



2013 Summary Report

Introduction

The Iowa Farm and Rural Life Poll is an annual survey of Iowa farmers. The survey project collects and disseminates information on issues of importance to communities across Iowa and the Midwest. The Farm Poll has been conducted every year since its establishment in 1982, making it the longest-running survey of its kind in the nation. Iowa State University (ISU) Extension and Outreach, the Iowa Agriculture and Home Economics Experiment Station, the Iowa Department of Agriculture and Land Stewardship, and the Iowa Agricultural Statistics Service are partners in the Farm Poll. The information gathered through the annual survey is used to inform the development and improvement of research and extension programs and is used by local, state, and national leaders in their decision-making processes. We thank the many farm families who responded to this year's survey and appreciate their continued participation.

Who Participates?

The 2013 Farm Poll questionnaires were mailed in February to a statewide panel of 2,145 farmers. Usable surveys were received from 1,209 farmers, resulting in a response

rate of 56 percent. On average, Farm Poll participants were 65 years old. Because the Farm Poll is a panel survey, in which the same farmers participate in multiple years, participants are somewhat older on average than the general population of farmers.

Most Farm Poll participants draw a significant proportion of their overall household income from farming. Fifty-two percent of participants reported that farm income made up more than half of 2012 household income, and an additional 17 percent earned between 26 and 50 percent of their household income from farming.

Farm Poll participants have a diversity of farming systems. Forty-three percent of the farmers surveyed reported that they planted only corn and/or soybean in 2012. Thirty-two percent had mixed row crop and livestock operations. Eight percent reported that they only raised livestock, five percent had only Conservation Reserve Program land, and three percent had only hay or pasture. Seven percent reported both corn/soybean and hay/pasture, and small percentages (one percent or less each) reported combinations of corn/soybean and hay or grain and alternative crops such as small grains or vegetables.

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This year's Farm Poll focused on a range of issues that are important to Iowa's agricultural communities and to all Iowans. Topics included climate change and agriculture, herbicide-resistant weeds and Bt-resistant corn rootworm, and management of soil health, including soil compaction. The survey also posed a number of questions about rented land.

Copies of this report and previous Farm Poll reports are available from your local county Extension office, the Extension Distribution Center (www.extension.iastate.edu/store), Extension Sociology (www.soc.iastate.edu/extension/farmpoll), or from the authors.

Climate Change and Agriculture

Iowa has experienced numerous weather extremes over the last several years, with extreme rain events, floods, drought, and temperature volatility leading to significant impacts on agricultural productivity. Such extreme weather events are predicted to become more common in Iowa and across the Corn Belt in the future.¹ The potential long-term impacts of climate change on food production are of significant societal concern, and agricultural scientists and other stakeholders believe that the agricultural community must improve the resilience of agricultural systems to ensure long-term food

security.^{2,3} This year's Farm Poll posed a series of questions about climate change beliefs, concerns about weather-related threats to agriculture, and attitudes regarding different types of potential responses. Several of the questions were also included in the 2011 Farm Poll survey, allowing us to compare data from 2011 and 2013.

Beliefs about climate change

In 2011, the Farm Poll survey posed a question set with five categories that represent different beliefs about whether climate change is occurring, and if so, what are its causes (table 1). In 2013, the same question was asked to measure how farmer beliefs might have changed over time. This section presents results only for the 852 farmers who participated in both surveys.

Recognizing that we only have data from two years, some marked changes were evident. The proportion of farmers who believed that climate change is occurring and due primarily to human activities increased from 11 percent to 16 percent, while the percentage who indicated that there is not enough evidence to know with certainty that climate change is occurring dropped from 27 percent to 23 percent (table 1). The proportions in the other categories shifted only slightly between 2011 and 2013.

Table 1. Climate Change Beliefs, farmers who participated in both the 2011 and 2013 surveys

	2011	2013
	Percentage	
Climate change is occurring, and it is caused mostly by human activities	11	16
Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities.....	35	37
Climate change is occurring, and it is caused mostly by natural changes in the environment.....	23	22
There is not sufficient evidence to know with certainty whether climate change is occurring or not	27	23
Climate change is not occurring.....	5	3

What influences farmers' beliefs about climate change?

Farmers were asked to consider how their perspectives on climate change may have been influenced by extreme weather and/or agencies and organizations. The introductory text, “thinking back over the last five years, how much influence have the following had on your beliefs about climate change?,” was provided and farmers were asked to rate six items on a scale from 1 (no influence) to 4 (strong influence) (table 2).

