POTENTIAL ACCEPTANCE AND MARKETING OF CORN GENETICALLY MODIFIED TO REDUCE PHOSPHATE EMISSIONS

Final Report

Issue Addressed

Nutrient pollution of streams, rivers, bays, and ground water is an important environmental concern. Phosphorus pollution in particular is a problem in many areas of the US. The result is excess algae growth, large swings in bacterial populations, eutrification, decreased dissolved oxygen levels, and ultimately, degraded water quality and biological resources and declining fish populations. These lead to additional economic impacts such as decreased fishing and tourism.

There are many causes of phosphorus pollution, including sewage, urban storm water, forests, and agricultural sources both from artificial fertilizer applications and manure. The focus here was on phosphorus pollution from agricultural operations and on means to reduce the problem. Specifically, phosphorus originating from fertilizer usage has been identified as a key factor in nonpoint source pollution. Rain induced runoff from land with excessive fertilizer and manure leads to over-enrichment of ground water, streams, and estuaries.

In Southern Delaware there is a large and highly concentrated poultry industry. Field crops, such as corn and soybeans, dominate the cultivated farm acreage in the area due to the influence of the poultry industry. The combination of field-crop agriculture and animal-based agriculture in Southern Delaware has contributed to high phosphorus levels in soils. As a result, nutrient pollution is an immediate concern to the Inland Bays and Chesapeake Bay as well as other regional streams and rivers.

In response to this problem, the state enacted the Delaware Nutrient Management Law in 1999. Nutrient management practices include, for example, proper timing and methods of fertilizer (commercial and manure) application, planting of cover crops and vegetative buffer strips, and erosion control. As a result of mandatory nutrient management, many farmers have adopted a phosphorus-limiting nutrient planning program. Instead of using the readily available chicken manure, farmers are applying more expensive nitrogen only sources of fertilizer, e.g., ammonia or urea. Another result is the poultry industry's use of expensive manure disposal outlets. Costs of current solutions to the phosphorus issue are thus high.

The possible solution examined here is in feeding poultry a new variety of corn containing the enzyme phytase. Phytase would allow for increased phosphorus conversion efficiency, reducing the need for additions to the feed, and thus reducing the ratio of phosphorus in the elimination process. This reduces the phosphorus level in the manure, changing the ratio to allow farmers to decrease the amount of nitrogen only sources of fertilizer without worrying about over application of phosphorus and thus

reduce input costs. The development and use of high phytase feed corn would therefore help reduce the phosphorus mass balance.

This corn, referred to as high available phosphorus (HAP) corn, does not yet exist as a marketable product. The current version has a yield reduction compared to other corn seed as it was modified from a lower yielding cultivar. However, this should be correctable in future generations through either traditional methods or the use of genetic engineering. This study examined the potential adoption of HAP corn by farmers and marketing of poultry raised on the feed as beneficial to the environment to consumers. The methodology involved surveys of consumers and corn farmers across the Delmarva region. Implications include better environmental conditions and cost efficient use of poultry manure.

The overall objective of this research is therefore to examine the market potential for HAP corn. The specific goals for accomplishing this objective were to determine:

1) Consumer willingness to purchase chickens fed HAP corn, including if they would be willing to pay a premium for the environmental benefit.
2) Combinations of attributes, such as seed price, yields, and possible crop premiums that farmers would desire in order to adopt HAP corn.
3) If adoption and acceptance of HAP would depend on whether the variety was genetically modified.

Project Approach

The project was conducted in two stages. The first stage focused on consumer interest while the second focused on farmer adoption. Both stages were conducted with the assistance of a Masters level graduate student that completed a thesis based on the project findings. Surveys were the primary methodology used to accomplish each goal. The survey procedures followed standard established protocols in order to maximize response rate. Specifically, an advance postcard was sent announcing the survey. This was followed shortly by a first mailing, including cover letter, survey, stamped return envelope and a token of appreciation in the form of $1. After another week, postcard reminders were sent. For the first stage consumer survey, a second full mailing was sent to all that had not responded. Further details pertinent to each stage are included below.

