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Corinne Alexander
Dept. of Agricultural Economics, Purdue University
West Lafayette, Indiana 47907-1145
cealexan@purdue.edu
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Dr. Alexander is an assistant professor in the Department of Agricultural Economics, Purdue University.

Corinne E. Alexander
Purdue University
403 W. State Street
630 Krannert
West Lafayette, IN 47907-2056
Ph: 765-494-4249
FAX: 765-494-9176

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Introduction

One of the most successful genetically modified crops is Bt corn, which has been modified to produce proteins from the soil bacterium *Bacillus thuringiensis* (Bt). These proteins are toxic to specific pests such as the European Corn Borer (ECB) and the corn rootworm (CRW). These Bt crops are highly effective at preventing insect damage, and as a result have been rapidly adopted since the release of Bt corn resistant to ECB in 1996 and Bt corn resistant to CRW in 2003. In 2005, Bt corn accounted for 35 percent of the corn acreage in the US either as a single trait or stack trait (NASS, 2005). The rapid adoption of Bt corn, particularly in specific regions of the US, has raised concerns about the development of insect resistance to Bt.

Insect resistance to Bt poses a major risk to the producers currently benefiting from the technology and to other producers who depend on Bt as a pesticide, such as organic producers. In order reduce the risk of insect resistance to Bt, the Environmental Protection Agency (EPA) issued insect resistance management (IRM) guidelines in 2001 (EPA, 2001). Registrants of Bt crops are responsible for overseeing IRM plans and they implement them by having producers sign legally binding agreements. Under the IRM guidelines, producers in the primary corn growing regions are required to plant at least 20 percent of their corn to a refuge, i.e. non-Bt corn. Currently, there are four approved refuge configurations: the border of the field, a block within the field, splitting the planter so that there are strips through the field, or an adjacent field which is required to be across a ditch or road for CRW corn and within half a mile for ECB corn. Producers are permitted to treat the refuge corn with a non-Bt insecticide. The effectiveness of refuges at preventing insect resistance depends in part on producers' compliance with the IRM plan regulations. Producers who are found to be not incompliance with the IRM plans for two years will face the penalty of no longer being allowed to purchase Bt crops (Wright and Hunt, 2004).

IRM guidelines have been in effect for about 5 years. The EPA will review the IRM regulations related to CRW corn in 2006 when the registration of CRW corn needs to be renewed. In anticipation of these policy discussions about IRM plans, the purpose of this paper is to present survey and focus group results that describe farmers' thoughts on and reactions to IRM plans.

Literature

The literature on farmers and IRM plans has focused on whether farmers comply with the refuge requirements. Several surveys have been conducted to determine producer compliance with IRM plans (Agricultural Biotechnology Stewardship Technical Committee, 2002; Langrock, Hurley and Ostlie, 2003; Goldberger, Merrill and Hurley, 2005; Wang and Van der Sluis, 2005). Overall, these studies which are individually described in detail find that producer compliance with IRM requirements ranges from about 70 percent to about 90 percent depending on how compliance is defined. If compliance is defined as meeting the 80:20 ratio of Bt corn to non-Bt corn at the farm level, then compliance is probably between 85 and 90 percent. If compliance means both meeting the 80:20 ratio and using the correct refuge configuration, then compliance

drops to the 72 to 76 percent range. In terms of managing resistance, it is critical that the majority of Bt corn acres meet the IRM requirements. Overall, the research shows that larger farms are more likely to be in compliance than smaller farms which suggests that on an acreage basis compliance rates are much higher than these estimates which are on a producer basis.

The Agricultural Biotechnology Stewardship Technical Committee (ABSTC) surveyed producers in the major corn-producing states to determine compliance with IRM plans in the 2002 crop year. The survey found that 86 percent of producers planted at least 20 percent of their acres to a non-Bt corn and that 89 percent of the producers planted their Bt corn fields within a half mile of non-Bt corn fields, with 65 percent of the refuges being planted within the same field as the Bt crop. In addition, the ABSTC found that 88 percent of respondents were aware of IRM requirements and of these 89 percent said they received enough information to implement a refuge.

Langrock, Hurley and Ostlie (2003) estimated the cost of compliance with IRM regulations for Minnesota corn farmers using a survey in 2002. They estimated that IRM compliance rate range between 70 and 85 percent with farmers preferring IRM regulations that do not allow for insecticide treatment on the refuge crop, that specify the minimum refuge that is biologically effective, and does not require the farmer to plant the refuge in pieces throughout the Bt corn field.

Wang and Van der Sluis (2005) documented the planting practices of corn-soybean producers in South Dakota for Bt corn resistant to ECB. About 82 percent of the 104 respondents had planted Bt corn. Of these, 91 percent had planted at least some of their corn fields to both Bt and non-Bt corn. The most likely configuration was to plant the borders of the fields to non-Bt corn, followed by split planter and finally the within-field block. Even though a seed blend is not an approved refuge configuration, 29 percent of the survey respondents had mixed the seed in at least one field. About 40 percent of the respondents had used the adjacent field configuration. When using the adjacent field refuge a sizable number did not comply with the requirement to be within half a mile of the Bt field; about 8 percent reported planting the non-Bt field over half a mile away from the Bt field and 19 percent planted the non-Bt field over a mile away.

Goldberger, Merrill and Hurley (2005) used survey data from Bt corn farmers in Minnesota and Wisconsin to measure IRM plan compliance rates for the 2003 crop year. About 58 percent of the respondents from Minnesota had planted Bt corn and 31 percent of the respondents from Wisconsin, with larger farms having much higher adoption rates in both states. Goldberger et al. separately considered compliance with the refuge size requirement of 20 percent non-Bt corn and with the refuge configuration requirements. Producers in full compliance met both the size and the configuration requirements, and about 76 percent of Minnesota producers and 72 percent of Wisconsin producer are in full compliance. In both states, about 85 percent of the respondents complied with an 80:20 ratio of Bt to non-Bt corn at the farm level, with the remaining 15 percent planting more than the 80 percent of Bt corn allowed. Refuge configuration compliance was at about 90 percent in Minnesota and 84 percent in Wisconsin. Goldberger et al. find that producer awareness of the IRM plan requirements is a strong predictor of IRM plan compliance, while producer awareness of the Compliance Assurance Program which includes IRM education was not significant in predicting IRM plan compliance. They also find that larger farms are more likely to comply with the size requirement and both requirements but not configuration alone.