Of the six categories, the two weather-related options were rated as having the greatest influence on climate change beliefs. Forty-nine percent of farmers indicated that drought had been a moderate or strong influence on their beliefs about climate change, and 41 percent expressed the same about extreme rains and flooding (table 2). Among the four types of organizations listed, ISU Extension and Outreach was most influential, with 28 percent of farmers indicating a moderate or strong influence. Environmental groups and government agencies followed at 21 and 20 percent, respectively, and farm groups were rated as the least influential of the six factors (14 percent moderate or strong influence).

Concerns about weather-related threats

Scientists have predicted that several weather and climate-related threats to agricultural productivity will become more prevalent in

the Midwest in the coming years.¹ The Farm Poll survey provided a list of some of those predicted changes and asked farmers to rate their level of concern about them becoming “potential problems for their farm operation in the future” on a four-point scale ranging from “not concerned” to “very concerned.”

Not surprisingly, given that all of Iowa was considered to be in moderate to extreme drought at the time of the survey, farmers rated “longer dry periods and drought” as their highest concern, with 67 percent of farmers selecting concerned or very concerned (table 3). Following in importance were increased insect pressure and increased soil erosion, with sixty percent of farmers selecting either concerned or very concerned for those items. Similar percentages were concerned or very concerned about increases in heat stress on crops (59 percent), weed pressure (58 percent), and crop diseases (56 percent). Farmers expressed less concern about some water-related threats. Smaller percentages were concerned or very concerned about increases in loss of nutrients into waterways (49 percent), more frequent extreme rains (44 percent), saturated soils (33 percent), and flooding (25 percent).

Three statements regarding general concerns about weather variability that were posed in 2011 were repeated in 2013. Farmers were asked to rate their level of agreement with each statement on a scale from 1 (strongly disagree) to 5 (strongly agree). Nearly half of farmers in

Table 2. Influences on farmer beliefs about climate change

	No influence	Slight influence	Moderate influence	Strong influence
	— Percentage —			
Drought.....	23	28	31	18
Extreme rains and flooding	25	34	28	13
Iowa State University Extension	34	38	24	4
Environmental groups.....	48	31	15	6
Government agencies	44	36	17	3
Farm groups.....	48	39	12	2

Table 3. Concerns about predicted impacts of climate change

	Not concerned	Slightly concerned	Concerned	Very concerned
	— Percentage —			
Longer dry periods and drought	8	25	45	22
Increased insect pressure	8	31	48	12
Increased soil erosion	12	28	40	20
Increased heat stress on crops.....	10	31	44	15
Increased weed pressure	12	31	46	12
Higher incidence of crop disease	9	34	45	11
Increased loss of nutrients into waterways.....	16	35	38	11
More frequent extreme rains.....	17	39	35	9
Increases in saturated soils and ponded water.....	24	43	28	5
Increased flooding.....	41	34	20	5

both surveys agreed or strongly agreed with the statement, “I believe that extreme weather events will happen more frequently in the future” (table 4). Forty-four percent of the respondents in both surveys agreed that they were concerned about the potential impacts of climate change on their farm operations. While levels of levels of agreement were stable, disagreement declined and uncertainty increased for both statements. For the third statement, “climate change is not a big issue because human ingenuity will enable us to adapt to changes,” the proportion of farmers who agreed dropped from 34 percent in 2011 to 29 percent in 2013, and disagreement rose from 30 to 35 percent. Statistical comparisons (paired samples t-tests) of responses from the

852 farmers who participated in both years found statistically significant⁴ differences for all three of the items.

Attitudes toward potential actions

A number of items that assessed farmers’ level of support for a variety of individual and collective actions in response to increasing weather variability and climate change in 2011 were also repeated in 2013. There were several noteworthy shifts over the two-year period. The 2011 questions were developed following several unusually wet years with extreme rain events, while 2012 was an exceptionally dry year in Iowa. As might be expected given the 2012 drought, levels of agreement on two water-related items declined. Agreement with the

Table 4. Concerns about climate change, farmers who participated in both the 2011 and 2013 surveys

		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
		— Percentage —				
I believe that extreme weather events will happen more frequently in the future.....	2011	6	16	33	37	9
	2013	3	12	40	34	12
I am concerned about the potential impacts of climate change on my farm operation	2011	10	17	29	35	9
	2013	4	18	34	36	8
Climate change is not a big issue because human ingenuity will enable us to adapt to changes.....	2011	9	21	37	29	5
	2013	9	26	37	24	5

statement, “Iowa farmers should take additional steps to protect their land from increased precipitation,” declined from 62 to 53 percent, and support for the statement, “Iowa farmers should increase investment in agricultural drainage systems (tile, ditches) to prepare for increased precipitation” dropped from 45 percent agreement to 37 percent (table 5).

