AgBioForum – Volume 2, Number 2 – 1999 – Pages 61-64

A FARM LEVEL PERSPECTIVE ON AGROBIOTECHNOLOGY: HOW MUCH VALUE AND FOR WHOM?

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Even the optimists among biotechnology proponents have been caught off guard by the extremely fast farm-level adoption of bioengineered crops. In 1999, just four years from commercial introduction, an estimated 40% of the total United States (U.S.) corn, soybean and cotton acreage were planted with herbicide- and insect-resistant bioengineered crops. To put this level of adoption in perspective, one may consider it against that of the most dominant agricultural technology of the past -- hybrid corn. To make the comparison more pronounced, one may consider the average adoption rate of hybrid corn for only Iowa, Illinois, and Wisconsin, which exhibited some of the highest adoption rates among all relevant states. The comparison is revealing. In 1999, an estimated 51% of soybean acres were planted with Roundup Ready® soybeans (figure 1). It took seven years for the selected States to reach similar adoption levels in the case of hybrid corn. In some States it took twenty years or more. *Bacillus thuringiensis* corn (Bt-corn), Roundup Ready®- and Bt-cotton also exhibit adoption rates significantly faster than hybrid corn. Adoption of bovine growth hormone in the dairy industry, on the other hand, has been slower.

What are the factors driving the speedy adoption and diffusion of bioengineered crops on the farm? What are the economic benefits delivered by such technologies, and how have such benefits been shared between the farmers and the innovators? In this issue, academic and industry experts provide empirical evidence on such benefits and their distribution.

Arriving at exact measures of "average" or aggregate economic benefits from biotechnology is less than straightforward. Early adopters, assumed to be above average managers, can upwardly bias the impacts of biotechnology simply through their superior management abilities. Impacts on yields and costs can also vary significantly from one year to another or from one location to another, due to the variability of insect and weed pressures, often making results difficult to interpret. Our traditional assessment techniques are also not well suited to the measurement of the impacts of bioengineered crops. Weed trials compare the performance of various weed control programs but overlook the yield potential of the varieties tested (Carpenter & Gianessi). Similarly, yield trials do not always leverage or account for the advantage in pest control of bioengineered crops.

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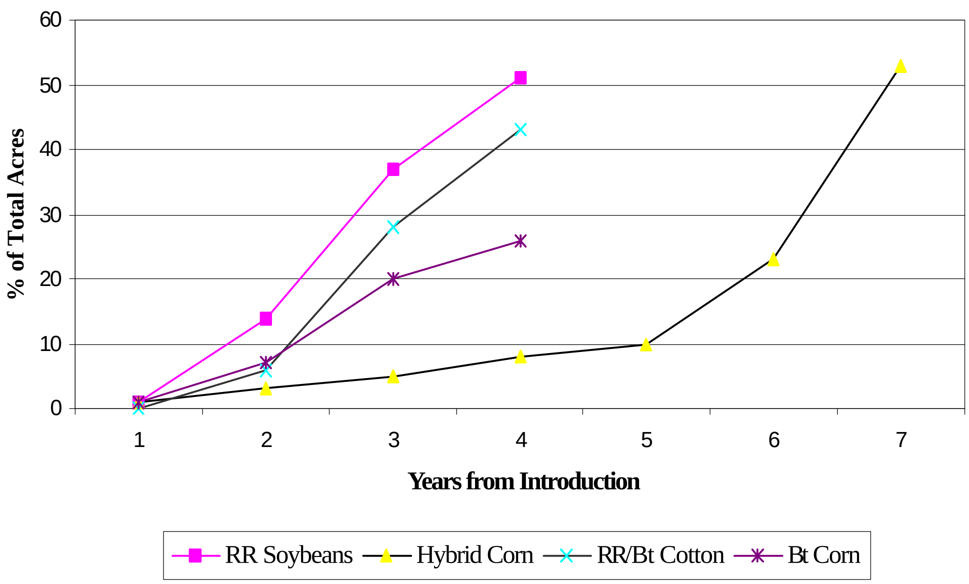
Despite inherent measurement difficulties, studies in this issue suggest that first generation biotechnologies have delivered tangible economic benefits on the farm[1] (Carpenter & Gianessi; Fetrow; Hillyer; Klotz-Ingram, Jans, Fernandez-Cornejo & McBride; Traxler & Falck-Zepeda) and could continue to do so in the future (Arabiyat, Segarra & Willis). Such benefits come in the form of the following:

- Cost reductions in pest management.
- Yield increases.
- Improved risk management and insurance against pests.
- Management time savings.
- Reductions in equipment outlays associated with no-tillage production systems.
- Land-use efficiency gains from improved plant spacing.

