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An Integrated Pest Management Adoption Survey of Sweet Corn Growers in the Great Lakes Region

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ABSTRACT. Sweet corn is one of the most common fresh market vegetable crops grown throughout the north central and north east regions of the United States. In 2008, the Great Lakes Vegetable Working Group measured integrated pest management (IPM) practice adoption by growers of this crop using online and hardcopy surveys over a 10-mo period. The survey asked growers from nine states and Ontario, Canada, which pest management practices they used on their farm operation in the following sections: education, preplant, at-plant, in-season, postharvest, scouting, and demographics. Each individual survey question was ranked by a panel of university specialists and designated as a low, moderate, or high IPM valued activity, with points assigned accordingly. On survey completion, the total points accumulated by the grower would place them into one of three categories; low, moderate, or high IPM adopter. Of the 407 respondents, 130 were placed in the low IPM adoption category, 251 were deemed moderate IPM adopters, and 26 were placed in the high IPM category. Some key general attributes of a high IPM adopter include someone who has grown vegetables for at least 10 yr and has a farm >51 acres (67%) and raises between 21–50 acres of sweet corn (44%). Some key general attributes of a low IPM adopter include less experience on smaller acreage, with 56% having grown vegetables for fewer than 10 yr with 57% on farms smaller than five acres.

Key Words: integrated pest management, sweet corn, Great Lakes, vegetable, survey

Integrated pest management (IPM) programs have been coordinated and organized at the state level since around 1973, with funds earmarked for Land Grant University Extension services (Gray 2006). Among the broad goals of any crop-based IPM program is the use of multiple tactics to suppress pests below an acceptable threshold, consideration of the environmental and economical factors associated with each treatment option, and the possible reduction of pesticides into the system. Since their inception, most state IPM programs have deployed a balanced approach of applied research and Extension education to train farmers and growers how to scout, identify pests, and use thresholds to manage locally important agronomic or specialty crops (Draper et al. 2011).

Although there are many types of IPM programs across the country, it is less clear to what extent these appropriate pest management practices are learned and incorporated into the average residential garden and landscape, crop field, or ranch operation. In the following article, we offer the results of one approach to assessing IPM adoption from a specific group of sweet corn (*Zea mays* L.) growers throughout the Midwest, including Ontario, Canada.

Background: Meet the Great Lakes Vegetable Working Group

The Great Lakes Vegetable Working Group (http://ncipmc.org/glvwg) is an international collaboration of Extension researchers and educational specialists from Illinois, Indiana, Kentucky, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and Ontario, Canada, formed in 2005 by a North Central IPM Center grant competition. Their mission is to conduct educational programming that addresses current pest management issues facing growers and the vegetable industry.

In 2005, the first Working Group project created IPM surveys for various vegetable crops—asparagus, carrots, horseradish, melons, peppers, pumpkin, sweet corn, fresh market and processing tomato. These surveys were based loosely on the Ohio State University IPM Elements that had been completed in 2000 and have since been revised (Welty et al. 2012). In 2008, the Working Group decided to revise the sweet corn survey and rerelease it on a regional basis, with the rationale to establish baseline adoption for IPM activities on that crop. The benchmark established by this group of growers on sweet corn would allow other entities, such as state IPM programs, nongovernmental organizations, or even this Working Group, to resurvey growers in 5–10 yr to determine any changes in the overall amount of IPM being practiced and adopted by growers on this specific crop. The intent was that state IPM programs would be able to draw correlations between increased IPM practices from specific programs conducted during the intervening years.

The Survey: Description and Methods

The survey was broken into eight main sections—educational IPM considerations, record keeping for IPM, preplant IPM considerations, at-plant IPM considerations, in-season IPM considerations, postharvest IPM considerations, scouting, and demographics. All survey questions were dichotomous (yes/no); survey respondents selected practices that applied to their current farming operation (creating a "yes" statement).

The sweet corn IPM adoption survey was distributed electronically using SurveyMonkey.com (Palo Alto, CA) from December, 2008 to August, 2009. In addition to using the web-based surveys, paper versions of the same survey were distributed at regional and local vegetable meetings, including the 2008 Great Lakes Fruit and Vegetable Exposition held in Grand Rapids, MI, and other sweet corn meetings and field days in 2009. In exchange for completing the sweet corn IPM survey, growers were given a copy of the "Sweet Corn Pest Identification and Management" pocket guide, released just a few months prior (Weinzierl et al. 2008). All 301 paper copies of surveys completed by growers were entered into the SurveyMonkey.com template online. This data set was combined with the 106 surveys completed online by growers for the final analysis.

SurveyMonkey.com provided initial frequency results that were imported into Microsoft Excel. Additional calculations and graphics were completed by Haley Consulting Services, LLC using SPSS and Excel.

Unanswered questions create missing data and cause the response number (n) to change from figure to figure and table to table. Questions answered incorrectly because of haste or misunderstanding the directions turn up in the data as reporting errors. This contributes to the varying response numbers as well.

Like all surveys, this study has limitations that should be considered when interpreting the results:

- It is not possible to know where responses reflect actual behavior. This disadvantage applies to all such studies.
- Data with response numbers <30 provide unreliable results. Take caution when interpreting these results (e.g., results for high IPM category).
- Growers who did not complete surveys may differ from respondents. The generalizability of the data is therefore bound by the response rates.
- An additional limitation of this survey is that it was piloted and vetted only on university faculty and staff, leaving some question as to the interpretation and possible ambiguity of certain questions by the respondents, who were growers.

Response rates were calculated using United States Department of Agriculture National Agriculture Statistics Service (USDA NASS) Census of Agriculture 2007 data because they contained the number of farms raising sweet corn (USDA NASS 2007). There were 407 valid respondents to the survey. The overall response rate was calculated using respondents from states included in USDA NASS surveys (USDA NASS 2007) and data available from Ontario Ministry of Agriculture and Food (2006). See Table 1 and Fig. 1 for overall and individual state and province response rates.

Because of the very low response rates, results from this survey are not generalizable to the larger population of sweet corn growers from the Great Lakes region. They do, however, provide a snapshot of a set of growers in this region. They also provide useful information for conducting applied research and planning Extension programs.