The proportion of farmers who agreed that seed companies should develop crop varieties adapted to changes in weather patterns rose from 62 percent in 2011 to 69 percent in 2013 (table 5). The percentage of respondents who agreed that ISU Extension and Outreach should do more to help farmers and landowners to prepare for increased weather variability rose from 33 to 35 percent. Levels of uncertainty on that item also rose substantially, from 42 to 47 percent, while disagreement declined from 25 to 18 percent.

Two items focused on reduction of greenhouse gas (GHG) emissions.⁵ Nationwide, agriculture

produces approximately seven percent of all GHGs. Iowa’s share of GHGs from agriculture, at 26 percent, is relatively high compared to other states.⁶ Farmers were asked to rate their agreement with the statement, “Government should do more to reduce the nation’s greenhouse gas emissions and other potential causes of climate change.” The distribution of responses on this item shifted between 2011 and 2013: disagreement declined from 39 percent to 33 percent and agreement rose to 34 percent from 31 percent (table 5). The last item—posed only in 2013—asked respondents whether or not they as individual farmers should reduce GHG emissions from their own operations: 33 percent disagreed and 26 percent agreed, with 42 percent uncertain. Statistical comparisons (paired samples t-tests) of the 2011 and 2013 responses from the 852 farmers who participated in both years found statistically significant differences for all items except for “Iowa farmers should take additional steps to protect their land from increased precipitation.”

Table 5. Attitudes towards potential responses to climate change, farmers who participated in both the 2011 and 2013 surveys

		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
— Percentage —						
Seed companies should be developing crop varieties adapted to coming changes in weather patterns.....	2011	4	7	28	56	6
	2013	1	5	25	60	9
Iowa farmers should take additional steps to protect their land from increased precipitation	2011	4	12	22	53	9
	2013	2	11	36	46	7
Iowa farmers should increase investment in agricultural drainage systems (tile, ditches) to prepare for increased precipitation.....	2011	5	15	36	39	6
	2013	2	16	44	34	3
Iowa State University Extension should do more to help farmers and landlords to prepare for increased weather variability (2013)/climate change (2011).....	2011	6	19	42	29	4
	2013	3	15	47	32	3
Government should do more to reduce the nation’s greenhouse gas emissions and other potential causes of climate change	2011	16	23	30	23	8
	2013	13	20	34	24	10
I should reduce greenhouse gas emissions from my farm operation.....	2011	-	-	-	-	-
	2013	10	23	42	22	4

Rented Land

More than half of Iowa’s farmland is rented, yet with few exceptions⁷ relatively little research has focused on issues related to rented land. Periodically, the Farm Poll includes questions about rented farmland to learn more about who owns it and how it is managed. This year’s questions focused on several dimensions of landlord-tenant relationships. Forty-five percent of Farm Poll respondents reported that they rent farmland. This section reports data only for those farmers who reported that they rent land.

On average, respondents rented 392 acres in 2012. Most farmers who rent land reported multiple landlords, and the average number of landlords was 2.8. Thirty-six percent of farmers had a single landlord, 23 percent two, 16 percent three, 10 percent had four, and six percent reported that they rent from five landlords. The remaining nine percent of farmers reported between six and 24 landlords (table 6).

Table 6. Number of landlords

	Percent
One.....	36
Two	23
Three.....	16
Four	10
Five	6
Six or more.....	9

The fact that most farmers who rent land have multiple landlords provides a challenge to survey research on landlord characteristics. To avoid making the survey questionnaire overly complex by asking about multiple landlords, farmers were asked to report on the landlord from whom they had rented the most land in 2012.

Several questions focused on landlord characteristics and ties to the land. Farmers were provided several categorical questions and asked to select the options “that best describe” their landlord. The gender distribution of

primary landlords was 62 percent male and 38 percent female. Just over half of farmers characterized their landlord as either a former farmer (34 percent) or the spouse of a former farmer (17 percent) (table 7). Twenty-nine percent selected “inheritor of farmland.” Eight percent were investors with some family ties to the land, and six percent were investors with no family ties. Three percent selected the category “farmland management firm” and three percent reported that the largest parcel was rented from the government.