In addition to the surveys on farmer compliance, there has been one study estimating the costs to farmers of implementing the within-field refuges. Hyde, Martin, Preckel, Dobbins and Edwards (2000) estimated the economics of three alternative refuge configurations including strips or split planter, within-field block and a perimeter or U-shaped refuge. They examined the costs for a 40-acre field and an 80-acre field and found that the increased labor costs range from $0.15 to $0.30 per acre for the within-field block and U-shaped refuge, and from $0.038 to $0.075 per acre for split planter refuge. Hyde et al. showed that implementing within-field refuges do not substantially increase producers' costs.

Data

The Department of Agricultural Economics and the Department of Agricultural Statistics (DAS) at Purdue University conducted the CRW Management Survey in the spring of 2004. The sample of 4,000 producers was drawn from a list maintained by DAS list of producers. We restricted the sample to farms that grow at least 200 acres of corn in order to focus on farms that produce the majority of corn in Indiana. Once mail survey respondents who did not grow row crops in 2003 were eliminated, there were 794 usable surveys. From the number of responses received, it was determined that a follow-up phone survey of non-respondents would be more valuable than a second follow-up mail survey, to determine non-response bias. There were 128 phone survey respondents, and of these, 127 were usable. The total number of usable mail and phone surveys was 921. When returned and unusable surveys were subtracted from the initial 4,000 mail surveys sent out, the response rate was 24 percent. In Indiana, there are approximately 7,000 producers who grow at least 200 acres of corn (IASS, 2004). This survey sampled over half of these producers, and the 921 respondents represent 13 percent of this population.

After the survey, we conducted three focus groups: one in Tippecanoe County with 5 producers on March 2, 2005, one in Cass County with 8 producers on March 8, 2005 and one in Allen County with 5 producers on March 9, 2005. We discussed how farmers choose which seed corn to plant, how they manage corn rootworm and whether they plan to use CRW corn, and their opinions about the refuge configurations including a proposed seed blend option.

Farm Characteristics

Because of the sample restriction, the survey respondents tend to operate relatively large farms with an average farm size of 1129 acres. Seventeen percent of the respondents operate a farm of less than 500 acres, 38 percent operate a farm between 500 and 1000 acres, 32 percent operate a farm between 1000 and 2000 acres, and 13 percent operate a farm of over 2000 acres. For gross farm income, 11 percent have gross farm income under $100,000, 37 percent are between $100,000 and $250,000, 30 percent are between $250,000 and $500,000, and 22 percent have gross farm incomes above $500,000. The average age of the respondents is 50.7, with 12 percent of the respondents under 40. Over 90 percent of the respondents say that farming is their principal occupation. Thirty-nine percent of the respondents have a high school diploma, 31 percent have some college education or vocational training, and the remaining 28 percent have a bachelors or graduate degree. Overall, approximately 77 percent of respondents reported they managed CRW during 2003 using a number of different methods including soil insecticide, seed

treatments or transgenic corn. The majority of these respondents (89%) used insecticide at planting.

General Attitudes towards Refuges

Producers in both the mail survey and the phone survey were asked about their attitudes towards refuges. They were asked to agree or disagree with various statements concerning refuges, on a 5-point scale, where 1= strongly disagree, 2= somewhat disagree, 3= undecided, 4=somewhat agree and 5= strongly agree.

The majority of producers agree that refuges will help maintain the effectiveness of the CRW technology, that refuges benefit all farmers, and that the benefits of planting a refuge justify the time and effort spent on them. From the statement as to whether or not they agreed that refuges benefit all farmers, 55% agreed with this statement, 15% disagreed and 29% were undecided. The majority of producers (44%) disagreed with the statement that the benefits of planting a refuge do not justify time and effort spent on them, indicating that they believe the time and effort spent on refuges is justified by the benefits. Overall, these three attitudinal questions and producer comments in the focus groups show that the IRM education campaigns have been effective at explaining their benefits.

> Well, it needs to be done. Otherwise, you get your genetic differences and mutate in time and then you have no control over it. [Cass]

> I don't like the aspect that you got to take 25% of your field on the ends or someplace and have regular corn versus the Bt corn, but if it's for the benefit of making sure we don't build resistance, I don't really have much choice... [Allen]

> Actually, it's to our own good to comply because you don't have the rootworms that are resistant, where if you do use that Bt corn and use it, you know, four or five years down the road, then maybe you'll have resistant rootworms, and it's to our advantage that we do that, and maybe people, whoever is selling this, imply that we do that, that's to our own advantage. [Allen]

Despite the belief that refuges are beneficial, almost a third of producers say that they would not plant a refuge if it was not required, and another 37 percent are undecided as to whether they would plant a refuge if it was not required. Based on the focus group discussions, one reason producers won't plant a refuge unless it's required is the perception that if producers who voluntarily plant a refuge are at a competitive disadvantage to producers who do not plant the refuge. Thus, a voluntary IRM plan will not be sufficient to ensure compliance; IRM plans must be required to ensure compliance.

As expected, producers who have experience planting Bt crops and implementing refuges have statistically significantly more positive views towards refuges than producers who did not plant Bt corps in 2003. Furthermore, producers with experience planting Bt crops are significantly more likely to say they will plant a refuge even if it's not required.