The Scale: IPM Score Calculations

A project committee of six sweet corn experts categorized each IPM practice into high, medium, or low, which was subsequently assigned points; 15 points for high IPM, meaning practices that were critical to crop production; 10 points for medium IPM, meaning practices that were important to crop production; and 5 points for low IPM, meaning these practices only had a small impact on overall production. The experts' original assessments were then averaged and recoded again into high, medium, and low IPM (i.e., 15, 10, and 5 points respectively). Averages falling between 5 and 8.3 were recoded as 5s, those between 8.4 and 11.6 were assigned 10s, and averages falling between 11.7 and 15 were coded as 15s. In a few cases, the final average rating for a practice was different than the raw average score would indicate because of special conditions surrounding the statement or practice. The IPM value of each practice has been incorporated into the appropriate figures and tables.

IPM scores for individual respondents (growers) were calculated by adding the points for each statement and section. Five points were given for each low-level practice, 10 points for each medium-level practice, and 15 points for each high-level practice being used on their farm. When all sections were totaled, respondents were assigned to the low, medium, or high IPM adoption category based on the point total. Table 2 provides the total number of possible points per survey section, along with the associated range of scores for low, medium, and high ratings. These ranges were assigned such that each category would have an equal distribution (i.e., each category represents one-third of the total). Missing data (e.g., questions left blank) were assumed to be a "no" response (zero points), for the purposes of calculating IPM scores.

Table 1. Overall grower response rate to the sweet corn IPM survey

Response rate category	USDA NASS[a] + OMAF[b]	USDA NASS[a] + OMAF[b] data minus WI, PA, NY respondents
All possible respondents	13,311	6,967
Survey respondents	407	396
Overall response rate	3.1%	5.7%

[a] United States Department of Agriculture National Agriculture Statistics Service.
[b] Ontario Ministry of Agriculture and Food.

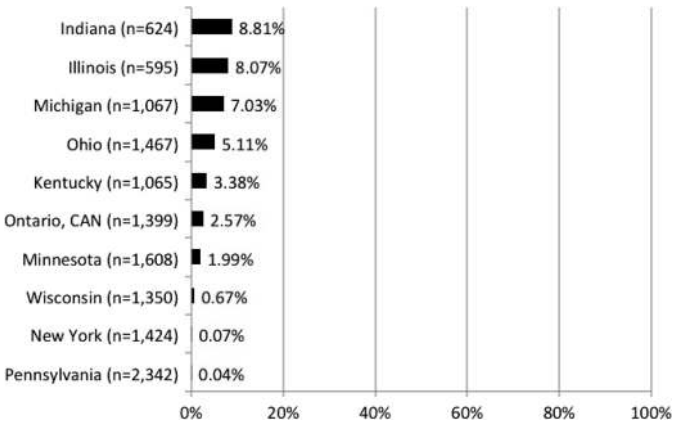

Fig. 1. Response rates by state and province.

The actual score distribution of all respondents is shown in Fig. 2. The scores represent a bell-shaped curve, skewed slightly toward the lower end of the adoption scale with regard to the overall point accumulation and assignment into low, medium, or high IPM adoption groups.

Survey Results—Education Section

Below are a series of tables that list individual IPM practices and the extent to which respondents in the low, medium, and high IPM adoption groups used that practice in 2008 with regard to sweet corn production. In Table 3, 72% of respondents attended annual state or provincial vegetable meetings to receive pest management updates, while only 38% attended field days during the growing season. This may be an indication of how busy growers are during the growing season versus the fall or winter when most annual meetings are held. During winter meetings, growers can attend educational sessions on a range of crops and topics in a 1 or 2 d span plus receive credit for their pesticide applicator license, which is much more efficient for them. The down side to respondents reducing field day visits is the opportunity to see the pest or condition as it exists in the field, which can appear different on a slide presentation at a winter meeting. Also lost is the opportunity to discuss with the specialist circumstances surrounding their particular situation in time to make in season monitoring or treatment adjustments. Only 23% of growers are interested in exploring alternate markets.

About 40% of respondents do not receive any type of pest management newsletter or report from their state or province, but of those who do, 41% receive the information via email, 29% by postal mail, and the remaining fraction get the information faxed to them (Table 4). The fact that such a large percentage of respondents don't receive these timely updates suggests they are accessing this information in some other way or simply going uninformed regarding the latest pest management information.

In Table 5, 42% of respondents chose Extension educators or specialists as their first source for sweet corn pest management information, followed by industry representatives (19%) and other growers (14%). Interestingly, respondents used internet searches and trade journals only ≈9% of the time, but relied on crop consultants even less. About 38% of the high IPM adopters used Extension personnel

Table 2. Total IPM scores by survey section

Survey section	Total possible	Low IPM range	Medium IPM range	High IPM range
Educational considerations	105	0–35	36–70	71–105
Record keeping	110	0–37	38–73	74–110
Preplant considerations	285	0–95	96–190	191–285
At-plant considerations	40	0–13	14–26	27–40
In-season considerations	375	0–125	126–250	251–375
Postharvest considerations	80	0–26	27–52	53–80
Scouting	10	-	10	-
Demographics	-	-	-	-
Totals	1005	0–335	336–670	671–1005

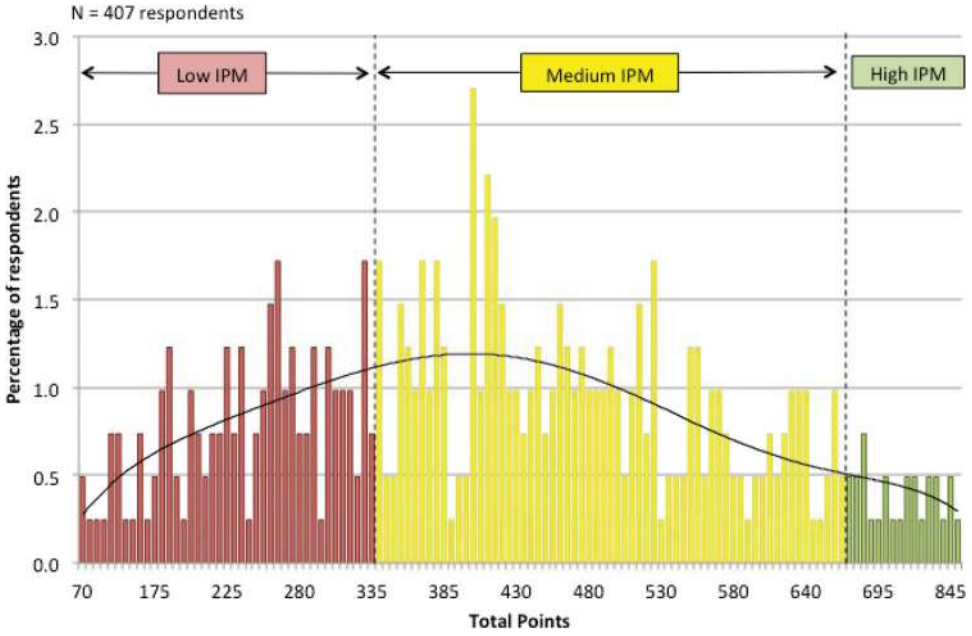

Fig. 2. Individual grower IPM adoption survey score distribution ($n = 407$). Total possible points equal 1,005, mean is 418 points, median is 410 points, mode is 400 points, SEM is 7.8 points.