Table 7. Landlord type, largest parcel rented

	Percent
A former farmer who used to farm the land.....	34
The spouse of a former farmer who used to farm the land.....	17
An inheritor of farmland	29
An individual investor with family ties to the land.....	8
An individual investor with no direct family ties to the land	6
A farmland management firm	3
City/County/State	3

Farmers were also asked where their landlord lived in relation to the rented land. Twenty-two percent reported that they lived on the land (table 8). Nearly half (47 percent) indicated that the landlord lived within 25 miles of the land. Six percent reported that the landlord lived between 25 and 49 miles from the land, and 8 percent reported that they lived 50 to 149 miles away. Seventeen percent reported that their primary landlord lived more than 150 miles from the land. Nineteen percent of farmers reported that their primary landlord lived outside of Iowa. Thus, over two-thirds of primary landlords lived relatively close to their land, and more than 80 percent within a few hours’ drive.

The next question examined familial or social ties to the primary landlord. Forty-four percent of tenants reported that the landlord from

Table 8. Distance from land to landlord residence, largest parcel rented

	Percent
On the land.....	22
Within 25 miles of the land.....	47
25 to 49 miles from the land.....	6
50 to 149 miles from the land.....	8
150 miles or more from the land.....	17

whom they rented the largest parcel of land was a relative (table 9). Twenty-one percent characterized their landlord as a friend of the family. Twenty-nine percent were neither a relative nor a friend of the family. Small percentages rented from a company or financial institution (4 percent) or from another type of entity (2 percent).

Table 9. Farmer relationship with landlord, largest parcel rented

	Percent
A relative	44
A friend of the family.....	21
A person who is neither a relative nor a friend of the family	29
A company or financial institution	4
Other	2

Respondents who rented land were also asked to estimate how many years they had rented land from their primary landlord. Responses ranged from less than one year to 70 years. The average length of time that they had rented land from their primary landlord was 18.7 years.

Several questions focused on farmer-landlord communication. Farmers reported that they had communicated with their landlords about farming practices an average of 14 times over the previous year. Communication about soil and water conservation was less frequent, at seven times over the past year. Farmers were also asked to estimate how many times their primary landlord had visited the land they rent over the past year. Excluding the landlords who lived on the land, farmers estimated that landlords

had visited an average of 23 times. Sixteen percent reported zero visits, 28 percent between one and two visits, 20 percent three to five visits, and 16 percent between 6 and 10 visits. The remaining 21 percent reported that their landlords visited the land more than 10 times.

A small percentage of farmers reported that their landlords communicated or visited on a daily basis, or 365 times per year. Because a small number of relatively high observations can inflate averages, the median was also calculated for each of the three communication-related variables. As can be seen from table 10, the median numbers for communication and visitation were substantially lower than the averages.

Table 10. Communication with landlord, largest parcel rented

	Average	Median
Over the past year, about how many times did you communicate with your landlord about farming practices?.....	14	4
Over the past year, about how many times did you communicate with your landlord about soil and water conservation needs?.....	7	2
Over the past year, about how many times did your landlord visit the land you rent?.....	23	3

Farmers were also asked to categorize their lease agreement for the largest parcel that they rented in 2012. Eighty-two percent reported a cash rent agreement, with 45 percent indicating that the agreement was written, and 37 percent verbal (table 11). Nineteen percent reported a crop share arrangement, with 12 percent indicating that their crop share lease agreements were verbal, compared to 7 percent written.

A final question asked farmers to indicate how the responsibility for addressing soil and water conservation needs on the land they rent was distributed. Thirty-eight percent reported that

they were solely responsible for conservation decisions, and 34 percent indicated that they were primarily responsible, with landlord input (table 12). Nineteen percent reported that responsibility was shared equally. Seven percent indicated that their landlord was primarily responsible, with some input from them. Two percent reported that their landlord was solely responsible for addressing soil and water conservation needs.

Table 11. Type of lease agreement, largest parcel rented

	Percent
Written cash rent agreement	45
Verbal cash rent agreement.....	37
Verbal crop share agreement	12
Written crop share agreement.....	7

Table 12. Responsibility for addressing soil and water conservation needs, largest parcel rented

	Percent
Me alone.....	38
Primarily me, with landlord input	34
Equally me and my landlord.....	19
Primarily my landlord, with my input ..	7
My landlord alone.....	2

Table 13. Experience with herbicide-resistant weeds

	Yes	No	Don't know
	— Percentage —		
In 2012, did you have weeds that were resistant to glyphosate (Roundup) herbicides in any of the fields that you farm?	32	56	12
In 2012, did you have weeds that were resistant to ALS inhibitor herbicides (e.g., Classic, Harmony, Firstrate) in any of the fields that you farm?	14	65	21
In 2012, did you have weeds that were resistant to triazine herbicides in any of the fields that you farm?.....	5	67	28
In 2012, did you have weeds that were resistant to HPPD inhibitor herbicides (e.g., Callisto, Impact) in any of the fields that you farm?	4	65	31
In 2012, did you have weeds that were resistant to PPO inhibitor herbicides (e.g., Flexstar, Authority, Kixor) in any of the fields that you farm?...	3	63	34

Herbicide-Resistant Weeds

Weeds that have evolved resistance to herbicides are of increasing concern in Iowa and the Midwest. The 2013 Farm Poll included several question sets to better understand how Iowa farmers manage weeds and their experience with herbicide-resistant weeds. The questions were developed in partnership with the ISU Department of Agronomy.⁸ These questions were posed only to farmers who planted corn, soybeans, or other row crops in 2012.