Table 1: Responses to statement "I believe refuges will help maintain the effectiveness of the corn rootworm technology."***

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	253	490	743
Strongly Disagree	5.1%	5.7%	5.5%
Somewhat Disagree	7.5%	7.6%	7.5%
Undecided	13.8%	31.4%	25%
Somewhat agree	39.5%	32.0%	34%
Strongly agree	34.0%	23.3%	27%
Mean	3.59	3.89	3.69

Table 2: Responses to statement: "Refuges benefit all farmers."*

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	252	493	745
Strongly Disagree	4.3%	6.3%	5.6%
Somewhat Disagree	5.1%	10.6%	8.7%
Undecided	22.2%	33.7%	29.8%
Somewhat agree	37.7%	29.6%	32.3%
Strongly agree	30.6%	19.9%	23.5%
Mean	3.85	3.46	3.59

Table 3: Responses to statement: "The benefits of planting a refuge do not justify time and effort I spend on them."*

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	252	490	742
Strongly Disagree	26.6%	17.8%	20.7%
Somewhat Disagree	30.6%	20.4%	23.8%
Undecided	25.0%	34.1%	31.0%
Somewhat agree	11.9%	20.8%	17.8%
Strongly agree	5.9%	6.9%	6.6%
Mean	2.40	2.79	2.65

Table 4: Responses to statement: "I would still plant a refuge, even if it was not required."*

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	253	491	744
Strongly Disagree	16.6%	16.5%	16.5%
Somewhat Disagree	13.4%	16.9%	15.7%
Undecided	29.6%	42.2%	37.9%
Somewhat agree	27.3%	15.7%	19.6%
Strongly agree	13.0%	8.8%	10.2%
Mean	3.07	2.83	2.91

The majority of producers (53%) disagreed with the statement that they will not plant a CRW resistant variety because of the refuge requirement. Twenty-four percent agree with this statement and 23% of producers are undecided. Producers who have planted either Bt corn or CRW corn in 2003 and have experience with refuges were significantly more likely than producers who do not have experience with refuges to say that the refuge requirement will not affect their planting intentions. However, it is clear that for a portion of producers, insect resistance management plans are a deterrent to planting CRW corn.

> "I wanted to plant the rootworm corn this year in a bad way, but my dad---I plant the beans and Dad plants the corn, and he doesn't want to deal with the [refuge]."[Cass]

Table 5: Responses to statement: "I will not plant a corn rootworm resistant variety because of the refuge requirement."*

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	251	492	743
Strongly Disagree	47.8%	23.4%	31.6%
Somewhat Disagree	25.1%	19.3%	21.3%
Undecided	15.5%	27.0%	23.2%
Somewhat agree	9.2%	16.5%	14.0%
Strongly agree	2.4%	13.8%	9.9%
Mean	1.93	2.78	2.49

Refuge Planting Preferences: Survey Results

With the mail survey, producers received an information sheet describing the four EPA approved refuge configurations: within field block, strip planting, border planting and adjacent field (see appendix). The order of the questions in the phone survey was slightly different from the mail survey, and the refuge questions were eliminated because of time constraints and because it was too difficult to supply the interviewees with the information sheet.

Mail survey respondents were asked how likely they are to use each of these configurations, how much extra time it would take them to implement each of these refuge configurations compared

to planting conventional corn, and how much more difficult, if at all, they anticipate it would be to plant CRW corn with a refuge relative to planting conventional corn. As before, the results are examined separately depending on whether the producers had experience planting a refuge in 2003. These results are summarized and discussed in detail in the section comparing the refuge configurations on page 14.

Table 6: Likeliness to use within field block refuges- producers of ECB, CRW corn or neither in 2003***

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	227	431	658
Not at all likely to use	19.8%	38.1%	31.67%
Slightly likely to use	12.3%	9.1%	10.15%
Somewhat likely to use	15.4%	15.3%	15.30%
Moderately likely to use	19.8%	17.4%	18.18%
Very likely to use	32.6%	20.2%	24.39%
Mean	3.33	2.72	2.93

Table 7: Likeliness to use strip planting refuges**

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	233	440	673
Not at all likely to use	29.2%	42.3%	37.7%
Slightly likely to use	7.7%	7.5%	7.6%
Somewhat likely to use	11.2%	8.9%	9.6%
Moderately likely to use	13.3%	12.1%	12.5%
Very likely to use	38.6%	29.3%	32.5%
Mean	3.24	2.79	2.94

Table 8: Likeliness to use border planting refuges*

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	218	431	649
Not at all likely to use	33.9%	41.3%	38.8%
Slightly likely to use	16.1%	10.7%	12.5%
Somewhat likely to use	18.8%	14.6%	16.0%
Moderately likely to use	15.1%	18.1%	17.1%
Very likely to use	16.1%	15.3%	15.6%
Mean	2.63	2.55	2.58

Table 9: Likeliness to use adjacent field refuges

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	224	428	652
Not at all likely to use	20.1%	36.2%	30.7%
Slightly likely to use	7.6%	9.4%	8.7%
Somewhat likely to use	12.9%	13.3%	13.2%
Moderately likely to use	20.5%	18.0%	18.9%
Very likely to use	38.8%	23.1%	28.5%
Mean	3.50	2.82	3.06

Time to plant refuge was also split into those that had experience with the different technologies in 2003 and those that had not.

Table 10: Extra time to plant within field block refuges- producers of either technology or neither

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	199	351	550
0	19.1%	20.8%	20.2%
1 to 5	40.2%	41.3%	40.9%
6 to 10	19.6%	13.1%	15.5%
11 to 15	5.5%	3.9%	4.6%
16 to 20	5.0%	5.7%	5.5%
21 to 30	7.0%	10.3%	9.1%
> 30	3.5%	4.8%	4.4%
Mean	8.8 min/ac	10.16 min/ac	9.67min/ac

Table 11: Extra planting time for split planting refuges

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	202	344	546
0	37.6%	41.9%	40.3%
1 to 5	38.6%	33.7%	35.5%
6 to 10	11.4%	9.6%	10.2%
11 to 15	4.5%	2.9%	3.5%
16 to 20	1%	2.9%	2.2%
21 to 30	4.5%	4.1%	4.2%
> 30	2.5%	4.9%	4%
Mean	5.55 min/ac	6.97 min/ac	6.44min/ac

Table 12: Extra time for planting border planting refuges

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	198	350	548
0	13.1%	17.4%	15.9%
1 to 5	41.9%	38.0%	39.4%
6 to 10	16.2%	15.7%	15.9%
11 to 15	9.1%	5.7%	6.9%
16 to 20	7.1%	7.1%	7.1%
21 to 30	8.1%	10.9%	9.9%
> 30	4.6%	5.1%	4.9%
Mean	10.31 min/ac	11.03 min/ac	10.77min/ac

Table 13: Extra time for planting adjacent field refuges**

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	199	348	547
0	55.3%	42.5%	47.2%
1 to 5	26.6%	34.2%	31.4%
6 to 10	9.6%	9.2%	9.3%
11 to 15	3.5%	1.7%	2.4%
16 to 20	1.5%	3.2%	2.6%
21 to 30	2.0%	6.3%	4.8%
> 30	1.5%	2.9%	2.4%
Mean	3.74 min/ac	6.21 min/ac	5.31min/ac