Table 3. Respondent results for the question, "Which of the following are ways you use to maintain and update your pest management knowledge?"

Survey statement	% low IPM ($n = 130$)	% medium IPM ($n = 251$)	% high IPM ($n = 26$)	% total responses ($n = 395$)
Annually attend state or provincial vegetable meetings	55	76	85	72
Update reference materials (books, manuals, bulletins, etc.) on crop pest management	36	56	85	53
Annually obtain the latest state, provincial, or regional vegetable production guide	30	59	81	52
Experiment with new IPM practices on your farm and gauge their success	18	47	96	42
Join state or provincial vegetable grower association(s)	18	47	73	41
Attend field days during the growing season	25	41	54	37
Explore alternative markets that encourage less pesticide use (organic, eco, or IPM labels)	26	17	62	24

Medium IPM value practices are shaded yellow, and high IPM value practices are shaded green.

as their first option, compared with ≈33% of both medium and low IPM adopters. Across all categories of IPM adoption, Extension educators and specialists ranked highest for respondents first source of information, which may reflect the value of nonbiased science-based information offered or may be an artifact associated with who completed the survey.

Survey Results—Record Keeping Section

The top two types of records kept among respondents were planting date (88%), and pesticides used (83%; Table 6). The least recorded information were weed field maps (17%) and plant growth stages (15%). The fact that keeping weed field maps is seen as a high IPM practice by university specialists but is such a low priority for growers points to a real disconnect between the two groups on the value of this practice. Respondents in the high IPM adoption group keep almost all records listed except for irrigation, weed maps, and plant growth stages. Irrigation monitoring and scheduling is expected to become increasingly more important, as water use issues continue to gain importance in this region.

Most respondents (90%) are keeping their records on paper or in a notebook (Table 7). Very few have computerized record keeping

Table 4. Respondent results for the question, "How do you receive your state or provincial vegetable pest management newsletter, update or report?"

Survey statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 397)
e-mail (actual articles or link to internet site)	25	44	73	41
Do not receive newsletter, report, or updates	58	31	12	40
Postal mail	19	31	42	29
Fax	1	3	15	3

High IPM value practices are shaded green.

Table 5. Respondent results for the question, "Which pest management source for information on sweet corn do you seek first?"

Survey statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 331)
Extension educators or specialists	34	33	38	42
Industry representative (seed, chemical, and fertilizer dealers)	9	19	15	19
Other farmers, grower groups	22	7	4	14
Internet searches	7	7	12	9
Agricultural periodicals (Farm Bureau news, Vegetable Grower News, etc.)	9	7	0	9
Independent crop consultants	5	6	15	7

Medium IPM value practices are shaded yellow.

Table 6. Respondent results for the question, "Select all the different forms of record keeping performed on your farm in 2008"

Survey statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 399)
Planting dates	74	92	100	88
Pesticides used (fungicides, herbicides, insecticides)	58	92	100	83
Cultivars planted	45	75	100	68
Field locations	50	71	100	67
Fertilizer applications	35	73	81	62
Harvest dates	32	54	85	50
Harvest yields	33	47	81	45
Irrigation monitoring and scheduling	14	28	50	25
Weed field maps (in season or after harvest to guide herbicide applications)	6	19	46	17
Plant growth stages	6	16	46	15

Low IPM value practices are shaded orange, medium IPM value practices are shaded yellow, and high IPM value practices are shaded green.

Table 7. Respondent results for the question, "How are your records (pesticides and pests) usually kept?"

Survey statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 398)
Written on paper/notebook	79	91	96	90
Recorded in a computer	16	29	54	27
Records kept by custom applicator	2	8	15	7
Other means not listed	8	4	4	5
Records kept by crop consultant	1	3	12	3
Recorded in a personal digital assistant	1	3	8	3

Medium IPM value practices are shaded yellow.

(27%), but many respondents commented on moving toward a computer-based record system in the near future. It should be noted that 54% of high IPM adopters have computerized their records in addition to the paper copies. With the availability of better record keeping software and the addition of regulations regarding good agricultural practices, third party audits, and food traceability, there is little doubt electronic records are on the horizon for most operations, especially for growers with sales over a specific threshold. Personal data assistants (PDA) were barely used when this survey was issued, but in recent years there has been surge in smartphone use by growers. In Ontario, Canada, 46% of growers indicated on a recent survey their smartphone was essential to their job, and was used for email, texting, browsing, calendars, and the weather (LeBoeuf et al. 2012). In this survey, the most commonly used applications included weather, market prices, plant population calculators, navigation (GPS), hybrid selector tools, record keeping, pest information, and scouting.

Survey Results—Preplant Activities Section

The highest practiced preplant activities include hybrid selection (78%), tillage for weed control (73%), and use of certified seed (66%), followed closely by residual herbicide applications (62%) and sprayer calibration (53%; Table 8). The practice of soil sampling every 2–5 yr was removed after the survey was released because it competed with another practice of soil sampling every year, which was kept. Based on grower response, it appears that soil sampling in longer

Table 8. Respondent results for the question, "Select the preplant IPM considerations that apply to your sweet corn operation in 2008"