Farmers were asked about their 2012 experience with herbicide-resistant weeds. Overall, 35 percent of farmers reported that they had weeds that they believed to be resistant to at least one herbicide group. Glyphosate resistance was most commonly cited, with 32 percent of farmers reporting glyphosate-resistant weeds (table 13). Weeds believed to be resistant to ALS inhibitor herbicides were reported by 14 percent of farmers. Lesser percentages reported weeds that were believed to be resistant to triazine herbicides (5 percent), HPPD inhibitor herbicides (4 percent), or PPO inhibitor herbicides (3 percent).

The next set of questions examined some general dimensions of weed management. Fifty-two percent of respondents indicated

Table 14. Management of herbicide-resistant weeds (part 1)

	Yes	No	Don't know
	— Percentage —		
Over the last five years, have you changed your weed management program due to herbicide-resistant weeds?	52	46	2
In the last five years, have you made more than one herbicide application to a single crop in a single season?.....	81	17	2
Do you develop your own herbicide programs?	45	54	2
Do you hire a custom applicator to spray herbicides?.....	65	35	0

that they had changed their weed management program in the past five years due to herbicide-resistant weeds (table 14). Among farmers who reported having identified resistant weeds in their fields, 85 percent had changed their weed management program. Among those who had not found resistant weeds in their fields, 34 percent had made a change. Less than half of farmers (45 percent) reported that they develop their own herbicide programs, and 65 percent indicated that they hire custom applicators to do at least some of their spraying.

The next set of questions focused on herbicide use, and asked farmers to estimate the proportion of their cropland on which three practices were used in 2012. Ninety percent of respondents reported that they employed postemergence herbicides, and 64 percent applied them to over 75 percent of their land (table 15). Eighty-five percent reported use of soil-applied herbicides, with half of farmers applying them to greater than 75 percent of their cropland. Eighty-one percent indicated that they employed formal scouting methods to determine the need for postemergence spraying on at least some of their land.

A final question set provided a list of strategies that can be used to manage herbicide-resistant weeds. The two-stage questions asked farmers to (1) indicate whether or not they had ever used the practice and (2) rate their perception of each practice's effectiveness for managing herbicide-resistant weeds.

Crop rotation (93 percent) and multiple herbicide application timings (80 percent) were the most commonly used practices (table 16). Majorities of farmers had also managed weeds using tillage (74 percent), multiple modes of herbicide action used in a season (71 percent) and, multiple modes of herbicide action in each application (60 percent). Smaller percentages had employed higher planting rates (49 percent), hand weeding (29 percent), use of crop cultivars that are resistant to herbicides other than glyphosate (27 percent), mechanical weed control (25 percent), inclusion of a forage in rotations (23 percent), or cover crops (16 percent) to control weeds.

The most commonly used strategies for managing herbicide-resistant weeds were also rated as the most effective. Eighty-three percent of farmers rated multiple

Table 15. Percent of cropland on which selected weed management practices were used in 2012

	None	1-50%	51-75%	76-100%
	— Percentage —			
Postemergence herbicides?	9	12	14	64
Soil applied herbicides?	15	17	18	50
Formal scouting to determine need for postemergence herbicide applications?	19	15	15	51

herbicide application timings as effective or very effective (table 16). Crop rotation (82 percent), multiple modes of herbicide action used in a season (78 percent), tillage (72 percent), and multiple modes of herbicide action in each application (70 percent) were also rated as effective or very effective management strategies by most farmers. Several practices were rated as effective or very effective by slight majorities: inclusion of a forage in the crop rotation (57 percent); hand-weeding (56 percent); and, mechanical weed control (i.e., cultivation) (55 percent). Forty-six percent of farmers rated use of cultivars resistant to herbicides other than glyphosate as effective or very effective. About 40 percent rated use of higher planting rates or cover crops as effective or very effective strategies for managing herbicide resistance.