Table 14: Difficulty of planting a within field block refuge compared to conventional corn-producers who used either technology in 2003 and those that used none

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	239	439	678
Same difficulty	20.9%	14.8%	17.0%
Slightly more difficult	18.0%	18.5%	18.3%
Somewhat more difficult	24.3%	26.2%	25.5%
Moderately more difficult	21.3%	19.6%	20.2%
Much more difficult	15.5%	20.9%	19.0%
Mean	2.92	3.13	3.06

Table 15: Difficulty of planting a split planting refuge***

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	241	437	678
Same difficulty	31.5%	30.9%	31.1%
Slightly more difficult	28.6%	18.8%	22.3%
Somewhat more difficult	18.3%	17.6%	17.9%
Moderately more difficult	11.6%	10.8%	11.1%
Much more difficult	10.0%	22.0%	17.7%
Mean	2.40	2.74	2.62

Table 16: Difficulty of planting a border planting refuge

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	234	438	672
Same difficulty	8.6%	11.2%	10.3%
Slightly more difficult	15.4%	13.9%	14.4%
Somewhat more difficult	29.1%	26.7%	27.5%
Moderately more difficult	25.6%	21.9%	23.2%
Much more difficult	21.4%	26.3%	24.6%
Mean	3.36	3.38	3.37

Table 17: Difficulty of planting an adjacent field refuge***

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	233	434	667
Same difficulty	51.5%	31.6%	38.5%
Slightly more difficult	21.5%	23.0%	22.5%
Somewhat more difficult	15.0%	19.1%	17.7%
Moderately more difficult	7.7%	11.7%	10.3%
Much more difficult	4.3%	14.5%	10.9%
Mean	1.92	2.55	2.33

Refuge Planting Preferences: Focus Group Results

When producers were asked which refuge configuration they use, the general answer was that it depends on the field size, the relationship of the field to other fields on the farm, the planter and whether or not a neighboring field would be planted to a specialty crop. Producers like have several options so that they can choose the one that best fits the circumstances.

> You want to keep all the alternatives open 'cause there's always a situation where... [Tipp]

> Well, in the past with the Bt corn, basically we're with [within field block] where we planted part of a field in the Bt corn part of it, and Bt---that was in the path because it was the planter that I had {a single seed box}. In the future, I would probably be looking at alternating with strip planting. {He now has a planter with seed boxes on each row} [Tipp]

I don't see a dramatic difference in any of them. It's still a matter of loading the planter and making the changes and this is something you're doing a natural flow. I think the issue is how big the plot's going to be. Are you going to fill the planter clear full when you start this or are you going to plant like half a bag per row, something like that, then you're getting into a situation that eats up a lot of time and manpower. [Tipp]

Adjacent Field

The producers in Cass county had the most in-depth discussion about the adjacent field refuge configuration. In general they felt this refuge configuration was not an option because they tend to have one large field per farm. When asked how large their fields are one producer said his largest field is 275 acres, another said 900 acres.

That's two trips around the county instead of one. If you're going to stay in one area you're going do that and then move on. [Cass]

We've tore all the fences out and you got one big farm. You're farming on one block and you're moving on. Too many. You're not farming the little 20-acre field here anymore. [Cass]

But it seems like if you had---if the fields were so small or, you know, let's say less than 40 acres…I mean if you have [an adjacent field]. [Tipp]

Split Planter

In both Tippecanoe and Cass counties, the split planter refuge configuration was the most popular because producers felt that it was the easiest to implement. Producers also cited the advantage of using this refuge configuration for side-by-side yield comparisons. One producer also felt that the Bt corn protects the non-Bt corn from wind. In terms of disadvantages, several producers were concerned about problems at harvest if the two hybrids perform differently. One producer was concerned about corn rootworm control on the refuge, but when he learned that the refuge seed could have a seed treatment, this alleviated his concern.

You're taking the strip till here, if you're going to fill up your, all your, you know, eight rows, you're going to fill 'em all up, the hopper is completely up on eight rows and the other hopper is completely up and you're going to go for… but it's quite a few acres without stopping, and so that's not costing, that's not going to cost you anything. No difference than if you filled them all up with the same number all the way across. [Tipp]

And that is the reason split planter, basically when I've used that, it's I'm trying to learn. It's a learning process for me to see if I can justify the cost of using the Bt or the rootworm hybrids against the conventional. [Allen]

I know the split planting is the best as far as we've come down to, but it's got problems, too. I mean if your refuge and your Bt corn are significantly different, you know, different maturity or something like that, sometimes one shells better than the other, it creates problems of setting the combine and things like that. It's not perfect. [Cass]

I believe that better standing Bt corn kind of protects that [the non-Bt corn from falling over]. [Cass]

That would probably make it less of a sacrificial area probably in the field overall. You could probably control---I don't know if you can control bugs any better by having smaller strips, but the kickback with split planter is what if you have to go in and do a rescue? You got to drive the whole field. [Allen]

Within-Field Block

Several producers had implemented the within-field block refuge configuration. The two advantages cited by producers were the ability to treat the refuge, and the ability to segregate the refuge corn and market it separately from the Bt corn. The main disadvantage was the need to clean out seed boxes when switching between the refuge and non-refuge seed, however one producer said that the clean-out was unnecessary.

