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The Gain to North Carolina Cotton Farmers from Changes In Insect Refuge Policy

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The U.S. Environmental Protection Agency (EPA) approved a plan this summer to eliminate the *cotton* refuge requirement in favor of a *natural* refuge in Texas, the Mid-South, and the Southeast for acres planted to a genetically engineered cotton called Bollgard II®. Bollgard II cotton is second-generation, insect-resistant cotton containing multiple traits to guard against harmful insects. It superseded an earlier variety – Bollgard®, also known as Bt cotton – that has only one insect-control trait. This issue of the *NC State Economist* reports the findings of a recent study estimating the likely net benefits to North Carolina cotton farmers due to the change in insect refuge policy.

Background

The purpose of a cotton insect refuge is to maintain a pool of insects susceptible to the insecticidal traits inserted into the cotton seed. As some insects are exposed repeatedly to the same insecticide, they may develop a resistance to it. This resistance renders the insecticide less effective over time. Several classes of conventional cotton insecticides have experienced insect resistance build-up in the past, pyrethroids being the most recent, so the cotton refuge policy was supported by entomologists and instituted by EPA as a way to avoid the problem in insect-resistant cotton.

The cotton refuge policy was instituted by EPA when cotton engineered to contain insecticidal traits first became available in 1996. It required that cotton farmers plant a portion of each cotton field with cotton seeds that do not contain the insecticidal traits. The size of these portions varied depending on whether the refuge cotton was sprayed with conventional insecticides or not. If the refuge cotton was sprayed for insects, 20% of the field area was required to be set aside as a refuge. This option meant that farmers had to spray 20% of the field for the target insects several times. If the refuge cotton was not sprayed, only 4% of the field area was required to be planted in non-resistant cotton. This option resulted in substantially reduced or no yield on the refuge portion of the field. (By way of contrast, Bollgard II cotton requires little or no sprays for the target insects).

Further study revealed that, in the cotton states located from Texas to the Southeast, non-cotton areas surrounding cotton fields – the so-called "natural refuge" – contained enough host plants for harmful cotton insects that a sufficient number of susceptible insects would be available to pass on their susceptibility to the general insect population. Further, Bollgard II was found to be effective enough to prevent resistance build-up within cotton fields, because it leaves almost no insects alive from which resistance build-up could develop. The natural refuge is now judged to be adequate by the EPA, although some scientists and environmental groups are still skeptical that the natural refuge will prevent resistance development to Bollgard II cotton in the future.

Economic Gains from the Policy Change

Two types of economic benefits accrue to farmers from the change in cotton refuge policy.

Pecuniary benefits are the economic gains that can be ascertained in a straightforward manner because they are directly tied to market transactions, and hence can be readily assigned a monetary value. The pecuniary gain on the refuge acres is the difference in profit attributable to switching from non-insect resistant cotton to Bollgard II cotton. The pecuniary gain on the Bollgard acres is the difference in profit from switching from Bollgard to Bollgard II varieties on those acres. To estimate the gains to North Carolina farmers of the change in cotton refuge policy, we employed a partial budgeting approach that focused only on the components of profit that are impacted by the change in policy. Using this approach, the net addition to profit is the sum of the additional revenue (including cost savings) less the sum of any decreases in revenue (including cost increases).

Non-pecuniary benefits are economic gains associated with services that are not traded in markets but are nonetheless valued by farmers. These include increased human safety, environmental improvements from lower insecticide use, and convenience. Convenience value could include the value of a simpler and more flexible production system, less worry about scouting for harmful insects, more consistent control of the lepidopteran pests (and associated reductions in yield risk), and the value to the farmer of his time savings. We know that a simpler, less risky, and more flexible system has value to growers, but we cannot measure it from market outcomes. Stated preference methods may be employed to obtain an estimate of their value.

The Estimated Gain to North Carolina Farmers from the Policy Change

We calculated the expected farm-level economic gain to North Carolina cotton farmers and the change in revenue to Monsanto Company resulting from the change in cotton refuge policy. These economic gains to farmers – both pecuniary and non-pecuniary – result from changes in land previously maintained as cotton refuge, as well as changes in acreage previously planted in Bollgard. Our analysis assumed that farmers replace all cotton acres on which Bollgard had been planted with Bollgard II, since planting Bollgard II eliminates the additional costs of the refuge requirement (due to greater input use or reduced yield) thus rendering Bollgard II economically superior.

Data

A formidable amount of data is required to calculate the net pecuniary benefits to farmers of eliminating the current refuge regime and replacing it with a natural refuge. The requirements include side-by-side yield comparison data for Bollgard II, Bollgard, and conventional cotton, where the insecticide sprays associated with each yield observation are recorded so that we can estimate the probabilities associated with spraying the three types of cotton in any particular year; the cost of each spray; the acreage in each type of cotton in the state; the acreage planted to each of the cotton refuge options; and the costs and levels of other inputs associated with the policy change. In addition, these data must be available in sufficient quantity to achieve statistical reliability. We used the data from the 2005 crop year in North Carolina for our analysis because that is the most recent year for which all necessary data existed.