Bt-Resistant Corn Rootworm

Planting of corn that is genetically modified to express genes from *Bacillus thuringiensis* (Bt) is a primary means of preventing injury by larvae of the western corn rootworm (*Diabrotica virgifera*) in the Midwest. Populations of western corn rootworm that have developed resistance to these transgenic technologies have been found in Iowa and other Corn Belt states.¹⁰ The 2013 Farm Poll included two sets of questions to better understand farmers' perspectives on the threat of Bt-resistant rootworms and potential management practices. The questions were developed in partnership with the ISU Department of Entomology. The question sets were asked only of farmers who planted corn, soybeans, or other row crops in 2012.

Table 16. Management of herbicide-resistant weeds (part 2)

	Have you used the practice?		How effective do you think the practice is?				
	Yes	No	Not effective at all	Somewhat effective	Effective	Very effective	Don't know
	— Percentage —		— Percentage —				
Rotation of crops	93	7	2	15	41	41	2
Multiple herbicide application timings.....	80	20	1	9	45	38	7
Tillage	74	26	3	21	40	32	4
Multiple modes of herbicide action used each season	71	29	1	9	39	39	13
Multiple modes of herbicide action used in each herbicide application.....	60	40	1	11	38	32	18
Higher planting rates.....	49	51	11	34	29	11	15
Hand-weeding.....	29	71	9	21	31	25	14
Use of crop cultivars that are resistant to herbicides other than glyphosate.....	27	73	5	15	30	16	35
Mechanical weed control (i.e. cultivation)	25	76	6	26	39	16	13
Inclusion of a forage in the crop rotation	23	77	3	18	32	25	23
Use of a cover crop.....	16	84	6	23	29	11	32

The first two questions focused on awareness of and concern about corn rootworm. Sixty-nine percent of farmers indicated that they were aware that populations of Bt-resistant corn rootworm have been found in Iowa (table 17). Nineteen percent reported that they were not aware, and 13 percent replied that they did not know. Fifty-three percent reported concern that Bt-resistant corn rootworm will become major problem in Iowa, 28 percent were not concerned, and 20 percent selected “don’t know.”

Three questions centered on current management practices. When asked whether they had changed their approach to rootworm management over the past five years, 38 percent of farmers responded affirmatively (table 17). Seventy-seven percent of those who planned to plant corn in 2013 reported that they would use a rootworm-resistant variety.

The establishment of “refuge” areas of corn plants that do not express Bt genes is an important mechanism for maintaining rootworm susceptibility to Bt toxins. If farmers do not follow the refuge recommendations, this can lead to a rapid buildup of rootworm resistance to the Bt toxin. Respondents were asked whether or not farmers in their area generally comply with refuge requirements. Sixty-three percent reported that farmers in their area comply, seven percent indicated that they do not, and 31 percent selected “don’t know” (table 17).

Another question set provided a list of practices that can be employed to reduce the risk of corn rootworm larvae damage to corn plants. The two-stage question set asked farmers to (1) indicate whether or not they had ever used the practice and (2) rate their perception of each practice’s effectiveness for managing rootworm risk. The question set was prefaced by the introductory text, “The following is a list of methods for reducing the risk of corn rootworm injury. Please indicate whether you have used each method and provide your opinion about each method’s effectiveness for managing rootworm risk. Please provide your opinion about effectiveness whether you have used it or not.”

Rotation of corn and soybean (93 percent), planting of rootworm-resistant corn (86 percent), and following the “refuge” requirement (86 percent) were the most commonly reported practices (table 18). Majorities of farmers reported that they had employed seed treatments (76 percent), planted corn varieties with multiple traits (73 percent), or rotation of Bt traits (51 percent). Smaller percentages indicated that they had scouted for adult rootworms in July or August (45 percent), used soil insecticides (42 percent), rated root injury (29 percent), extended their rotations to include a third crop (15 percent), or applied foliar spray to control adult corn rootworm (13 percent).

Table 17. Corn rootworm management (part 1)

	Yes	No	Don’t know
	— Percentage —		
Are you aware that populations of western corn rootworms that can survive on Bt corn have been found in Iowa?	69	19	13
Do you worry that Bt-resistant corn rootworm will become a major problem in Iowa?	53	28	20
Over the last 5 years, have you changed your approach to rootworm management?	38	58	5
If you plant corn in 2013, will you use a rootworm-resistant variety?	77	15	7
Do farmers in your area generally comply with “refuge” requirements?	63	7	31

Table 18. Corn rootworm management (part 2)