Practice or activity statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 405)
Select hybrids well adapted for your growing area and time of planting, i.e., cool season vigor	51	89	100	78
Use fall or spring tillage to control established perennial weeds	59	79	85	73
Select certified seed	48	72	96	66
Apply residual herbicide for control of annual grasses and broadleaves before, at, or after planting as directed by label	28	76	96	62
[a]Fields are soil tested every 2–5 years; fertility and lime rates are adjusted according to state or provincial guidelines	49	60	62	57
Select herbicides and plan other weed management practices based on your knowledge of weeds present in the field	25	69	92	57
Calibrate pesticide sprayer(s) annually	18	67	96	53
Avoid planting in last year's cornfield to reduce corn rootworm injury	40	55	62	51
Use recommended seed treatments for insect control (corn flea beetle, seed corn maggot, wireworms, white grubs, etc.) in high-risk situations	11	60	96	47
Use recommended seed treatments for disease control (damping off) in high-risk situations	8	53	96	41
Use fall or spring herbicide application to control established perennial weeds	15	49	88	40
Select Bt cultivars for insect management to reduce insecticide sprays	23	44	65	39
Select cultivars that discourage bird damage	15	45	88	39
Select cultivars with moderate to high genetic resistance to Stewart's wilt	8	39	92	33
Fields are soil tested annually; fertility and lime rates are adjusted according to state or provincial guidelines	18	28	50	27
If planting into soybean field, consider a seed treatment or soil insecticide for corn rootworms where the variant western corn occurs	2	20	65	17
Modify hybrid selection or use systemic insecticide seed treatment if Stewart's wilt prediction is moderate to severe	1	15	73	14
Use plastic mulch (dark or clear), especially on early planted corn	7	16	19	13
Use stale seedbed (fallow seedbed) technique to control weeds	4	13	38	12
Use Poast Protected (BASF Corporation, Research Triangle Park, NC) hybrids when available	4	12	31	11
Use a corn flea beetle model to predict potential severity of Stewart's wilt	1	8	42	8
Practice weed seed exclusion tactics such as high pressure washing machinery shared between farms	2	6	31	6
Use row covers for protection against pests, especially on early planted corn	3	6	12	6

Low IPM value practices are shaded orange, medium IPM value practices are shaded yellow, and high IPM value practices are shaded green.
[a] Question removed from scoring on all surveys.

intervals is preferred over annual sampling. It should be noted that sprayer calibration is practiced by 96% of respondents in the high IPM adoption group, but only 68% in the medium and 18% in the low IPM adoption groups.

The following practices were used by <8% of respondents: the corn flea beetle model, washing equipment between fields, and use of row covers. A key early season pest to manage is corn flea beetle, *Chaetocnema pulicaria* Melsheimer, which vectors Stewart's wilt, *Erwinia stewartii* (Fig. 3). University specialists agree the corn flea beetle model is critical to predict Stewart's wilt and key in selecting the proper hybrid resistance level, but respondents rated the value of this model extremely low in their overall production scheme. It should be noted that the model predictions are generated at the end of February and is out of sync with the purchase of most sweet corn hybrid seed, which usually happens 1 to 2 mo earlier, essentially rendering the outcome of the prediction model moot for most growers. In reality, growers who follow general university recommendations to purchase Stewart's wilt resistant hybrids (Welty 2009, Egel et al. 2014) with ear qualities preferred by their customer base, usually do not experience large losses because of this insect and pathogen complex, especially for late season plantings or if seed has been treated with a systemic insecticide.

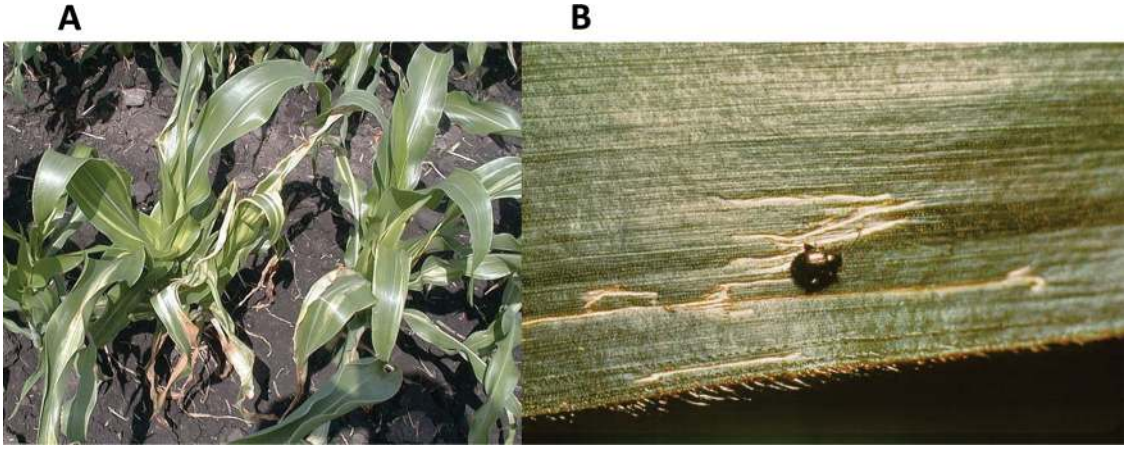

Fig. 3. Stewart's Wilt symptoms on sweet corn (A; photo, J. Pataky) and corn flea beetle (B; photo, H. Willson).

Table 9. Respondent results for the question, "Select the at-plant IPM considerations that apply to your sweet corn operation in 2008"

Practice or activity statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 358)
Use a preemergent herbicide to control annual and perennial weeds	38	84	96	80
If planting into fields with insect pressure (rootworms, wireworms, white grubs), use a soil insecticide or systemic seed treatment	20	55	92	52
Adjust planting date (earlier or later) to reduce risk of certain insect populations	28	26	35	31

Medium IPM value practices are shaded yellow, and high IPM value practices are shaded green.

Table 10. Respondent results for the question, "Select the in-season IPM considerations that apply to your sweet corn operation in 2008"