For the consumer stage, a mailing list was purchased from USAData containing 1500 people in the states of Delaware, Pennsylvania, New Jersey and Maryland. The final survey design allowed for investigating consumer willingness to purchase chickens fed GM HAP or non-GM HAP corn, as well as fed conventional (non-GM) corn, Bt corn, and Roundup Ready corn. Since we expected knowledge of these feeds and phosphorous pollution to be limited, we included a description sheet for each in the mailing. Conjoint analysis was used in the construction of the survey questions.

Next, **t**he mailing list was divided into three strata of 500 each, with the first representing locations where phosphorus pollution should be the highest and the other two

progressively further away. Each of these parts was further constructed to be half male and half female as both of these factors were hypothesized to be important in willingness to purchase. After accounting for undeliverable surveys, the total response was 585 of 1456, or 40%. This was believed to be a large response rate, especially given the potential complexity of the topic for many consumers.

Analysis of survey data was conducted using a Tobit regression model, including quadratic and two-way interaction terms, and corrected for heteroskedasticity. The base model included feed types and prices. Given the large number of possible demographic and other characteristics of the respondents, a modeling process was constructed that looked in turn at interactions with gender, age, income, education level, location (strata 1, 2 or 3), race and having children under 18 present in the household. Categories found to be significant were added to the base model. The results of all these tests were used to construct a final model.

The second survey was targeted towards corn farmers to assess the feasibility of farmer acceptance and adoption of HAP corn under different potential scenarios. The last was essential since the research is an *ex ante* investigation of adoption, conducted prior to being certain what characteristics a finalized HAP corn may possess. In order to understand which characteristics are most important to farmers in their decisions to adopt new seed varieties and thus help design the survey, a focus group was conducted. The focus group consisted of grain farmers, crop scientists, and Cooperative Extension experts from various areas throughout Delaware in order to obtain a wide range of knowledge and opinions.

Using the information gained from the focus group and the experiences of the investigators, the survey was designed. The main focus was on seed price, yield, and premium potential. A unique conjoint design where farmers were asked to project adoption over the next three years for various possible HAP corn outcomes was used. Other questions were used to judge if it mattered whether the HAP trait was the result of genetic modification or not.

The mailing list was provided by the National Agricultural Statistics Service (NASS), an agency of the USDA. The list provided by NASS included 1,902 Delmarva corn farmers after removing bad addresses and those who do not grow corn on the Delmarva Peninsula. Timing of the survey was carefully planned to arrive during farmers' non-busy season. To aid response rate it was also kept as short as possible and had minimal need for farmers to check records to complete. After the first mailing and reminder postcard, 740 usable surveys were returned, yielding a final response rate of 38.91%, which exceeded initial expectations. Analysis of the data was carried out using Tobit regression in a manner similar to that described above.

Private and Public Contributions

A number of private contributions to this research were made, primarily in the early stages. In the planning stages, technical consultation was provided from Fraunhofer

USA, Inc., which had been engaging in development of GM HAP crops. Letters of support and interest in the study were additionally obtained from all three poultry companies based in Delaware: Allen Family Foods, Mountaire Farms, and Perdue. Many other private contributions were made throughout the research and design of the surveys. These included key information and insight from many farmers, animal scientists, individuals at seed companies, and Cooperative Extension Agents.

Public contributions came especially from the Federal State Marketing Improvement Program (FSMIP), particularly in funding of the research. Other important contributions were made by the University of Delaware and the National Agricultural Statistics Service (NASS).

Project Results

Results for the first goal showed that consumers have serious concerns about phosphorus pollution and may be willing to help the issue by purchasing chickens fed HAP corn. Certain segments of consumers did have greater interest. The most interesting demographic finding was an interaction of age with feed type. Interest in chicken fed conventional feed decreased steadily with age from being the most popular at age 20 to least desired at age 80. Interest in HAP corn products increased steadily with age so that by age 45, non-GM HAP corn had the greatest likelihood of purchase.

In all situations, likelihood to purchase chickens fed GM HAP was essentially parallel to non-GM HAP corn, but lower. Thus, given a choice between the two, consumers will clearly select chickens fed non-GM HAP. This is consistent with previous studies showing consumer reluctance to purchase GM versions of food products, while extending the finding into an area where the product has an environmental benefit. This lower acceptance of GM foods may be due to the perception of a large percentage of the respondents that GM foods can lead to long term health problems. For such individuals, these concerns can outweigh potential environmental benefits.