We use within-field block there. We felt that if we had to treat it, it would be a lot easier to do it with that distinct separation between them, so that was the reason we use that. [Allen]

We don't have to be perfect to have something like this. We got to have a minimum of 20%, so, you know, we don't stop and clean out boxes in the middle of planting. You know, if you've got enough for 25% because that's what it's going to take to keep it feeding down, then you just go ahead and put the other on top of it and you're going to have some scattered, too, if you go out there. If you don't plan on coming back and having to treat, you're going to have some sprinkled strips in there of the other mixed in. [Allen]

We used 3 and 9 last year [the split planter refuge]. Prior to that, we did---tried blocks within the field. Well, that got to be too much of a pain switching, cleaning boxes, and that kind of thing. [Cass]

Well, actually, when I did mine, I planted 20% of the field with Bt and the rest of it was a regular corn. Okay? It was regular corn, non-genetically modified, because I wanted to harvest the 20% at one time and store it either in a bin by itself or take it to market, as opposed to the strip planting, when you got three boxes on a 12-row planter and you harvest the field, it's co-mingled, okay, so you have to be careful where you put it and how you market it, all right? So that's one of the reasonings, I guess, to plant it within---with the 20% all together so you can just be done with that variety, segregate it, and then move on to another variety, so. [Tipp]

How many people end up using within-field block where any of them go out and spray that refuge? If we'd get in a severe situation, you might, but I don't hear anybody talking about going out and spraying their 20% refuge. [Allen]

Border Planting

Most producers felt that the border planting refuge configuration was too much work. However, at least one producer in each focus group discussion said that it is an important option that can be

used to protect either their own or their neighbor's specialty crop fields from contamination due to pollen drift. One producer said that if he buys a bulk planter, he'll use the border planting refuge with one planter dedicated for the borders and the bulk planter for the interior. Another producer thought the border planting fit his planting routine.

> You know, planting time, too, where it's time to go and we don't like to mess around with cleaning boxes out and doing test plots and a lot of that stuff. When the time's right, you want to get on it and not tinker around with doing a border and then cleaning your boxes out, I mean just. [Tipp]

> I wouldn't want to do [border planting]. I mean I agree with Speaker 4 totally. You're not going to change the planter every time. I mean I suppose if you have to, you're going to have to, but I mean from a farmer's standpoint, that's a pain in the butt. But for your neighbors, if he's going to try and raise a crop that isn't contaminated, that's the only way to go. [Cass]

> Well, unless you're just trying to isolate the field, like you say, from any other foreign pollen or anything like that, I don't see where the bordering, 20% of the border's even possible unless you just got a small enough field where you're in, then I mean how you going to set it up that way? [Tipp]

> If we do have one [bulk fill planter], we'll probably go to a border because we'll have one planter to just plant borders. [Cass]

> The reason I like border planting would be that I could plant a relatively inexpensive corn on the ends around the perimeter of my field because half of them are, you know, some of them are going to get tracked down from side dressing more compaction on end rows, anyway. You know, if you could pull in the field and just do the outside of the field, that does usually catch, depending on the field, you know, a good majority of the field acres. So if I was planting one, I would look at border planting first. [Allen]

> When I did this, I specifically was trying to protect a neighbor who was going non-GMO so what I did, I planted my 32 rows on a perimeter, and then I just went to my start point and started planting, and when I emptied the planter is when I put the Bt variety in and started the planter there. I didn't stop and totally clean out or make a---I only had it on the exterior 32 rows. [Tipp]

Comparison of Refuge Options

From the comparison of refuge options shown in table 18, corn producers regardless of 2003 refuge experience are on average the most likely to use the adjacent field refuge option and the least likely to use the border planting refuge option. For producers with refuge experience in 2003, they are on average more likely to use within-field block than split planting. In contrast, producers who did not have refuge experience in 2003 are more likely to use split planting than within-field block. Consistent with the mean likeliness to use ranking, producers with and without refuge experience on average find that the adjacent field refuge takes the least amount of extra time to plant and poses the least amount of difficulty and that the border planting refuge option is rated as taking the most extra time to plant and as the most difficult. Interestingly,

despite the inconsistency in mean likeliness to use depending on refuge experience, all producers rank the split planting configuration second and within-field block third in terms of least amount of extra time to plant and least amount of difficulty.

While the adjacent field appears the most favorable refuge option, the focus group discussions revealed that for many producers, the adjacent field refuge is not an option due to the locations and sizes of their fields. Instead, the split planter refuge option was one of the most popular for the focus group participants because it was the least difficult and took the least amount of extra time of the refuge configurations that they could implement on their farms. Perhaps one explanation for the higher ranking of within-field block over split planter by survey respondents who had refuge experience in 2003 is due to producer concerns about ability to manage corn rootworms and ability to segregate the refuge corn. Finally, the focus group discussions and survey respondents consistently rank the border planting option as the most difficult and taking the most extra time, with the primary advantage of the border planting being the ability to protect nearby crops from pollen drift.

Table 18: Comparison of Refuge Options

Ranking	Mean Likeliness to use	Mean Amount of Time (min/acre)	Mean Difficulty
Refuge Experience in 2003			
Adjacent field	3.50	3.74	1.92
Within field block	3.33	8.80	2.92
Split planting	3.24	5.55	2.40
Border planting	2.63	10.31	3.36
No refuge Experience in 2003			
Adjacent field	2.82	6.21	2.55
Within field block	2.72	10.16	3.13
Split planting	2.79	6.97	2.74
Border planting	2.55	11.03	3.38

Seed Blend Option

Producers were presented with a fifth option for insect resistance management which we call the seed blend option. The survey respondents were told:

> "There is a proposed insect resistance management plan that would allow seed companies to pre-mix the seed needed for the 20% refuge directly into the seed bag. Thus, you would not need to plant a separate area of each field to a refuge. This pre-mixed seed would cost the same as buying each hybrid separately."

About a third of the survey respondents said that they would be very likely to choose the seed blend option. More importantly, producers who did not have refuge experience in 2003 were significantly more likely to prefer the seed blend option over the four EPA-approved refuge configurations. This finding suggests that the refuge requirement may be a deterrent for some who are not currently planting Bt crops, and that the seed blend option would eliminate this barrier to adopting Bt crops.

Table 19: Likeliness to choose Seed Blend Option instead of the 4 EPA approved refuge configurations.**

Responses	Refuge experience in 2003	No refuge experience in 2003	Total
Frequency of mail respondents	249	469	718
Not at all likely	22.9%	22.2%	22.4%
Not likely	12.9%	7.7%	9.5%
Slightly likely	16.1%	13.0%	14.1%
Somewhat likely	19.3%	18.1%	18.5%
Very likely	28.9%	39.0%	35.5%
Mean	3.18	3.44	3.04

In the Cass and Allen county focus group discussions, when the producers were asked what they would want to be able to do for an insect resistance management plan, one of the producers mentioned reading about the seed blend. A producer in each group described the seed blend option, before the moderator posed this option to the group. In Tippecanoe county, when the seed blend option was presented, one of the producers said he'd been wondering if that would work.