Practice or activity statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 404)
Use cultivation to control weeds	75	79	81	78
Apply postemergence herbicide to control annual and perennial weeds	38	73	92	63
Minimize nontarget pesticide drift by not spraying during windy conditions	25	74	88	59
Near harvest, select pesticides with shorter preharvest interval restrictions	14	63	85	49
Scout whorl stage corn for European corn borer (egg masses or feeding), treat if thresholds are exceeded	15	61	92	49
Minimize nontarget pesticide drift by selecting proper nozzle type	8	56	88	43
Minimize nontarget pesticide drift by lowering boom height	10	53	77	41
Spray silking sweet corn with insecticide based on corn earworm moth catch in pheromone trap and maximum air temperature	18	46	92	40
Scout seedling corn (up to 7-leaf stage) at least twice per week for corn flea beetles, treat if populations exceed threshold	14	45	85	38
Minimize nontarget pesticide drift by lowering nozzle pressure	7	46	77	36
Scout silking corn for silk-clipping beetles, treat if thresholds are exceeded	7	43	85	34
Use bird scare devices (balloons, noise makers) to protect corn ears from black birds	12	41	46	32
Scout at tassel stage for corn leaf aphid, treat only if pollen shed is being affected and no beneficial insects are present	7	34	77	28
Scout seedling and older corn for rust and northern corn leaf blight, treat if thresholds are exceeded	4	34	85	28
Scout for fall armyworm foliar feeding and treat if thresholds are exceeded	7	32	92	28
Use electric fencing or other means to deter raccoon feeding damage	27	26	31	27
Remove uncommon or new weeds from the field prior to seed production	15	26	62	25
Use pheromone traps to monitor corn earworm activity	5	26	77	23
Control Johnsongrass to reduce maize dwarf mosaic virus and maize chlorotic	8	25	42	21
Use pheromone traps to monitor European corn borer moth activity and to time scouting	5	24	69	21
Use insecticides such as Bt or Entrust for organic control of European corn borer, corn earworm, or fall armyworm	10	19	42	18
Scout for western bean cutworm in tassel or later stage corn for eggs and larvae, apply treatments if thresholds are exceeded	5	20	58	18
Use fencing or other means to deter deer feeding damage	18	16	15	17
If no corn earworm moths are caught in traps, treat corn between silk and harvest based on catch of European corn borer moths in pheromone or light traps	2	15	69	14
Use degree day models to predict European corn borer moth flight to time scouting	2	13	23	10
Use pheromone traps to detect fall armyworm moths	1	10	46	10
Use pheromone traps to detect western bean cutworm moths	1	5	23	5
Use a blacklight trap to monitor European corn borer moths to time scouting	0	4	8	3

Medium IPM value practices are shaded yellow, high IPM value practices are shaded green.

Survey Results—At-Plant Activities Section

The number of practices related to at-plant IPM considerations is limited, but 80% of respondents used preemergent herbicides, 52% use some form of soil insecticide, and only 31% of respondents adjust their planting dates to avoid specific insect populations (Table 9). Over 50% of respondents in the medium and high IPM adopter group performed two of the three practices. None of the low IPM adopters used any of these practices over 38% of the time. Respondents in general did not see the value in adjusting their planting date to reduce insect pressure, possibly because some farm operations plant sweet corn continuously from early to late season, not allowing them to take advantage of this practice.

Survey Results—In-Season Activities Section

This section has the most practices (28) available for respondents to choose. Looking at the total number of responses, only three practices were adopted >50% of the time—weed cultivation (78%), use of postemergent herbicides (63%), and minimizing spray drift (59%; Table 10). Of the remaining 25 practices, 21 of them were adopted by >50% of the high IPM adoption pool and only 4 of them were adopted by >50% of medium IPM adopters. No practices were adopted by >50% of the low IPM adopters.

Several practices in sweet corn production relate to identifying and managing larvae and adults of key lepidopteran insects (Fig. 4). One important practice is monitoring corn earworm, *Helicoverpa zea* (L.), moths using pheromone traps, which only 23% of all respondents use, but 77% of high IPM adopters use. One of the lowest adopted practices by all respondents is the use of Bt insecticide to control caterpillars in the ear zone (18%). The lack of product use could be a reflection of higher costs and lower efficacy compared with other broad-spectrum insecticides such as pyrethroids. Additionally, Bt sprays would be favored more by organic growers, who represent only 5% of survey respondents. Use of insect protected transgenic sweet corn hybrids includes 23% of low IPM adopters, 44% of medium IPM adopters, and 65% of high IPM adopters (Table 8). We were not able

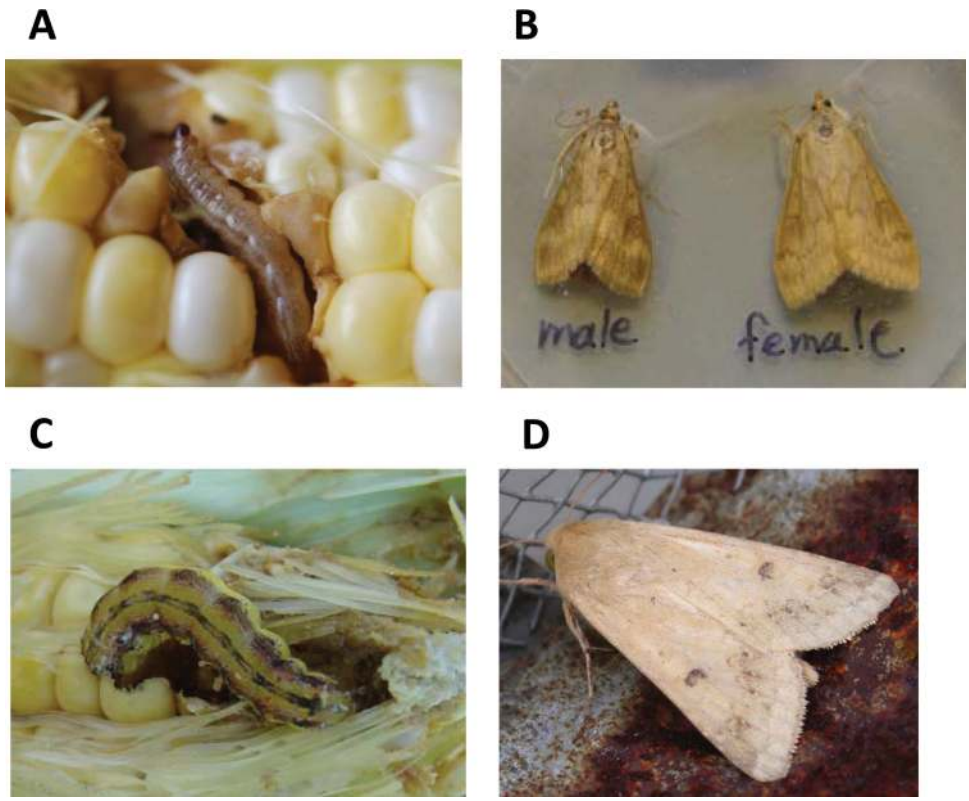

Fig. 4. Common sweet corn lepidopteran pests. European corn borer larva (A; photo, C. Welty) and adults (B; photo, C. Welty). Corn ear worm larva (C; photo, C. Welty) and adult (D; photo, J. Jasinski).