Pecuniary Benefits in North Carolina

Table 1 summarizes the results of our analysis. We found the total annual pecuniary gain from the *converted refuge acres* to be $12,528,109 per year, or $267.12 per refuge acre. The total pecuniary gain on the *acres planted previously to Bollgard varieties* equals $509,505 per year, or $0.97 per Bollgard acre. The sum of the two pecuniary impacts is $13,037,614 or $22.82 per impacted acre.

Non-Pecuniary Benefits in North Carolina

Although the value of the non-pecuniary benefits of several other crop biotechnologies has been estimated, the non-pecuniary benefits of Bollgard II cotton have not. We used the measures of central tendency derived

from stated preference estimates from five previous studies of the non-pecuniary benefits accruing to genetically engineered cotton, corn and soybeans, to develop a proxy for the non-pecuniary benefits of Bollgard II cotton. Although the proxy is imperfect, it is derived from the only data available that address these values.

The medians of the total value of the individual non-pecuniary benefits derived from these surveys range from $2.43 to $10.00 per acre. The midpoint is $7.57 per acre. This midpoint formed the basis for our estimates of the per-acre additional value to North Carolina cotton farmers of the non-pecuniary gains on former cotton refuge acres. To be conservative, we used half the midpoint, $3.79, as our estimate of the non-pecuniary value of the per-acre change on the current Bollgard acres. The non-pecuniary gain, therefore, is estimated to be $355,033 per year on the refuge acres and $1,986,482 on the Bollgard acres. The total non-pecuniary gain is estimated to be $2,341,515 per year.

Total Net Gain

The total annual net gain North Carolina farmers would have received in 2005 as a result of the policy change is the sum of the pecuniary and non-pecuniary gains on the former refuge acres and Bollgard acres. Assuming no non-pecuniary benefits, the gain is $13,037,614 per year, or $21.91 per impacted acre. The total net gain that includes our proxy for the non-pecuniary benefits is $15,379,129 per year or $26.90 per impacted acre. If the cotton price is, say, $0.52/lb. lint and a typical cotton yield in North Carolina is 700 lb. lint per acre, then total revenue would be $364 per acre. The net gain from elimination of the cotton refuge would amount to a 7.4% increase in revenue per impacted acre.

Sensitivity Analysis

To provide a range of possible estimates of the net gain, we considered variations in some of the important parameters. Changes in expected cotton price and the level of the technology fee were found not to have much influence on the per-acre net gains. The parameter that appears to influence the net gain the most is the spray cost. Increased spray cost is a savings because acres are being switched from a technology that requires several insecticide sprays in a typical growing season to a technology that requires little or none. An assumed 50% increase in per-acre spray cost per acre – from $16.49 to $24.74 – results in an increase in net gain of about 70% (or $11.52 per acre), whereas a 50% increase in the technology fee results in a 3% decrease in net gain ($0.78 per acre). Increasing the cotton price by 50% – from $0.536/lb to $0.80/lb – increases the net gain by 13% ($3.44 per acre).

Table 1. Total Gain to North Carolina Farmers of a New, Natural Refuge Policy for Bollgard II Cotton Varieties

	Total Acres	Value/Acre	$/State/Year
On current BG and BGII refuge acres:			
Non-bt to Bollgard II			
Pecuniary gain	46,900	$267.12	$12,528,109
Non-pecuniary gain	46,900	$7.57	$355,033
Sub total			$12,883,142
On current Bollgard acres:			
Bollgard to Bollgard II			
Pecuniary gain	524,830	$0.97	$509,505
Non-pecuniary gain	524,830	$3.79	$1,986,482
Sub total			$2,495,987
Total Gain Per Year to North Carolina Farmers		**$26.90**	**$15,379,129**

Conclusion

The net gain at the farm level from the change in cotton refuge policy attributable to only pecuniary factors considered is estimated to be $13 million per year, or $22.82 per acre. The total farm-level benefit to North Carolina cotton farmers (inclusive of non-pecuniary benefits) from a change in refuge policy is estimated to be $26.90 per acre. This amounts to a total expected benefit of $15.4 million per year for North Carolina cotton farmers. The gain in revenue to Monsanto is estimated to be $2,427,620, or about 16% to 18% of the amount gained at the farm level. The total net gain at the farm level and to Monsanto is estimated to be $15.5 million if non-pecuniary gains are assumed to be zero or $17.8 million if non-pecuniary gains are assumed to be equal to the median value from the earlier studies. This policy change looks to be a win-win situation for North Carolina farmers, Monsanto, and North Carolina residents concerned about the environmental and health impacts of pesticides.

For more information:

Marra, M.C. and N.E. Piggott. 2006. "The Value of Non-Pecuniary Characteristics of Crop Biotechnologies: A New Look at the Evidence." Chapter 8 in Just, Alston, and Zilberman (eds.), Regulating Agricultural Biotechnology: Economics and Policy, New York: Springer-Verlag Publishers, pp.145-178.

Piggott, N.E. and M.C. Marra. 2007. "The Net Gain to Cotton Farmers of a Natural Refuge Plan for Bollgard II® Cotton". AgBioforum 10(1): 1-10.

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