Not all these benefits apply to all biotechnologies, or are enjoyed by all farmers (Fulton & Keyowski). Farmers using no-till systems, or confronting large weed or insect pressures, for example, will tend to benefit most from bioengineered crops. In general, however, average economic benefits have been large enough, and a significant portion has been passed onto farmers (Traxler & Falck-Zepeda). Hence, the empirical evidence presented in this issue suggests that the adoption rates observed in the last few years are in-line with the benefits delivered by various biotechnologies. Where benefits are less obvious to farmers, adoption had tended to be more sluggish (Butler).

Figure 1. Adoption of Bioengineered Crops and Hybrid Corn



Looking Into The Future

It is quite possible that these on-farm economic benefits derived from the first generation agrobiotechnologies are transitory. Professor Willard Cochrane taught us back in the 1950s that as long as farmers deal with technical innovations in commodity markets they are on a "technological treadmill". The faster they adopt technology, and increase supply, the faster prices fall due to inelastic demand, ultimately resulting in a loss of value. Whether, or how soon, such a scenario will materialize, will be determined by future demand conditions, and the relative balance of the various benefits from biotechnologies (e.g., risk reduction versus yield increases).

Another, more optimistic, scenario is that second-generation biotechnologies, still mostly at the development stage, will move agriculture away from its perpetual treadmill. Corn, soybeans, canola, sunflower, and other crops are being genetically modified to have improved qualities that match the needs of feeders and food processors, or which provide direct health and nutritional benefits to consumers. More exotic technologies that turn plants into protein factories are also being advanced. The assumption is that such improved qualities will have economic value. The amount of economic value, of course, will be a function of technological advance and substitution economics (Bohorova & Scrimgeour; Coaldrake & Thomas).

Monetarization of the economic value of quality-enhanced crops hinges on the transformation of traditional supply chains in order to allow for relevant information flows and successful segmentation of markets. Segmentation of a commodity market into specialty sub-markets, and a residual commodity market, should result in higher total market value. If the commodity market has an upward supply function then both the specialty and the commodity markets will benefit from the segmentation. In addition to creating value, such segmented markets are less vulnerable to the technological treadmill phenomenon as demand is typically more elastic.

How soon will value from quality-enhanced crops be delivered to the market? Unlike first-generation agrobiotechnologies, which fit existing systems with few or no adjustments, second-generation biotechnologies require many. Most importantly, end-users must reach a level where they are able to appreciate and take advantage of the value created by quality-enhanced crops. Feeders, through feeding trials, must experiment with and align these technologies with genetics. Processors must learn how to leverage quality enhancements and build additional value around them. Consumers must learn to recognize the products and to correlate nutritional benefits and value. Other parts of the system must also adjust. Crop merchandisers, for example, must learn how to effectively segregate quality-enhanced crops and how to optimize identity preserved supply chains. And so on down the list of participants.

The higher the investments required for the commercialization of quality-enhanced crops --whether in learning or in physical infrastructure -- the slower market penetration will be. To be sure, there is significant innovation and investment taking place in all parts of the supply chain at this time. Feeders and integrators are experimenting with a variety of quality-enhanced crops and animal genetics. Significant investments are being made in information systems for the creation of virtual markets and management systems appropriate for identity preserved supply chains. Most elevators expect that within five years 25% of their turnover will come from quality-enhanced crops, and are either preparing for, or carrying out, relevant investments in storage suited for identity preservation. All these investments will assist with the placement of second-generation biotechnologies. Nevertheless, these investments also suggest that adoption and market penetration of such technologies will likely be slower than that of the first-generation.

How much value will farmers capture from second-generation agrobiotechnologies? At this time, any answer to this question is by necessity speculative. What is clear is the lower bound of such value. Since farmers can always choose to produce commodities, quality-enhanced crops must deliver value at least equal to that delivered by commodities. And since commodity markets could also benefit from market segmentation, farmers will, at minimum, capture value equal to any hike in the commodity price. Beyond that, and given that value from quality enhanced crops is distributed through up-front conjecture and negotiation across the supply chain, individual assets brought to the negotiating table by each player will likely determine value distribution. Hence, the relative negotiating position of individual farmers in each supply chain will likely determine their share of value from second-generation agrobiotechnologies.

As agricultural markets become more differentiated and information-driven, competition for specific land, management, weather, and location properties will likely increase. Within this context, land and farmers are not perfectly substitutable and anonymous as they are in commodity markets. Precision farming and the Internet will only strengthen these trends over the next few years. Farmers may therefore be in a position to claim a larger share of the value created by agrobiotechnology by actively participating in the knowledge transformation of agriculture.

Increased information flows are also changing the bargaining position of the individual consumer. With enhanced infrastructure geared toward transferring data and information up and down the food chain, the agrifood system is increasingly able to listen and respond to the demand of the individual consumer. Accordingly, public acceptance of agrobiotechnology in various parts of the world will determine the value delivered by agrobiotechnology, now and in the future.

Endnotes

[1] This does not include environmental benefits from reduced soil erosion and pesticide use.