Table 11. Respondent results for the question, " Select the postharvest IPM considerations that apply to your sweet corn operation in 2008"

Practice or activity statement	% low IPM (n = 130)	% medium IPM (n = 251)	% high IPM (n = 26)	% total responses (n = 400)
Plow down or mow residue after harvest to reduce disease inoculum	60	79	85	75
Plow down or mow residue after harvest to reduce overwintering insects	61	77	85	74
Perform postharvest operation to reduce weed seed production (e.g. flail chop stalks, disk, plow or apply postemergence herbicides)	38	76	92	66
Identify and evaluate successful practices, incorporate them in future years	41	67	96	62
Establish cover crops for next years crop for soil erosion control or nitrogen	40	46	58	46
Control fall germinating annuals and perennials to eliminate potential cutworm egg-laying sites	15	31	77	29

Medium IPM value practices are shaded yellow, high IPM value practices are shaded green.

to determine the percent of Bt acres grown compared with the total number of sweet corn acres in this survey, but a research report by Shelton and Olmstead (2011) estimates the overall use of Bt sweet corn is around 10% for fresh market acreage, with very little used in the processing market. Pheromone trapping for insects other than corn earworm, such as European corn borer, *Ostrinia nubilalis* Hübner, is also not a high priority to most respondents (21%).

Survey Results—Postharvest Activities Section

Plowing down or mowing crop residue for either reducing disease inoculum (75%) or destroying overwintering insects (74%) is the number one practice identified by respondents (Table 11). Almost 62% of respondents identify, evaluate, and adopt successful practices; that rate soars to 96% for members in the high IPM adoption group. Controlling fall germinating weeds is the lowest adopted IPM practice (29%). The use of fall planted cover crops has an overall adoption rate of 46% and is highest among the high IPM adoption group (58%). Given the nutrient cycling, general soil fertility, and erosion prevention benefits of cover crops presented at field days, workshops, and other meetings, this practice should show increased adoption in future years.

Table 12. Respondent results for the question, "Would you like to receive more training and education on sweet corn pest management (scouting, pest monitoring, trapping, etc.)?"

Response	% low IPM (n = 116)	% medium IPM (n = 239)	% high IPM (n = 25)	% total responses (n = 380)
Yes	83	83	76	83
No	17	17	24	17

Survey Results—Scouting Section

The majority of respondents (83%) indicated they would like to receive more pest management training in sweet corn (Table 12), but surprisingly 24% of the high IPM adoption group indicated they did not want any more training! The disinterest in training by some growers could be interpreted as a high level of confidence in pest monitoring and insecticide spray timing skills. However, no vegetable

Table 13. Respondent results for the question, "How do you usually scout this crop?"

Practice or activity statement	% low IPM (n = 127)	% medium IPM (n = 248)	% high IPM (n = 25)	% total responses (n = 400)
Scout and monitor crop yourself	72	77	72	75
A mixture of self scouting and crop consultant	10	17	20	15
Do not scout myself; do not hire a crop consultant	16	3	4	7
Hire a consultant to scout and monitor the crop	2	2	4	3

Medium IPM value practices are shaded yellow.

Table 14. Respondent results for the question, "Listed below are possible reasons for NOT scouting or hiring a crop consultant, select all appropriate responses"

Practice or activity statement	% low IPM (n = 19)	% medium IPM (n = 7)	% high IPM (n = 1)	% total responses (n = 28)
Not familiar enough with pests and scouting methods	68	86	100	71
Too expensive to hire a crop consultant	37	29	0	32
Too busy to self scout	32	14	100	29
No crop consultant working on my crop	16	43	0	21
No crop consultant in my area	0	43	0	11
Other (please specify)	5	14	0	7

system is a static one, and as new pests, insecticides, and hybrids enter the system, even the most experienced growers can benefit from retraining.

The majority of respondents (75%) scouted their sweet corn directly while only three percent hired crop consultants to perform all scouting (Table 13). Seven percent of respondents indicated they did not scout their crop citing a lack of familiarity with the pests and scouting protocols (71%), the expense to hire a consultant (32%), or too busy to scout it themselves (29%; Table 14). The lack of local crop consultants (11%) did not appear to be the issue. By attending sweet corn workshops and field days, this group of nonscouting growers could become self reliant at pest identification, monitoring, application timing, and insecticide selection, substantially improving their pest management approach to this crop, while potentially producing more marketable ears.

Survey Results—Demographics Section

The demographics of the survey respondents are detailed in the following series of figures. Although originally phrased as, "What are your markets by percentage?" the data have been transformed to show the percentage of growers categorized into the various possible markets (Fig. 5). The majority of growers (92%) list conventional fresh market as at least one of their markets, with production for processing (7.3%) and organic fresh market (5.2%) representing only a small part of overall market composition.

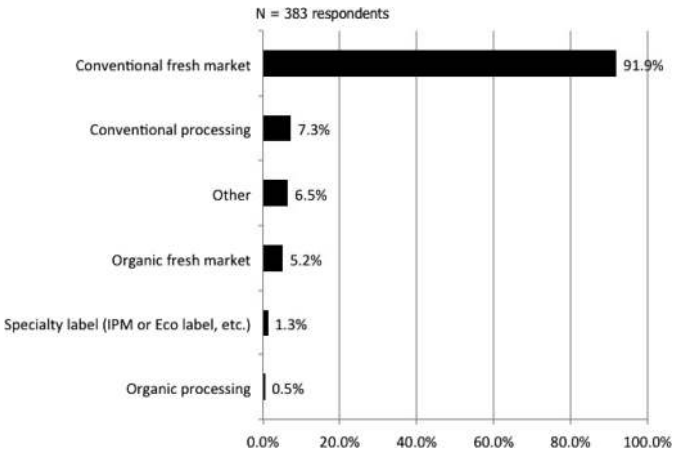

Fig. 5. Respondent results for the question, "What are your markets?"

Respondents ranked their greatest challenge to sweet corn production as insects (43%), animals (26%), and weeds (20%; Fig. 6). Less than 10% of respondents thought that irrigation, disease management, fertility, equipment, or other (weather, labor, germination, etc.), was their biggest concern. It is interesting to note that, despite the relatively high percentage of respondents identifying animal damage as the area that causes them the most difficulty, the corresponding practice that would help address this issue, namely fencing, was used by a relatively small percentage of respondents (16.6%; Table 10). Likewise, 38.7% of all respondents selected varieties with tight husks to prevent bird feeding (Table 8) and 31.9% of respondents used bird scare devices (Table 10).

The largest group of respondents (47%) grow less than five acres of sweet corn per season (Fig. 7), and as sweet corn production increases, the number of growers decreases except for production over 100 acres, which is higher than the 51–100 acre sized operation.

