Corn Producer Practices and Insect Resistance Management Requirements

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The use of transgenic crops has become widespread in the United States over the past decade. Growing genetically modified crops is popular among farmers in part because of low management requirements associated with crops developed for insect resistance, herbicide tolerance, or crops having both (stacked) characteristics.

Concerns about the use of transgenic crops center around the safety of consuming food products made from such plants and potential environmental effects associated with growing the crops. This paper deals with the latter concern. In particular, report on the degree to which South Dakota corn producers follow Insect Resistance Management (IRM) requirements administered by the Environmental Protection Agency (EPA). IRM plans are required for all farmers growing Bt corn, which is a genetically modified crop containing a gene from the soil bacterium Bacillus thuringiensis. Corn with the Bt gene produces proteins that are toxic when consumed by European corn borers (ECB), as well as corn rootworms and other insects.

The specific objectives of the paper are to document planting practices among Bt corn growers in South Dakota, identify factors that help farmers follow the IRM requirements, and verify whether current IRM requirements are sufficient to avoid – or at least postpone – future pest resistance and to help maintain pesticides effectiveness.

Insect Resistance Management Requirements

Traditionally, several tools have been available to agricultural producers for managing crop insect problems. Simple physical ways are to plant and harvest early, or destroy stalks after harvest, allowing over-wintering ECBs to be killed. Other, more effective control options used by farmers are the use of granular and liquid insecticides. However, insecticides are generally not fully effective in killing ECBs (Ostlie, Hutchison, and Hellmich, 1997).

Since its commercial introduction in 1996, Bt corn has proven to be an effective tool for managing pests such as the ECB and the corn rootworm. The insects are killed when consuming the protein containing the Bt toxins of the corn. However, when large amounts of pesticides are used in the environment, organisms often adapt and gradually become immune to the toxins. To preserve the efficacy of Bt corn in controlling pest, the EPA has established requirements on the use of the crop, based on a plan developed by the EPA and member companies of the Agricultural Biotechnology Stewardship Technical Committee (Agricultural Biotechnology Stewardship Technical Committee, 2005).[1]

In general in the United States, the use of transgenic crops such as Bt corn is regulated by three departments or agencies. The primary responsibility of the EPA is to ensure the environmental safety of new plant pesticides and substances, including transgenic crops. The Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture is responsible for ensuring the safety of growing transgenic plant varieties. The main task of the third government component, the Food and Drug Administration (FDA), is to ensure human health is not adversely affected by consuming food products made from transgenic crops.

The EPA's insect resistance management requirements for the Upper Midwest entail growing a minimum of 20 percent non-Bt corn varieties out of the total number of corn acres. The planting of conventional corn must be located within one-half, and preferably within one-quarter, of a mile away from areas where Bt corn is grown. Refuge areas may also consist of blocks or strips of conventional corn in the Bt corn fields, allowing the genes of nonresistant insects to swamp those of any resistant insects from the Bt fields (Mitchell, Hurley, and Hellmich, 2000). Further, farmers are not allowed to use microbial Bt insecticides to control

[1] Each of the four members of the Committee were producers of Bt corn, and include Dow AgroSciences, Monsanto, Pioneer Hi-Bred and Syngenta Seeds.

insects in the refuge acres, and other insecticides are only permitted when economic thresholds are reached. The latter minimum limits must be established on the basis of recommendations by local or regional professionals (Wright and Hunt, 2004).

The IRM requirements are based on a high-dose refuge method, designed to make sure a sufficient amount of Bt toxin is produced to kill all the ECBs in a specific area, except the most resistant ones. Farmers are required to plant non-Bt corn in the refuge area, so that ECBs non-resistant to Bt can survive and mate with resistant ECBs emerging from the Bt crop. If a sufficiently large refuge area is planted, most of the surviving ECB, as well as their offspring, will remain non-resistant to the Bt toxin.

As part of the IRM requirements, Bt corn growers must sign agreements for program compliance. Farmers failing to implement IRM plans on their farms for two years will not be allowed to grow Bt corn a third year (Wright and Hunt, 2004). To monitor farmer compliance with the program, the four seed companies are required to conduct an annual survey among corn growers, and must establish a program for investigating "legitimate tips and complaints" about growers who may not abide by their compliance agreements. Local seed dealers bear responsibility for monitoring compliance (Kram, 2002).

Because Bt corn is visually very similar to conventional corn, it is difficult to monitor the extent to which growers follow the IRM requirements. For example, there are concerns growers may plant a smaller refuge area then required, or just ignore the requirement entirely due to the additional technical, labor and administrative burdens associated with planting the non-Bt refuge area. Thus, in this paper, we seek to report on general planting practices among Bt corn growers in South Dakota, to identify factors important for farmers to follow the insect resistance management requirements, and to learn from the experiences the Bt corn producers.