	Have you used the practice?		How effective do you think the practice is?				
	Yes	No	Not effective at all	Some-what effective	Effective	Very effective	Don't know
	— Percentage —		— Percentage —				
Rotating corn and soybean.....	93	7	0	8	41	48	4
Planting rootworm resistant corn	86	14	0	11	48	34	7
Following the “refuge” requirement...	86	14	2	18	38	26	16
Seed treatment	76	24	2	24	44	18	11
Using a corn variety/hybrid with different traits.....	73	27	1	17	48	21	13
Rotating Bt traits.....	51	49	1	17	41	16	24
Scouting adult rootworms in July/August	45	55	2	23	36	14	25
Soil insecticide.....	42	58	1	12	43	29	17
Rating root injury.....	29	72	3	22	29	9	36
Extended rotation of a third crop in addition to corn and soybean.....	15	85	3	14	27	23	33
Foliar spray for adult corn rootworm..	13	87	2	21	28	10	38

The two most commonly used strategies for preventing injury to corn by rootworm larvae were also rated as the most effective. Rotation of corn and soybean was rated as effective or very effective by 89 percent of farmers, followed by planting of rootworm-resistant corn (82 percent effective/very effective) (table 18). Use of a soil insecticide was rated as effective or very effective by 72 percent of respondents, followed by corn varieties with different traits (69 percent), the refuge requirement (64 percent), seed treatments (62 percent), rotating Bt traits (57 percent), including a third crop in the rotation (50 percent), and scouting for adult rootworms (50 percent). Practices that were rated as effective or very effective by smaller proportions of farmers were foliar spray for adult rootworms (38 percent) and rating root injury (38 percent).

Soil Health

It is increasingly understood that soil is a living system, and that maintaining or improving soil health is imperative for the long-term sustainability of agriculture.¹⁰ The 2013 survey included several sets of questions on soil health. Two of the question sets had been asked in the 1993 Farm Poll survey, which allows for comparisons across the two decades.

The first set of questions examined farmers’ beliefs about the trajectory of soil health at the global, national, and local levels. The questions were preceded by the text, “soil health refers to soil quality and the soil’s ability to be productive and support life. How is soil quality changing? In general, would you say that soil quality is declining, staying the same, or improving?” Except for at the global level, most Iowa farmers believed that soil health is either remaining the same or improving. The percentage of respondents who felt that soil health was stable or improving ranged from

47 percent for “worldwide,” to 91 percent for “on your farm” in 2013 (table 19).

Comparison of 1993 and 2013 responses show similar ratings, but with slightly more optimism about larger geographic scales and slightly less optimism about more local levels (table 19). For example, the percentage of farmers who believed that soil health is remaining the same or improving worldwide increased from 43 percent in 1993 to 47 percent in 2013. On the other hand, the proportion of farmers who believed that soil health in their county is stable or improving declined from 83 percent in 1993 to 78 percent in 2013.

A second set of questions focused on indicators that are used to judge the health of soils. Farmers were provided with a list of 14 different characteristics that can be used to assess soil health and asked to rate the importance that they place on each when they evaluate the health of soils. Nine of these items were also provided in 1993. It is important to note that (1) the 1993 question set used the phrase “quality of the soil” rather than “soil health” and (2) the response categories in 2013 contained a “don’t know” option that was not included in 1993, so comparisons between the

two surveys must be made with some caution. Results for 2013 are presented first, then comparisons with 1993 are discussed.

The most highly rated characteristic in 2013 was moisture holding capacity, with 79 percent of farmers rating this characteristic as a very important indicator of soil health (table 20). Amount of organic matter was a close second in importance, with 76 percent of farmers rating it as very important. Four other characteristics were rated as very important by more than 70 percent of farmers in 2013: [degree of] compaction (74 percent), results of soil tests (73 percent), amount of fertilizer needed to attain yield goals (72 percent), and water infiltration rate (71 percent). Sixty-six percent of farmers indicated that soil texture is a very important characteristic when judging soil health. Presence of earthworms was selected as very important by 63 percent, while crop residue decomposition rate was seen as very important by 56 percent.

A number of other characteristics received lower ratings. Bulk density and the presence of macropores were rated as very important indicators of soil health by just 38 percent of farmers (table 20). Following in perceived importance were the color of the soil

Table 19. Perceived trajectory of soil health, global to local

		Is Declining	Remaining Same	Is Improving
		— Percentage —		
Worldwide	1993	58	34	9
	2013	53	37	10
In the U.S.	1993	31	41	28
	2013	30	46	24
In Iowa	1993	21	35	44
	2013	24	38	38
In your county	1993	18	35	48
	2013	21	38	40
On your farm	1993	9	35	57
	2013	9	36	55

Table 20. When you judge soil health, how important are the following characteristics?