Overall vegetable production of the respondents is skewed toward smaller operations, with 29% under five acres and 28% between 6–20 acres (Fig. 8). Sixteen percent of respondents have vegetable production >100 acres on their farm.

In terms of total farm size (Fig. 9), the largest group of respondents are on farms between 51–200 acres (31%), followed closely by farms

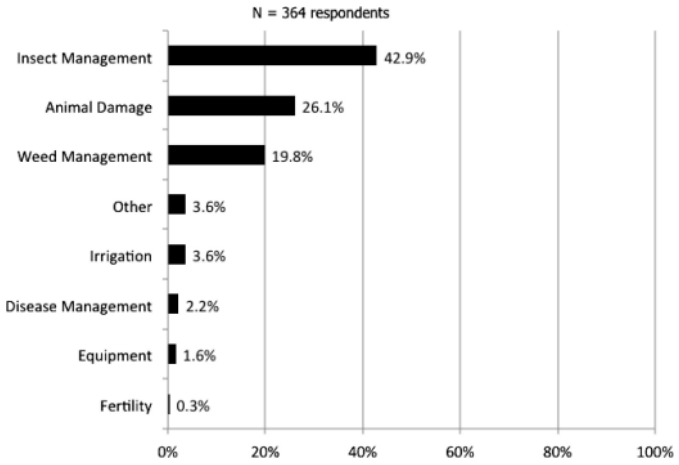

Fig. 6. Respondent results for the question, "If you had to choose one area that causes you the most difficulty in producing sweet corn, what would it be?"

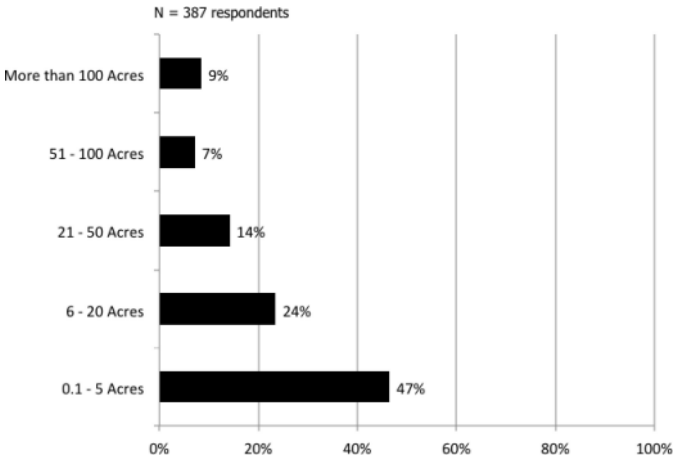

Fig. 7. Respondent results for the question, "My sweet corn acreage in 2008 was. . . ?"

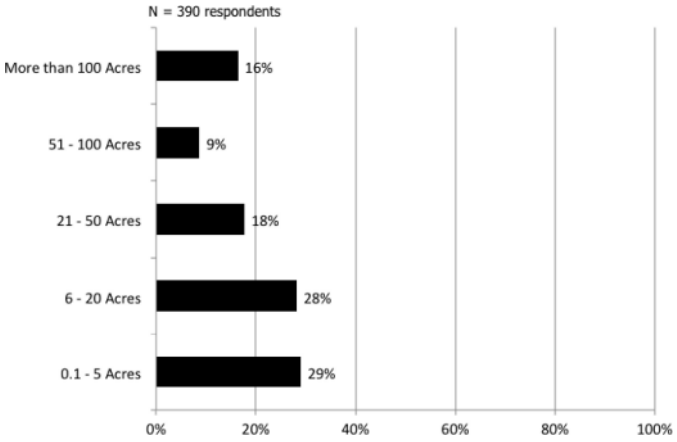

Fig. 8. Respondent results for the question, "My total vegetable acreage in 2008 was. . . ?"

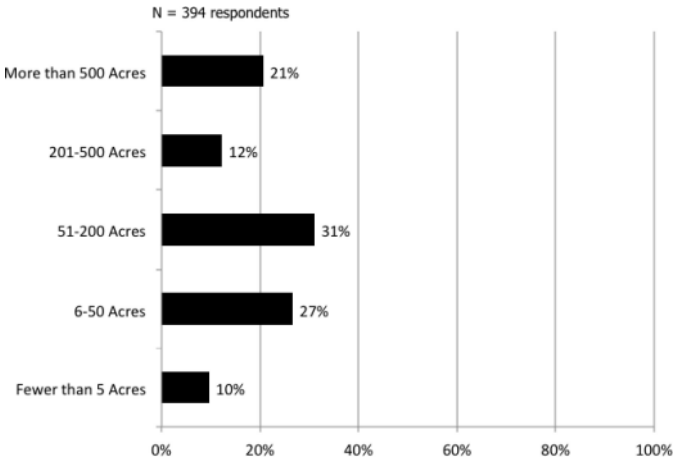

Fig. 9. Respondent results for the question, "My total farm operation size in 2008 was. . . ?"

between 6–50 acres in size (27%). Ten percent of farms were <5 acres in size and 21% of the very largest farms were >500 acres.

In terms of experience, 63% of respondents have been involved in production for >10 yr (Fig. 10). The 37% of respondents who have <10 yr experience growing vegetables represents a large pool of growers who could potentially benefit from learning proper pest management techniques if they have little or no formal training.

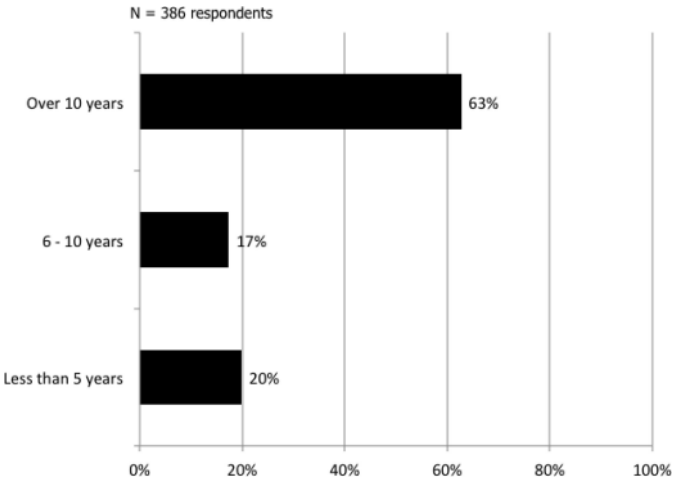

Fig. 10. Respondent results for the question, "I have been growing vegetables for. . . ?"