A larger issue with regard to the GM version however may be the lack of knowledge regarding the technology and the extent of its use in the food system. Almost 66% of the consumers reported little or no knowledge of GM foods. Ignorance could therefore be another main cause of consumer distrust of GM foods and reduced purchase likelihood. An increase in consumer knowledge of GM foods or a move towards labeling of such products may significantly alter results. The study shows that a large number of consumers read product labels. GM labeling may affect consumer purchasing decisions and is an avenue for additional investigation.

Price, as expected, was another key factor in purchasing decisions. Price was found to interact with gender, race and education level with the findings that, in general, females, African-Americans, and those with some college education are more sensitive to price changes. Also, as would be suggested by consumer theory, income had a positive effect on the likelihood of purchasing chicken. Interestingly, however, there were no

interactions between type of feed and price. This suggested consumer purchasing decisions adjusted with price changes in a similar fashion for each feed type.

While acknowledging some of the concerns above, it seemed reasonable to conclude that both non-GM HAP and GM HAP would be accepted by consumers although there may be a need to educate younger consumers. The former would clearly have an advantage in the marketplace, at least in the absence of a stronger marketing and educational campaign for the GM version.

Turning to the second goal, results indicated that an optimal HAP corn variety for farmers would have a low technology fee, a low yield drag, and a high harvest premium. Assuming farmers do not incur financial losses, the study suggests that HAP corn adoption would increase over time. However, in the hypothetical HAP corn scenarios farmers were less tolerant of negative aspects, such as technology fees and yield drag, as time progressed.

The study also found that certain groups of farmers, such as those with high soil phosphorus levels, may be more inclined to adopt HAP corn. This higher willingness to pay for HAP corn sometimes manifested itself as a higher tolerance for negative characteristics. Farmers with lower levels of education were less sensitive to increases in HAP technology fees and yield drags. Older farmers also appeared to be more tolerant of yield drags associated with HAP corn. Aside from differences in adoption resulting from the underlying characteristics of HAP corn, the farmers' adoption of HAP corn seemed to be affected by the farm size, the portion of farm income from corn, and the use of a computer for financial management.

There are, of course, some aspects of development and management that could improve the ease of adaptation to HAP corn. Ideally HAP corn would not require any specialized management, such as on farm storage or segregation, but this is doubtful since it is a nutritionally beneficial product. Segregation would likely deter many farmers from purchasing HAP corn unless markets offered a very large premium. Therefore, Delmarva grain handlers should develop an efficient way to segregate corn which does not greatly inconvenience farmers. This may require handlers to update processing equipment or to purchase additional storage bins. Another option is to dedicate certain locations or days to accept HAP corn at grain handling facilities. Fortunately, the precautionary measures taken to avoid contamination of non-GM foods should not be necessary in segregating HAP corn.

For HAP corn to be successful it should also be available in combination with other value added traits, such as YieldGard Corn Borer and RoundupReady. The results indicated that the average Delmarva corn farmer would not be opposed to a GM version of HAP corn. In fact, farmers may prefer a GM version if it meant they would not have to compromise good agronomic characteristics for the benefits of HAP corn. While the corn growers do have some reservations, overall they appeared concerned about the environment and willing to do their part in reducing pollution.

Outputs

Outputs from the project remain ongoing. In addition to the outputs below, other articles are in progress. This list will be updated as appropriate on the project's web site.

Theses

Gupta, Meeta. "Consumer Behavior towards Chicken Fed with Genetically Modified High Available Phosphorus (HAP) Corn." MS Thesis, University of Delaware, August 2005.

Parish, Amy. "Farmer Willingness to Adopt High Available Phosphorus (HAP) Corn" MS Thesis, University of Delaware, August 2007.

Presentations

Gupta, Meeta, John C. Bernard and John D. Pesek. "Consumer Acceptance of Chicken Fed with Genetically Modified High Available Phosphorus (HAP) Corn." Paper presented at the Northeastern Agricultural and Resource Economics Association 2005 Annual Meeting, Annapolis, MD, June 12-15, 2005.