> We get it in big, bulk boxes of corn now. That's what I thought we should do, just mix it all together, blend it in that box. [Cass]
>
> Actually, I like Alternative 6 that I was interviewed on a few years ago: 20% of your seed in each bag is non-rootworm corn as your regular corn. That way it's mixed together, so maybe in every hundred kernels you drop, 20 of them is the non-rootworm and the other 80's rootworm, and it's scattered throughout the whole field. That way, when you plant, you dump one bag in. [Allen]
>
> That ran through my head when I was doing the refuge work, you know, is why don't they just mix it together, you know, but what may be a great idea today could be a disaster tomorrow. [Tipp]
>
> I think in summary that the two options that seem to rise to the top for us here should meet the desires of the companies, as well as be simplistic in the farmers' compliance. You know, that's percent of sale is a simple way or the, as Speaker 1 referred to it, Option Number 6, just put it in the bag and then there is no concern about compliance and if you put a treated seed in the bag it lets no farmer vulnerable from the yield perspective and I'd say the management is greatly minimized or completely eliminated. [Allen]

The primary concern with the seed blend option was whether it would be effective at managing resistance.

> So are you really creating a refuge is the big question. [Cass]
>
> I don't think that blending is a refuge. [Cass]

In the corn borer situation, how are you going to retain that corn borer if it's---if you got 20% within the field. How is that 20% bug going to survive in a field where there's 80%? You know what I'm saying? Eventually, they're going to---eventually, they're going to get to a plant that's going to kill them so you've eliminated the refuge. [Tipp]

Allen county producers said that the seed blend option would remove any concern about producer compliance with the IRM plan requirement.

From a government standpoint or from the Monsanto standpoint where they know you've got that refuge, yeah, they know everybody's planting the 20% like they're requesting, requiring. [Allen]

If they can guarantee the seed treatment's going to get us as close as we can get to having the refuge do what the stacked hybrid's going to do and we don't have to do the paperwork on it, don't have to keep track of it, I still like the mixing possibility. From the farmer's standpoint, knowing we've got the compliance I still like the initial thought of mixing it. I'm concerned about the concerns that Speaker 2 mentioned with mixing it and, like he said, making sure the seed company doesn't make it a 79/21 percent blend, and I guess you got to trust who you're doing business with seed-wise there. [Allen]

As with some of the previous refuge configurations, the producers were concerned about their ability to manage the refuge corn and potential harvest problems due to differences between the refuge and non-refuge corn. The producers were concerned about protecting the refuge corn from rootworm damage, and this concern was alleviated if the refuge corn is treated with Poncho 1205.

It takes away the ability for you to manage the non-treated stuff, you know, the way it needs to be. [Tipp]

But have you seen that when they add Bt corn it seems like it adds more moisture? I've always heard, you know, if you have Variety A and Variety A with Bt, that variety seems to be a little wetter, maybe like two days. [Allen]

If you're definitely needing something for corn rootworm and you put 20% out there just in the row that's not having any protection, then you're going to force these guys to either use an insecticide at 100% of it or they're going to quit the technology altogether because they need a hundred percent protection one way or another. In a refuge situation, you're still allowed to use soil-applied insecticides for corn rootworm, for example. If you went out there and said, okay, 20% of this row is going to have no protection unless you just go ahead and cover all of it, then you've defeated your purpose of the technology to begin with, which was to get away from applying what admittedly is a chemical that maybe none of us want to have to use or have in the dirt but it's there and we're using it because it's economical, you know. [Tipp]

When Speaker 1 was talking about it, I didn't consider the non-Bt corn or rootworm corn being treated with Poncho 1250, but if you put it in the bag that way, I would have to say I like the option. You're saying that it is the same hybrid, correct? I like that option. [Allen]

I wouldn't want to see it be mandatory. I'd say it might be an option, but I don't think if you're going to buy Bt corn and that'd be the only way you could buy it, I don't want to see that. [Allen]

IRM Plan Compliance

Producers in all the focus groups believe that most farmers are complying with the IRM plan requirements to plant refugia.

You got the bigger percentage. There's always going to be some. You could say the same thing along the line of spraying fungicide and herbicides and all that. You think, I'd say 95% is being applied right because it's where you live and all that, but there's going to be some that skew that mark. [Cass]

I complied, and I really don't know the acreages in the fields of friends or neighbors that had it that did not comply, so I really don't know the level of noncompliance, but I made an effort, and even this 34-acre field, I complied. [Tipp]

They should be doing it right. [Cass]

Producers in all the focus groups discussed how they would like to plant the seed wherever, as long as the total added up to 80:20. Several of the producers were concerned that this would lead to an uneven distribution of refuge across a county, lessening the effectiveness of the refuge. In the end, the producers agreed that this was not a realistic proposition.

I think that maybe they ought to have like a whole farm or a whole operation situation where you could come in if you had a thousand acres of corn, plant 200 acres of refuge, but yet could go to a farm over here and put a hundred percent. If I've got a farm over here and it's an 80-acre farm and I know that the neighbors are going to have beans a hundred percent around it, there's no reason why I should not be able to not put that a hundred percent in my view into corn with the corn rootworm or Bt as long as I had at least 20% corn, non-tech, corn somewhere planted. [Tipp]

I'll buy 20% of the seed, but I want to plant them whatever field I feel like planting them in. And the other fields I want to plant 100% of the rootworm corn. [Cass]

I intentionally stayed quiet because I was interested to hear what you fellows would say. Of course, you never get all of anybody's business, so you don't know for sure what they're doing, and I would say in the quantities that I'm dealing in, in Bt corn, I am selling no one that I can think of as a customer all Bt corn, so I would say that the compliance is there, at least the way they're purchasing their corn. The ability to comply is there. [Allen]

But we made an effort to comply when we used it last year, and I think the seed companies have made more of an emphasis on complying with it because they---I think they'd restrict their rules on it if they caught you that you weren't complying and there'd be some penalties for it. I also heard about a person that was hired as an intern to go around and check on farmers to see if they were complying, so I think they're making an effort to see that there is compliance. [Allen]

> For compliance, I would think that they would almost be satisfied if they just monitored your seed corn purchases. Maybe you haven't done Option 2 or you haven't done Option 3 but to know that the percent of the corn crop out there is still diversified to their percent of blend---I'm not using the word I want here---But I think it would almost be satisfactory. [Allen]
>
> It may not be in the exact field they want it, but I don't know that that's as critical as knowing at least 20% of our crop in Allen County has got refuge in it. So that would be to keep it simple method. I mean I like that "KISS" method real well. Any regulation that gets thrown in that somebody monitors it is going to cost us as producers more money and time. [Allen]

When asked why a producer would choose not to comply with the refuge requirement, the two top reasons are ease at planting and the lower yields in regions where the CRW corn performs markedly better than soil insecticides or seed treatments.