In any IPM program, it is often useful to determine what portion of a target audience is receiving training and adopting techniques, and which portion of the audience is either not being reached or is choosing not to adopt practices. The final two sections of this article provide summaries of the characteristics of respondents in the "high" and "low" IPM adopter categories. Understanding the characteristics of these two sweet corn grower groups—based on survey respondents—can help guide future applied research and Extension efforts.

Profile of a "High IPM Adopter"

The typical high IPM respondent has been growing vegetables for at least 10 yr, with 25% on farms 51–100 acres and 42% on farms larger than 100 acres. The number of sweet corn acres raised range between 21–50 acres (44%), 51–100 acres (12%), and >100 acres (28%). This individual maintains and updates their pest management knowledge most often by experimenting with new IPM practices on their farm and gauging their success (100%), annually attending state or provincial vegetable meetings (85%), updating reference materials (books, manuals, bulletins, etc.) on crop pest management (85%), annually obtaining the latest state, provincial, or regional vegetable production guide (81%), and joining state or provincial vegetable grower association(s) (73%). They are most likely to receive pest management newsletters, updates, and reports by email (73%), and they are most likely to seek pest management information from extension educators or specialist first (45%).

While using a wide variety of practices throughout the season, the typical high IPM respondent is most likely to conduct the following preplant IPM activities: select hybrids well adapted for their growing area and time of planting, i.e., cool season vigor (100%); calibrate pesticide sprayer(s) annually (96%); apply residual herbicide for control of annual grasses and broadleaves before, at, or after planting as directed by label (96%); select certified seed (96%); use recommended seed treatments for disease control (damping off) in high-risk situations (96%); use recommended seed treatments for insect control (corn flea beetle, seed corn maggot, wireworms, white grubs, etc.) in high-risk situations (96%); select herbicides and plan other weed management practices based on their knowledge of weeds present in the field (92%); select cultivars with moderate to high genetic resistance to Stewart's wilt when appropriate (92%); select cultivars that discourage bird damage (tight husks, husks extended above ear tip, narrow angle of ear on stalk; 88%); use fall or spring herbicide application to control established perennial weeds (88%); use fall or spring tillage to control established perennial weeds (85%); and modify hybrid selection or use systemic insecticide seed treatment if Stewart's wilt prediction is moderate to severe (73%).

At-plant IPM practices most commonly used by high IPM respondents include using a preemergent herbicide to control annual and perennial weeds (96%), and using a soil insecticide or systemic seed when planting into fields with insect pressure (rootworms, wireworms, white grubs; 92%).

In-season practices most commonly used by high IPM respondents include applying postemergence herbicide to control annual and perennial weeds (92%); scouting whorl stage corn for European corn borer (egg masses or feeding) and treating if thresholds are exceeded (92%); spraying silking sweet corn with insecticide based on corn earworm moth catch in pheromone traps and maximum air temperature (92%); scouting for fall armyworm foliar feeding and treating if thresholds are exceeded (92%); minimizing nontarget pesticide drift by not spraying during windy conditions (88%); minimizing nontarget pesticide drift by selecting proper nozzle type (88%); near harvest, selecting pesticides with shorter preharvest interval restrictions (85%); scouting seedling corn (up to 7-leaf stage) at least twice per week for corn flea beetles and treating if populations exceed threshold (85%); scouting silking corn for silk-clipping beetles and treating if thresholds are exceeded (85%); scouting seedling and older corn for rust and northern corn leaf blight and treating if thresholds are exceeded (85%); and using cultivation to control weeds (81%).

Postseason practices most commonly used by high IPM respondents include identifying and evaluating successful practices, and incorporating them in future years (96%); performing postharvest operations to reduce weed seed production (e.g., flail chopping stalks, disking, plowing, or applying postemergence herbicides; 92%); plowing down or mowing residue after harvest to reduce disease inoculum (85%); and plowing down or mowing residue after harvest to reduce overwintering insects (85%).

Profile of a "Low IPM Adopter"

The typical low IPM respondent (44%) has been growing vegetables for >10 yr on smaller farms with <5 vegetable acres (57%). Most low IPM respondents grow <5 acres of sweet corn (77%). The low IPM respondent maintains and updates their pest management knowledge most often by annually attending state or provincial vegetable meetings (55%); updating reference materials (books, manuals, bulletins, etc.) on crop pest management (36%); and annually obtaining the latest state, provincial, or regional vegetable production guide. Note that these numbers are considerably lower than their high IPM counterparts, where percentages for these three items are 85, 85, and 81%, respectively. More than half the low IPM respondents (58%) do not receive newsletters, reports, or updates; for those who do, most receive them by email (25%). Like their high IPM counterparts, low IPM respondents most often seek pest management information from extension educators or specialists (40%).

There are only two preplant practices that more than half the low IPM respondents use: fall or spring tillage to control established perennial weeds (59%) and selecting hybrids well adapted for their growing area and time of planting (51%). However, there are 10 preplant practices that fewer than 10% of low IPM respondents use: seed treatments for disease control (damping off) in high-risk situations (8.5%); selecting cultivars with moderate to high genetic resistance to Stewart's wilt when appropriate (8%); using plastic mulch (dark or clear), especially on early planted corn (7%); using stale seedbed (fallow seedbed) technique to control weeds (4%); using Poast Protected (sethoxydim resistant) hybrids when available (4%); using row covers for protection against pests, especially on early planted corn (3%); considering a seed treatment or soil insecticide for corn rootworms in areas where the variant western corn rootworm is known to occur, if planting in last year's soybean field (2%); practicing weed seed exclusion tactics such as high pressure washing machinery shared between farms (2%); modifying hybrid selection or using systemic insecticide seed treatment if Stewart's wilt prediction is moderate to severe (>1%); and using a corn flea beetle model to predict potential severity of Stewart's wilt (>1%).

There are no at-planting practices that more than half the low IPM respondents use, and only one practice that just over a third use: a preemergent herbicide to control annual and perennial weeds (38%), compared with 96% of high IPM respondents for this same practice.

For in-season practices, there is only one practice used by more than half of the low IPM respondents: cultivation to control weeds (75%). All other in-season practices are used by ≤38% of the respondents.

Postseason practices gain a little traction with two activities being used by more than half the low IPM respondents: plowing down or mowing reside after harvest to reduce overwintering insects (61%) and plowing down or mowing residue after harvest to reduce disease inoculum (60%).

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