# Growing genetically engineered (GE) and conventional crops side by side

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Thank you for the opportunity to address the GMO Committee regarding opportunities and challenges for growing genetically engineered and conventional corn in Iowa. This presentation draws upon my personal experiences conducting research on corn pollination and pollen drift, many interactions with regulatory agencies responsible for the safe deployment of genetically engineered (GE) crops, collaboration with members of the Biosafety Institute for Genetically Modified Agricultural Products (BIGMAP) at Iowa State University, and information on public perceptions on biotechnology provided by the International Food Information Council. I am providing this testimony at the request of the Iowa Seed Association and as a representative of the College of Agriculture at Iowa State University.

Many factors are working in favor of growing conventional and GE corn successfully in Iowa. First, we understand the biology of corn pollination quite well. The release of pollen from the plant and its movement from one plant to another (commonly referred to as pollen drift) are natural aspects of the pollination process. And we've learned these are fairly predictable phenomena. As such, it is possible to design management schemes that limit the extent of undesired cross pollination between plants to meet desired production goals. I'll present an example later from our field research.

A second key factor is the coordination of regulatory oversight provided by the Animal Plant Health Inspection Service (APHIS), Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA) for the commercialization of GE crops. These agencies, in cooperation with the USDA Biotechnology Regulatory Services (BRS) are providing a coordinated framework of standards and regulations for the safe deployment of GE crops. Because of their oversight, and their persistent application of science-based policies, there have been no instances of public safety problems to date with commercially approved GE products. Careful management during product development, however, remains a key issue for deploying new GE crops. The Starlink case, for example, is a clear example to the seed industry how the lack of established tolerances in food forces these regulatory agencies to require zero presence of the GE trait in foods, even when there is no evidence of risk to the public or environment.

It has been my experience working with BRS that these agencies are very serious about ensuring commercialized GE products are safe. The Coordinated Framework of Agricultural Standards and Regulations is designed to provide a 'Federal Safety Net' for the public. All new GE crops are subject to science based regulation. Individual products or categories of compounds are eligible for exemption with time based on experience and relevant performance and safety data. The "Precautionary Approach" adopted in 1986 is being followed to ensure biotechnology-derived crops are as safe to grow as conventional crops. And to ensure that crops intended for food or feed are as safe to eat as conventional crops. The USDA-APHIS is charged with ensuring new GE products are safe for agriculture. The EPA works to ensure it is safe for the environment. And the FDA is involved with food products to ensure they are safe to eat. The good news, of course, is that following this coordinated framework of standards and regulations has delivered the expected results for agriculture and the general public: all GE crops in commercial use within the US have gained regulatory clearance, all are considered safe to eat and have gained waivers for food tolerances.

A recent survey conducted by the International Food Information Council provides some insight into the general public's concerns about food projects derived from 'biotech' crops. When asked, "What, if anything, are you most concerned about when it comes to food safety?" less than 0.5% (5/1000) of the respondents indicated 'biotechnology.' When those who purposefully avoided some food ingredient were asked, "...What food ingredient did you avoid or eat less of?" again, less than 0.5% indicated 'biotechnology.' Clearly, products derived from some form of biotechnology did not present food safety concerns to the vast majority of those surveyed.

There are a number of complicating factors associated with the development and deployment of new GE crops, however, that still need to be addressed. The unintended occurrence in conventional agricultural products of GE crops or GE-derived materials *for which there is no tolerance or exemption* is of primary concern. Our regulatory agencies have no choice but to force the parties involved to eliminate the GE product from the food chain. The solution for the seed industry has been to establish food tolerances or seek exemptions for all their GE products intended for commercial use. Asynchronous approval by importing countries forces agbiotech companies to channel GE products away from markets where approvals are not in place. And grower preference for producing non-GE crops to serve organic food markets currently requires them to produce seed completely free of GE DNA .

The Biosafety Institute for Genetically Modified Agricultural Products (BIGMAP) is addressing these concerns at many levels. The Institute was created to provide science-based analysis of the risks and benefits of genetically modified plant and animal products. Through basic research projects, it member scientists develop methods to help growers take advantage of new products to spur economic growth, while safeguarding valuable agricultural resources. And it serves as an un-biased resource for guidance and education about genetically modified agricultural products (GMAPs) to help safeguard consumers and the environment.