Data and Methods

A modified survey instrument developed by Barham, et al., (2003), and also used in Nebraska (Hunt 2003) was mailed to a sample of 317 corn producers in South Dakota in July of 2004, using a modified “Total Design Method” developed by Salant and Dillman (1994). The sample of corn farmers consisted of respondents who had completed a survey on agricultural biotechnology in 2002. The original random sample was drawn from a proprietary list of active corn and soybean farmers, and the 2002 survey was administered by the National Agricultural Service (NASS) in Sioux Falls, South Dakota. A total 132 questionnaires were returned, but 18 respondents did not qualify for participation in the survey, and ten expressed no interest in completing the questionnaires. The remaining 104 completed and partially completed surveys were used for analysis.

Farm Characteristics

Among the responding farmers, 84 percent had organized their farms as sole proprietorships, ten percent as family partnerships, five percent as family corporations, and one percent as a cooperative, estate or trust, county farm, or other institutional farm. About one-fourth (24.7 percent) of the sample operated fewer than 250 acres, 21.6 percent between 250 and 500 acres, and also 21.6 percent operated between 500 and 750 acres of cropland. The remaining 32.0 percent of the producers farmed at least 750 acres of cropland in 2004. Exactly 25.0 percent of the farmers owned one-fourth of their cropland, 17.7 percent indicated owning between one-fourth and one-half of their cropland, 16.7 percent owned between one-half and three-fourths of their cropland, and the remaining 40.6 percent owned more than three-fourths of their cropland. Further, over three-fourths (76.0 percent) of the farmers indicated doing all farm work by themselves or with the help of family members, 22.0 percent did more than one-half their required farm work by themselves, and the remaining two percent stated that less than one-half of all of their farm work was done by themselves or a family member. Nearly one-third (29.4 percent) of the respondents reported having total farm receipts of less than $50,000 per year, 14.1 percent received between $50,000 and $100,000, 23.9 percent between $100,000 and $200,000, 26.1 percent received between $200,000 and $500,000, and the remaining 6.5 percent of the respondents had at least $500,000 in farm receipts in 2003.

While the survey participants are characterized as crop farmers, the majority of the respondents had some dependence of their income on livestock. In particular, only one-fourth (24.7 percent) of the respondents reported receiving less than five percent of their income from livestock. Nearly one-fifth (19.2 percent) of the farmers received between five and 15 percent of their income from livestock, 20.5 percent received between 25 percent and 50 percent of their income from livestock, and the remaining 35.6 percent received more than one-half of their income from livestock in 2003. Further, nearly one-third (30.9 percent) of the farmers stated having no debts, and the remaining 69.1 percent indicated having at least some farm debt. Finally, more than one-fourth (26.6 percent) of the respondents indicated planning to cease farming within five years, and 14.9 percent planned to quit between five and ten years. The remaining farmers indicated planning to farm indefinitely, either because their farm returns (31.9 percent), or their off-farm incomes (26.6 percent of the respondents) were deemed sufficient to provide for an adequate standard of living.

Corn Insect Problem Perceptions

To obtain a baseline of farmer perceptions about crop losses associated with pests, the crop producers were asked to report corn damage due to specific insects over the previous five years. Nearly all (89.6 percent) of the farmers reported having problems with the European corn borer, and slightly fewer (80.5 percent of the farmers) had experienced crop damage due to the corn rootworm. In addition, 51.9 percent experienced crop damage due to cutworms, 29.9 percent because of wireworms, 14.3 percent as a result of seed-corn maggots, as well as 14.3 percent due to white grubs. Fewer than five percent of the farmers had experienced damage due to seed-corn beetles, corn flea beetles, or other insects. Further, 41.9 percent and 32.6 percent of the farmers stated that of all the aforementioned insects, the ECB and the corn rootworm, respectively, had caused the most severe production loss.

To acquire further details about crop damage perceptions caused by insects, the farmers were asked to provide estimates of crop damage. In particular, 62.8 percent of the respondents stated that stalk breakage and eardrop damage due to the ECB was less than 20 percent. The remaining 37.2 percent of the respondents estimated such damage at more than 20 percent. In terms of yield loss, 29.8 percent of the respondents stated losing fewer than ten bushels per acre, 39.3 percent lost between ten and 20 bushels per acre, and the remaining 31.0 percent of the farmers estimated their losses due to ECB damage at more than 20 bushels of corn per acre.