> Because it's a lot easier just to drop the seed in the planter and zoom, go, you're done with it. You don't have to fool around with it. I'm kind of that way myself, drop the seed in and go, but, you know, if you got to do it, we do it. [Allen]
>
> Well, I think if you go to the areas where there's a high demand for Bt or a high demand for where they've got to just have it, you might have more of an issue, but for us, most of us, we're running this stuff just to make sure that this is what---that our current program is the best for us, so we try a little of this, we try a little of that. [Tipp]
>
> I don't know if somebody has data like I did four years ago where you had 20 bushel yield difference, they're going to say I don't want to plant---I got a thousand acres of corn I'm planting, I don't want to plant 200 acres of corn that I know I'm going to get 20 bushel less. Now, in our part of the world, we don't see that difference every year. I mean I saw that the one year. I have not seen that much difference since. I've seen yield advantage but not near 20 bushel. But if I was seeing 20 bushel yield increase every year using---that was Bt that year---it was corn borer Bt, yeah, you'd have a tendency to want to plant 100% and use your neighbor's crop if they knew---you knew they weren't planting as your compliance, but that's not legal now. [Allen]

Producers in several of the groups said that they had read about spot-checks for refuge compliance and that the penalty for being out of compliance is losing access to the technology. Producers said that the threat of not being able to purchase Bt crops is a substantial deterrent to shirking on the insect resistance management plant.

> Yes, because you don't want the IRS looking at your taxes, you don't want EPA looking at---even drive by your place, because they can find anything they look for. [Cass]
>
> We don't want to lose these technologies or the right to have these technologies, and if we're proven to be out of compliance all the time, we just give, you know, a handful of activists group an opportunity to take. [Tipp]

Also we don't want to become resistant to it, either, and we know that, in time, if that's all they have, these insects will become resistant to even Bt. [Tipp]

Basically, I heard in magazines or whatever that if you---they could spot-check you because you bought this corn and if they found that you weren't in compliance or negligent or whatever that they could ban you from using genetically-modified hybrids in the future. [Tipp]

Well, it worked for me, not that I wouldn't have done it, anyway, but, you know. I don't know, it just depends, you know, it all boils down the integrity of the people using the stuff, you know what I mean? [Tipp]

I think spot-checking or at least having that potential would, you know, would be good enough. I mean, you know, if they do that the first year and find out that after, you know, 40% of the farmers are out of compliance then they would probably want to institute some new measures, but I would say they probably would find out that 95 to 99 percent of the farmers are doing the best job they can. [Tipp]

Well, we're convinced because EPA--- I read the article I kept on my bulletin board just before I came to make sure I knew---I knew this was going to come up. The seed companies, the dealers, and the farmers are all three equally responsible for that 20% refuge, and they can really put some fines on you, and in two years, if you don't correct that, you're out. You don't get to use the product and that company may not to get to use it either because if a farmer really abuses it. They're getting serious. [Cass]

Producers in Allen county mentioned that they would like to have a simple template to help them keep track of where they plant the refuge. They stressed that using this form would need to be voluntary.

Planting's not the biggest deal. It's keeping track of where you've got it and if you're---if whoever's going to come out and check out to make sure you've got the right records and know where to find it and where to tell them accurately it's at afterwards is, to me, is more the hassle than the planting site. As long as I know I've put it out there, you know. [Allen]

I wouldn't want to have to interpret the responses, where if it's a form it's pretty standard. I would just---on how to handle that as far as timing, I think most farmers designate their hybrids to farms and that when they order 'em. If the form was, if it was done on a form approach and you did your form at the time you purchased your seed when you're not already busy, I would think that would have merit, as well. [Allen]

Importance of One IRM Plan

Producers were asked about insect resistance management plans for stacked traits:

> "Assume that you are planning to plant CRW corn stacked with CB resistant corn. You may be required to file two insect resistance management plans, one for each. Alternatively, you may be able to file just one insect resistance management plan. How important, if at all, is it to you that **only one** insect resistance management plan be required?"

Producers clearly prefer only one IRM plan if they choose to plant a stacked variety with both resistance to corn borer and corn rootworm. Producers who have experience planting refuges in 2003 were significantly more likely to stress the importance of having only one IRM plan.

Table 20: Insect Resistance Management Plan **

Responses	**Refuge experience in 2003**	**No refuge experience in 2003**	**Total**
Frequency of mail respondents	240	462	702
Not at all important	2.5%	6.7%	5.3%
Not important	4.6%	3.0%	3.6%
Slightly important	11.3%	18.2%	15.8%
Somewhat important	23.3%	24.2%	23.9%
Very important	58.3%	47.8%	51.4%
Mean	4.30	4.03	4.13

In the focus group discussions, the producers said that IRM plans need to be as simple as possible, otherwise producers either would not use the technology or they would not comply with the IRM plan requirements.

> Forget it. [Cass]
>
> Nightmare. [Cass]
>
> I think if you're buying seed, all of the biotech that you buy in that one seed should only have to require one refuge because it's a single management system that you've employed there. The refuge there would be the same as to what you always had, and I don't see the advantage of having two refuges for the two, for a stacked variety. [Tipp]
>
> My impression would be that if you have to go to 40% something, if you want noncompliance, you're going to get it. [Tipp]
>
> Man, that'd really be a nightmare, wouldn't it, two different plans. [Tipp]

Conclusions

Based on this analysis of survey and focus group data on producers' perceptions of IRM requirements, we can draw four conclusions. First, based on producers' attitudes towards refuges, the education campaign has succeeded at explaining that refuges are important to delay insect resistance and that the benefits of IRM accrue to all farmers. Second, while the majority of producers do not base their planting decisions on IRM requirements, there is a small group of producers who choose not to plant Bt crops because they do not want to implement refuges. Third, producer compliance with the IRM requirements depends on the simplicity and flexibility of the requirements. Producers in the focus groups emphasized that it is very important to offer many options for meeting the requirements and to keep the options simple. In particular, producers felt it was essential to only require one IRM plan for stacked varieties that are resistant

to both ECB and CRW. Fourth, producers view a seed blend refuge very favorably, with producers in the focus groups saying that the seed blend refuge should only be offered as an option as long as it is effective in managing resistance. More importantly, producers who currently do not plant Bt crops say they are very likely to use the seed blend refuge which may indicate that the seed blend option would increase adoption of Bt corn among those producers who say IRM plans are a deterrent.

