs to check compliance across the landscape (Do we want a weed police?)
4. Public or private technology/practice subsidies can have similar problems…….
   – Difficult to identify strategic targets
   – Additionality? -- payments can become income transfers without altering behavior

5. Resource privatization is generally infeasible due to geographic scope of weed mobility.

6. What’s left? -- Community-based common pool resource management, an exercise in institutional (socio)economics (Ostrom et al)
1. Clearly define resource boundaries
2. Adapt rules to local conditions
3. Ensure broad participation by “appropriators”
4. Monitor accountability to appropriators with sanctions
5. Employ graduated sanctions
6. Use cheap and easy conflict resolution mechanisms
7. Recognize self-determination of the community, e.g., state statutes
8. Consider “polycentric” governance (multiple layers) for larger issues
Meta analysis of 91 CPR studies found good empirical support for all principles.

Suggested refinement of principles 1, 2 & 4:

1a. Clearly defined boundaries: Individuals or households who have rights to withdraw resource units from the common-pool resource (CPR) must be clearly defined.

1b. Clearly defined boundaries: The (geographical) boundaries of the CPR must be well defined.
2a. Congruence between appropriation and provision rules and local conditions: Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions.

2b. Congruence between appropriation and provision rules and local conditions: The benefits obtained by users from a CPR, as determined by appropriation rules, are proportional to the amount of inputs required in the form of labor, material, or money, as determined by provision rules.
4A. Monitoring: Monitors are present and actively audit CPR conditions and appropriator behavior.

4B. Monitoring: Monitors are accountable to or are the appropriators.
CPR applications relevant to HRM

- *Public initiatives* (e.g., invasive and noxious weed control)
- *Joint private-public* strategies (e.g., boll weevil eradication)
- *Producer associations* with sanctions written in state law (e.g., pink bollworm control in CA, AZ and NM)
Agrawal (2003) – meta review of studies

- Factors affecting formation do not have unequivocal effects, e.g., size of group.
- Higher group heterogeneity is not always a disadvantage.
- Need to account for resource, social/political contexts and personal values
Insights from literature

- Exchange of information important
  - Multi-directional vs. uni-directional flow
  - Listening is underrated

- Building institutional capacity takes time and requires maintenance (even after crises subside).

- “If/then” statements based on scientific information that show economic consequences are more effective than exhortations of what people “should” do.
Concluding Observations

1. HR is a *wicked problem* (interacting biophysical, technological, economic and social systems), that defies simple solutions.

2. Private and/or public collective approaches are necessary when mobile HR traits exist.

3. Ostrom’s design principles can help guide development (but aren’t a blueprint).

4. Success will likely require participatory research that uses local knowledge and social capital to foster trust and minimize transaction costs.
References


References


Thank you! Dave Ervin  dervin@pdx.edu
Economic effects on non-GE producers are mixed and poorly understood

Planting GE crops can have positive and negative effects on non-GE producers

– price decreases for replaced pesticides
– landscape level pest suppression (Science)
– protection measures and loss of markets for “GE free” food products due to gene flow, e.g., Oregon wheat example