While crop damage associated with the corn rootworm was perceived slightly smaller than that caused by ECBs, the perceptions among the responding farmers about yield losses due to corn rootworms were similar to yield loss damages due to ECBs. Specifically, 46.2 (53.8) percent of the respondents stated that lodging damage due to corn rootworms was less (more) than 20 percent. Perceived yield losses as a result of the corn rootworm were similar to those of the ECB – 27.9 percent of the respondents stated losing fewer than ten bushels per acre, 37.2 percent lost between ten and 20 bushels per acre, and the remaining 34.5 percent of the farmers estimated their yield losses due to the corn rootworm at more than 20 bushels of corn per acre.

One of the main remedies against ECB damage is using resistant non-Bt hybrids – 38.4 percent of the respondents utilized this method. A second important solution against ECB is to conduct crop rotations, which was implemented by 26.7 percent or the individuals who indicated seeking to manage ECB damage. When asked about the most important way to manage damage from corn rootworms, 35.8 percent of the respondents reported using crop rotations, one-fourth (25.3 percent) used soil insecticides, and 10.5 percent of the farmers used resistant non-Bt corn hybrids to control corn rootworm damage.

Importantly, a relatively small number of farmers agreed that insect pests have developed resistance to management programs utilized among farmers. In particular, 13.8 percent of the farmers reported experiencing a decrease in the effectiveness of their corn insect management program. Nearly one-half (44.7 percent) of the respondents did not notice a decrease in their corn insect management program effectiveness as a result resistance. The remaining 41.5 percent of the respondents did not know whether insect resistance to management programs had changed.

Experiences with Bt Corn Plantings

In 2004, more than four out of five (81.9 percent) of the responding farmers had planted Bt corn varieties, such as the “YieldGard”, “KnockOut”, “NatureGard”, and “Maximizer” varieties. The remaining 18.1 percent of the respondents did not plant Bt corn varieties in the same year. The main reasons for not planting Bt corn included dissatisfaction with Bt corn yields, disappointing net returns, and concerns about selling their Bt corn crop. However, because the total number of respondents who did plant Bt corn was small (only 17 out of 94 individuals reported not planting Bt corn), their motivations for not planting the genetically modified corn is not representative South Dakota crop farmers as a whole.

The Bt corn-using farmers considered a number of motivations for planting Bt corn. In particular, 92.9 percent reported planting Bt corn in part to achieve improved insect control, 89.6 percent sought to increase corn yields, 51.9 percent wanted to reduce overall insecticide use, 36.4 percent stated that planting Bt corn fit well with their existing production practices, and 28.6 planted Bt corn partly because of a seed dealer's or a crop consultant's advice. When asked to list their single most important reason for planting Bt corn, 62.9 percent of the farmers stated that increasing corn yields, and 18.6 stated that allowing improved insect control were central incentives.

A further of indication farmers are largely satisfied with Bt corn varieties is that almost four out of five farmers (79.2 percent) reported higher Bt corn yields than those associated with conventional corn varieties, and an almost equal share of the respondents (76.7 percent) stated that pest damage per acre was lowered as a result of using Bt corn in comparison to non-Bt corn. Further, 62.0 percent of the farmers reported a drop in insecticide use associated with planting Bt corn. However, nearly three out of four farmers stated that Bt corn expenses exceeded those of conventional varieties, and nearly three-fourths (71.8 percent) of the farmers reported no change in labor needs per acre associated with using Bt corn in comparison to conventional varieties. Overall, the positive aspects outweighed any negative elements associated with the technology for the majority of the farmers. In particular, 63.1 percent of the respondents reported earning higher profits when using Bt corn. Nevertheless, 27.4 percent reported no difference in profits between using Bt corn and conventional varieties.

IRM Requirements Compliance

A preliminary indication of the degree of compliance with the IRM requirements is provided by information on whether and how both Bt corn and conventional corn varieties are planted in the same field. Nearly all (91.4 percent) of the farmers stated that at least some of their corn fields were planted with both types of corn, but the remaining 8.6 percent of the respondents stated that none of their fields had both types of corn. Among the farmers who had planted both types of corn, the most frequently-used system of incorporating the non-Bt corn into the Bt corn plantings so as to comply with the IRM requirements was to plant the outside edges of the fields to non-Bt corn. Only 5.1 percent of the respondents did not use this system and the remaining 94.1 percent of the farmers had planted one or more of their fields in this way. The second most frequently used system was by way of planting a narrow strip to non-Bt corn or by using a split planter. Nearly two-thirds (64.6 percent) of the farmers reported using this system in at least one of their fields, and the remaining 35.4 percent of the farmers had not utilized the narrow strip system in any of their fields. Further, 42.9 percent of the respondents had planted the non-Bt corn as a block in at least one of their fields, whereby a solid portion of the field was planted to non-Bt corn. The other 57.1 percent of the corn farmers did not use this IRM compliance method on any of their fields.