The research we are conducting on corn pollen dispersal is an integral part of the overall BIGMAP approach for assessing and mitigating the risks associated with GE corn production. The 'precautionary approach' taken by BIGMAP assumes there is some risk for loss of transgene confinement at each step in the process of developing a new GE corn hybrid from the initial transgene insertion event to the delivery of the finished product to the consumer. The challenge is to use a scientifically based rationale to assign the risks at each step, and then identify means to minimize the risk, and mitigate it if loss of gene confinement occurs.

When a new GE crop reaches the stage of seed production, then the potential for loss of gene confinement associated with pollen dispersal becomes a primary concern. Our research on pollen dispersal in corn has focused on understanding both the biological and physical aspects of the pollination process. The first point I need to make is that cross pollination resulting from pollen drift from one plant to another is a very positive aspect of yield formation in corn. Corn breeders take full advantage of this fact when then cross two inbred lines to produce hybrid corn seed. In a similar fashion, when we plant two genetically dissimilar corn hybrids together in such a way that they pollinate each other, we often observe an increase in grain yield relative to the pure hybrids stands. In short, the way we produce hybrid corn and our corn producers' need to produce high yields rely on pollen drift.

The problem arises when unintended pollen drift interferes with the need to produce genetically pure seed. This issue is of great concern to organic corn producers because the markets they have chosen to serve generally require 0% GE products. Resolving this issue for organic growers is problematic for several reasons. First, organic production is certified as a process by which the crops are grown. But the USDA does not consider the presence or absence of transgenes as a basis for certifying a crop as organically grown. This is a market requirement. Second, companies supplying organic growers with seed do not certify their seed as transgene-free. Third, and most problematic, is that the absence of transgenes (i.e. 0% GE seed) cannot be proven. We do not have the technical ability to measure zero levels of any chemical. Therefore, we cannot defend the assertion that there is absolutely no 'foreign DNA' is a sample of seeds.

Current guidelines for isolating an organically-grown corn crop from one that is not organic have little impact on preventing pollen flow between the two crops. To demonstrate this point to organic producers near Newell, IA, in cooperation with the local Extension Agent, Tom Olsen, we planted a strip of purple corn in the middle of yellow corn and separated the two hybrids by an open space of various distances up to 150 ft. Since purple seed color is dominant over yellow seed color, the presence of a purple seeds on the ears of the yellow hybrid is a clear indication that pollen drift and cross-pollination had occurred. The results of this simple demonstration confirmed that 100 ft of isolation distance, typically used in organic production, would not be sufficient to prevent gene flow caused by pollen drift. The results also showed that most of the cross-pollination occurred at the edge of the open space, where there was much less yellow pollen. The picture provided here indicates the extent of cross pollination at the edge of the yellow corn at 30 ft from the purple corn. The level of cross-pollination decreased dramatically only a few rows into the yellow corn. This result prompted us to test how we might limit the impact of unintended pollen drift when there is abundant local pollen available.

Our studies of pollen drift and its consequences for loss of transgene confinement always take into consideration three fundamental aspects of corn pollen biology: the timing and extent of pollen production, the potential for pollen transport in the air, and the interaction between pollen grain and the female flower (silks). Studies lacking any one of these components will likely be misleading. We have discovered that the basic biology of corn pollination is very predictable. With a minimum of information about the dynamics of pollen shed and silk emergence, we have been able to simulate the yield of kernel in many hybrid seed production fields consistently and with remarkable accuracy. When we have additional information about adventitious pollen entry from a neighboring field, we also can calculate the percentage of cross-pollinations that will occur.

Predicting how much pollen will flow from one field to another depends largely on the physical characteristics of the pollen grain and the physical nature of the path between the fields. In cooperation with Ag Meteorologist, Dr. Raymond Arritt, we have developed a computer model to calculate the movement of pollen away from a source field. In the example provided, a steady 7 mile per hour (3 m/s) wind from the Northwest was sufficient to cause pollen drift more than 330 ft (100 m) from an isolated field. In the absence of competing local pollen, the density of pollen at that distance would have pollinated fewer than 3 out of every 1000 exposed silks. The accuracy of these pollen drift calculations has been repeatedly confirmed by in-field measurements.