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Appendix: **Refuge Alternatives**

If you plan to plant CRW corn, you will be required by the Environmental Protection Agency (EPA) to implement an insect resistance management plan, which means that you will need to plant a portion of your corn to a non-CRW hybrid. The EPA mandates that a refuge (the non-CRW hybrid) be planted on **every farm**, where the refuge must be within or adjacent to the CRW corn field. The refuge can be treated with a soil-applied, seed-applied, or foliar-applied insecticide to control rootworm larvae and other soil pests.

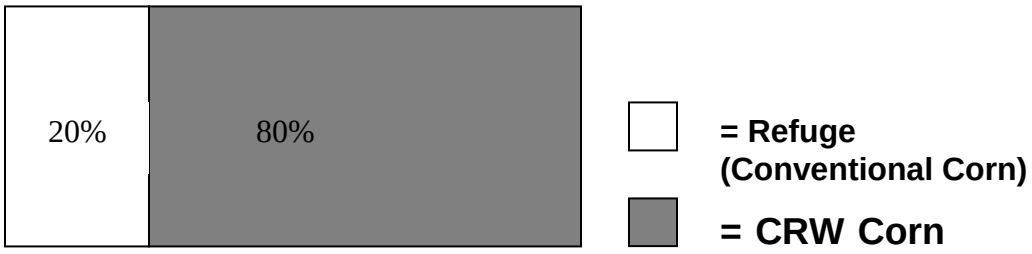
Currently, there are **4** EPA approved refuge placement alternatives. These are illustrated below. Given that you will be required to plant a refuge for your CRW corn, we would like to know your overall impression, and your most preferred alternative.

For purposes of this exercise please assume the following:

- CRW corn will require a 20% refuge area
- CRW corn will be available in your preferred hybrids
- CRW corn will have a fair and reasonable price

For example, if a grower were to have 400 corn acres, he/she may plant up to 80%, or 320 acres, with CRW corn. Alternatively, if he/she were to choose to plant 100 of those acres with CRW corn, a minimum of 20 of the remaining 300 non-CRW acres need to be left considered as a refuge. The non-CRW corn refuge acres must be planted within or adjacent to the CRW corn field(s) in the following alternatives described below.

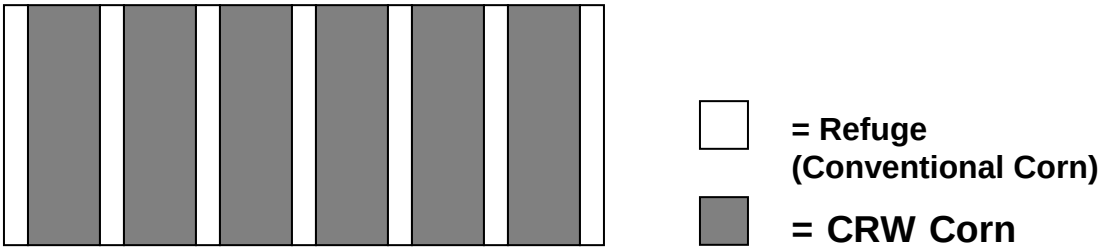
Refuge Alternative 1- Within Field Block



Refuge planted within the same field as one or more large blocks. The refuge must be at least 20 percent of the CRW corn acres.

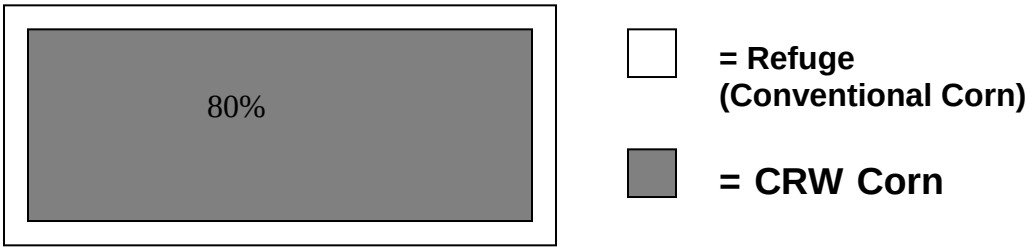
(Turn over)

Refuge Alternative 2- Strip Planting (split planter)



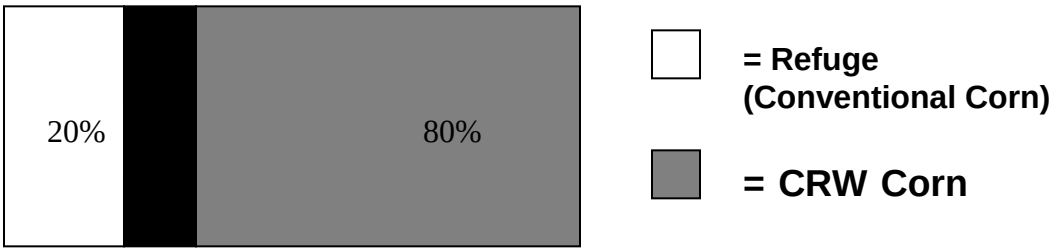
Refuge planted in strips throughout the field, with a minimum of 6 rows per strip. For example, 3 boxes next two each other on a 12 row planter. The refuge must be at least 20 percent of the CRW corn acres.

Refuge Alternative 3- Border Planting



Refuge planted within the same field, where a minimum of 6 rows are planted around the CRW corn portion of the field. The refuge must be at least 20 percent of the CRW corn acres.

Refuge Alternative 4- Adjacent Field



Refuge planted in an adjacent field, separated by a road, path, ditch, etc., but not by another field. The refuge must be at least 20 percent of the CRW corn acres.