Parish, Amy, John C. Bernard and John D. Pesek. "Farmer Willingness to Adopt High Available Phosphorus (HAP) Corn." Paper presented at the Northeastern Agricultural and Resource Economics Association 2007 Annual Meeting, Rehoboth Beach, DE, MD, June 10-13, 2007.

Working Papers

Pesek, John D., John C. Bernard, and Meeta Gupta. "Consumer Behavior towards Chicken Fed With Genetically Modified High Available Phosphorus (HAP) Corn" Food and Resource Economics Working Paper, University of Delaware, November 2007.

Further Research Suggested

A couple of appropriate avenues exist for further research. First would be to examine acceptance issues on the poultry industry side. Since broiler integrators make decisions on feed, their say may have an impact on success and usage of HAP corn varieties. A second extension would be to investigate the interest in HAP corn in other regions and as potential feed for other livestock, particularly swine. Phosphorus pollution concerns are not unique to the Delmarva region and the development of an acceptable variety of HAP corn may aid other areas of the country.

Benefits Derived from Project

The primary benefit of this study was the determination that, under the conditions discovered, HAP corn could be a successful product both in terms of farmer adoption and

consumer acceptance. Both sides expressed serious concerns regarding the problems from phosphorus pollution and interest in assisting with a solution. Being able to do so in a fashion in which all market participants are satisfied would be an important improvement over existing and more costly methods.

The immediate benefit would be in guiding seed developers as their work continues on a marketable version of HAP corn. This would include the recommendations that the effort to create a non-GM version may aid consumer acceptance, but is not necessary for the farmer, while poor yields and the lack of standard accepted traits would likely prevent large-scale farmer adoption. From there, the discovery of consumer interest in aiding the environment through their chicken purchases will great assist marketers and food companies.

The greatest future benefit would be that HAP corn is developed, adopted, and marketed under the findings here and becomes a useful tool to combat phosphorus pollution in the Delmarva region and perhaps beyond. While agriculture is only one source of this problem, the reduction would aid waterways and reduce economic implications.

Additional Information Available

Additional and expanded information, including the survey materials, presentations and publications, can be found at the project's web site:

> *Potential Adoption and Marketing of High Available Phosphorus (HAP) Corn*
> http://www.udel.edu/FREC/bernard/HAP/hap_home.html

Other sources can be found using the links from that site.

Contact Information

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Description of Project Beneficiaries

The poultry industry and the grain farmers working with it on the Delmarva Peninsula will be the primary beneficiaries. These two groups make up the majority of agricultural activity and receipts in the area. Local poultry companies employ over thirteen thousand people and produce more than 567 million chickens per year, or over 6% of the US total. Meeting the demand for corn and soybeans to feed these chickens is the main focus of many of the region's farmers. Helping find a solution to phosphorus pollution concerns stemming from this system will thus aid a substantial number of participants. These benefits, importantly, would not go to only a small set within the system. For farmers, potential benefits should be consistent regardless of their scale of operation, length of time farming, or minority status.

Members of the swine industry should also benefit from this study. As noted earlier, using HAP as a feed ingredient in this sector should yield similar results in terms of reducing phosphorus pollution. Potential regional differences would need to be examined, but the farmer findings in particular should be highly applicable.

Answers here will also be beneficial to biotechnology research companies by helping them more clearly focus research and development. The encouraging aspect of interest in products with environmental benefits should indicate a promising future market. This information is of great importance in a field where successful creation of a new GM crop is an expensive undertaking, and understanding here will aid efficiency in effort. The lack of knowledge about their products, and underlying concerns expressed by many on the survey should additionally point to the need for better education and marketing.

Consumers should also benefit from this research. Results give an indication of what some of their concerns are, what sorts of information they would like, and an idea of how they may want to help environmental issues through their food purchases. Products matching consumer demand increase their utility. Individuals who enjoy fishing and the waterways will also benefit, with increased tourism aiding local economies as well.

Lastly, the two graduate students working on this project benefited significantly. Both learned a great deal, gained valuable experience working on a large-scale project, presented findings at professional conferences, completed a thesis, and will be co-authors on articles in preparation. Both have also begun successful careers since completion.