Farmers are advised against simply mixing the two types of corn during planting because this practice actually increases the chance of resistance development. Nevertheless, over one-fourth (28.6 percent) of the farmers reported using this method in at least one of their fields, and the remaining 71.4 percent of the respondents reporting not using this method in any of their fields. A further indication not all farmers may be aware of all IRM details is that 36.4 percent of the respondents had at least one of their fields planted entirely with Bt corn. The remaining 63.6 percent of the farmers had none of their fields planted with Bt corn only.

An additional requirement of IRM plans is that the non-Bt corn be planted in close vicinity of the Bt corn fields. In particular, the refuge must be within one-half of a mile of the Bt corn, or within one-fourth of a mile if refuge spraying is needed. About two out of five (40.5 percent) of the farmers who indicated having planted Bt corn stated having at least one field in which non-Bt corn was planted adjacent to the Bt corn area. Further, 28.4 percent of the respondents who planted Bt corn indicated their non-Bt corn was within one-fourth of a mile away from at least one Bt corn field, 9.5 percent had planted their non-Bt corn between one-fourth and one-half of one mile from at least one Bt corn field, and 4.1 percent had planted their non-Bt corn about one-half of one mile from their Bt corn area in the case of at least one Bt corn field. However, 8.1 percent of the farmers reported having at least one field in which their non-Bt corn area was further than one-half of a mile away from their Bt corn, and 18.9 percent of the respondents had at least one field whereby the non-Bt corn area was about a mile or further away from the nearest Bt corn field.

In refuge areas, insecticides may be applied if economically justified – based on the advice of seed representatives, crop consultants, or extension agents – but microbial Bt foliar sprays are not allowed for controlling ECBs. The large majority (88.6 percent) of the farmers did not use non-microbial insecticides such as “Capture”, “Pounce”, “Regent”, or “Warrior”, but the remaining 11.4 percent of the respondents had used such pesticides at least once. One individual admitted to having used a microbial Bt insecticide such as Dipel on non-Bt corn acres.

Following the questions related to Bt corn management practices, the survey instrument listed the specific IRM requirements. In response to a follow-up question related to the requirements, 96.3 percent of the farmers stated being aware, and the remaining 3.8 percent indicated not being aware of the IRM requirements when planting their Bt corn in 2004. Almost all (97.5 percent) of the respondents judged themselves to have met the IRM requirements. One of the two individuals who admitted to not having complied with the requirements stated not having enough land to satisfy the requirements, and the other individual's refuge area was too far from his Bt corn plantings.

In response to the question of whether other farmers in the respondents' area who had planted Bt corn had satisfied the IRM requirements, 24.7 percent believed their neighbors satisfied all criteria, and 49.4 percent thought at least three out of four of their neighbors met the requirements. Further, 21.8 percent of the respondents were of the opinion that between one-fourth and three-fourths of their neighbors satisfied the requirements, and 2.7 percent of the respondents believed fewer than one out of four of their neighbors fulfilled the requirements.

The respondents listed several reasons farmers may not abide by the IRM requirements. Over two in five respondents (41.6 percent) stated noncomplying farmers may use their neighbor's field as refuge, and an almost equal proportion (40.3 percent) stated noncomplying farmers do not think following the requirements is sufficiently important. One in three respondents (33.8 percent) thought changing planters is too cumbersome, one out of five respondents (19.5 percent) stated lack of enforcement, and the same percentage (19.5 percent) stated difficulty to control corn borers without insecticides as a reason other farmers may not comply with the IRM requirements.

The respondents were asked to indicate the degree to which corn production had been made more difficult as a result of the four IRM requirements. Planting the 20 percent refuge was deemed (no) more difficult than planting regular corn by 46.0 percent (one-half) of the farmers. The remaining respondents indicated this requirement did not apply to them. Planting a refuge within one-half of a mile from Bt corn plantings was judged (not) to increase corn production difficulties by 39.2 (51.4) percent of the respondents. Further, 37.5 (41.7) percent of the respondents thought the inability to use microbial insecticides did (not) make it more difficult to produce corn, and 50.0 (30.6) percent of the farmers thought the use of economic thresholds (did not) increased the difficulty to produce corn.

Concluding Comments

In this paper we describe selected preliminary results of a survey conducted among a small sample of 104 South Dakota crop farmers in the summer of 2004. The farmers were chosen because they had completed a questionnaire on the adoption of genetically modified crops in spring 2002. Preliminary results indicate almost all of the responding farmers comply with the IRM requirements. However, the results also raise questions about the degree of awareness among crop producers about the need to implement their own IRM plans. Clealry, there is a need for further and ongoing educational efforts to motivate farmers to actively participate in improving, and comply with, the requirements. Additional results will be forthcoming, and will based on frequency and regression analyses to detect causal relationships between variables.

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