We combined our capabilities for simulating kernel set from flowering dynamics with those for predicting pollen flow to determine whether it would be possible to manage gene flow from a GE corn crop by surrounding it with non-GE corn. The approach was to isolate a 2-acre plot of Bt-Roundup Ready® corn within an 80-acre field of white corn. This allowed us to follow gene flow using color, the Bt gene, and glyphosate resistance as redundant markers for gene flow. The results of this study indicated that 35 m of surrounding corn provided sufficed isolation to limit gene flow to 0.9% or less, which meets purity requirements for seed delivered to Europe. At 100 m, the gene flow was limited to less than 0.1%. It is important to note that these values were attained in all directions relative to the source, and were observed in two environments in central Iowa.

Even more important for today's discussion is that the pattern of gene flow that we documented by sampling intensively in the surrounding field could have been predicted. Information about pollen shed and silking for the two hybrids, combined with weather data collected at the field site enabled us to calculate pollen drift from the Bt-RR corn plot and the resulting cross-pollination in the surrounding white corn. The figure shows how remarkably accurate this approach can be, even at very low levels of adventitious pollen. This capability can provide valuable information about genetic purity of a crop that have direct implications for harvesting and marketing options for both GE and non-GE corn producers.

Our modeling approach for calculating percent out-crossing is well suited for managing genetic purity at isolation distances typically used by the hybrid seed industry (100 – 200 m). But how do we deal with the potential for pollen drift across greater distances? This is of particular concern for isolation of GE-corn plots producing chemicals not intended human or animal consumption (PMPs, PMIs, etc.). It is very important to distinguish the requirements for isolating this class of GE-crops from those that are not regulated and are currently in commercial production. Here we are concerned about predicting the potential for transport of pollen 0.5 mi and beyond. The approach to this problem requires taking a meteorologist's view of the atmosphere and its capacity to lift pollen up from a field of corn. The animation of pollen flow provided is designed to show that corn pollen can and does get lifted into the atmosphere above the corn field. This pollen that is lifted higher can be transported farther downwind. What is not obvious because of the image scale is that the vast majority of pollen falls to the ground in close proximity to the source area. Nonetheless, there we are concerned that isolating the corn plot by a much shorter crop or bare soil (per APHIS regulations) itself might contribute to the problem of pollen drift. Preliminary evaluations confirm that the physical shape of the corn canopy affects the potential for pollen dispersal. When the change in canopy height is taken into account, our pollen dispersal model deposits less pollen in the lee of the plot and more pollen travels downwind away from the plot. This is just what we've measured in the field around isolated corn plots.

Based on these observations, we are now working to identify management options that might limit pollen dispersal in the field for plots isolated in accordance with APHIS requirements. For detasseled corn, that means spatial isolation of 0.5 mi from the nearest corn used for feed. This past summer, in cooperation Bill and Joe Horan of Horan BioProduction, LLC, we tested whether a windbreak about twice as tall as the corn it surrounded would provide sufficient change in canopy aerodynamics to decrease pollen movement from the plots. This study, supported by funding from USDA Biotechnology Risk Assessment Program and BIGMAP included documentation of pollen deposition up to 15 m above the canopy, as well as 300 m away from it. The results of pollen flow from plots with and without a windbreak are currently being summarized. The results can be made available to the GMO Committee when they become available.

In the meantime, there are a number of practical management options already available to producers concerned about adventitious pollen entry. The list includes physical, biological, mechanical, spatial, and temporal isolation techniques, many of which are being used already by the hybrid seed industry. Their application, of course, is a practical balance between cost of implementation and risk of unacceptable loss of genetic purity. For organic seed producers in particular, minimizing the potential for product impurity requires a combination of management strategies. These include i) testing the seed to be planted for genetic purity, ii) using time, distance, and intervening corn to isolate the crop from other pollen sources, iii) document wind patterns during pollination, and iv) cooperate with the neighbors to help isolate fields more effectively.

The bottom line for any product, whether GE-corn, conventional corn, or organically grown, is that 100% pure cannot be proven or defended. As such, we cannot logically devise a management system to ensure this outcome. Low levels of impurity, however, can be measured reliably. Therefore, it is essential that low, but acceptable levels of product impurity (transgene content) be identified and promoted.

Thank you again for this opportunity. Please do not hesitate to contact me be phone or email regarding these important issues.