		Not at all important	Not very important	Moderately important	Very important	Don't know
		— Percentage —				
Moisture holding capacity	1993	0	2	31	67	-
	2013	1	1	14	79	5
Amount of organic matter ("Visible organic matter")	1993	1	5	48	47	-
	2013	1	1	17	76	6
Compaction	1993	1	4	36	59	-
	2013	1	2	18	74	6
Results of soil test	1993	0	4	37	59	-
	2013	1	2	17	73	7
Amount of fertilizer required to produce targeted yields	1993	— Not asked in 1993 —				
	2013	2	2	19	72	6
Water infiltration rate	1993	— Not asked in 1993 —				
	2013	1	1	20	71	8
Texture of the soil	1993	1	2	44	53	-
	2013	1	2	26	66	5
Presence of earthworms	2013	1	2	29	63	6
	1993	1	6	44	50	-
Crop residue decomposition rate	1993	— Not asked in 1993 —				
	2013	1	2	33	56	8
Bulk density	1993	— Not asked in 1993 —				
	2013	1	3	36	38	21
Presence of macropores	1993	— Not asked in 1993 —				
	2013	1	3	29	38	28
Color of the soil	1993	4	21	51	25	-
	2013	2	12	45	36	6
Plant vitality/tissue tests	1993	— Not asked in 1993 —				
	2013	2	8	38	35	17
Smell of the soil	1993	6	30	44	20	-
	2013	3	15	37	34	10

(36 percent very important), plant vitality/tissue tests (35 percent very important), and the smell of the soil (34 percent very important). It is notable that substantial proportions of farmers indicated that they could not rate how important the presence of macropores (28 percent "don't know") or bulk density (21 percent "don't know") are to assessing of soil health, suggesting that some farmers are unfamiliar with the terms.

While the levels of importance placed on the various characteristics tended to be lower in 1993 than in 2013 (perhaps due to the differences in phrasing of the introductory statement), the importance that farmers placed on some characteristics relative to others was practically identical. Among the nine indicators that were included in both years, the order of importance was the same for eight of them (table 20). The only item that was

Table 21. Assessment of soil health indicators, in general, for all land farmed

	Not familiar with term	Familiar with term, but don't know	Poor	Fair	Good	Very good	Excellent
— Percentage —							
Overall health of the soil	1	5	1	15	47	27	5
Percent organic matter	3	8	2	17	41	26	5
Soil PH	2	8	2	16	41	26	5
Soil test phosphorus	2	10	3	15	40	25	5
Potassium	3	9	3	15	41	25	5
Available water capacity	5	10	5	16	39	21	5
Presence of earthworms and other beneficial soil organisms	2	11	7	22	34	19	6
Water infiltration rate	7	10	3	16	40	20	4
Soil nitrate	3	11	3	17	47	17	3
Bulk density	17	13	2	17	34	14	3
Aggregate stability	24	14	1	12	35	13	2
Presence of macropores	27	19	3	13	25	11	3

rated differently was organic matter, and this difference was likely due to shifts in wording from “visible organic matter” in 1993 to “amount of organic matter” in 2013.

A third question set asked farmers to rate the current condition of the soils they farm on a series of soil health and fertility indicators that were selected in consultation with soil health experts from the USDA Natural Resources Conservation Service. Farmers were provided with the introductory text, “The following are different measures of soil health. Considering all of the land you farm, on average what is the current condition of the soil for each measure?” and asked to rate the land that they farm on each indicator on a five-point scale from poor to excellent. Farmers were also provided with “not familiar with term” and “familiar with term but don’t know” options.

“Good” was the most common response for nearly all of the items (table 21). Percent organic matter was the highest-rated item, with 79 percent of farmers rating their current condition on this variable as good or better. Several other items received similar scores:

current levels of soil PH, soil test phosphorus, potassium, available water capacity, and water infiltration rate were all rated as good, very good or excellent by at least 60 percent of farmers. Presence of earthworms and other beneficial soil organisms, bulk density, and aggregate stability were rated as good or better by between 50 and 59 percent of farmers. Presence of macropores received the lowest rating, at 39 percent good or better. Results for an item rating the overall health of the soil showed that 79 percent of Farm Poll respondents believe that the soils they farm are in good, very good, or excellent health.

Lower-rated items had higher percentages of farmers who indicated that they were either unfamiliar with the terms or familiar with the terms but did not know the current status of their soils (table 21). Items for which substantial numbers of farmers indicated unfamiliarity or lack of knowledge of current status included bulk density (30 percent), aggregate stability (38 percent) and presence of macropores (46 percent).

Soil Compaction

As farm equipment including tractors, combines, and grain carts has become larger and heavier, concern about soil compaction and its impacts on crop yields has increased.¹¹ A series of questions examined farmers' experience with soil compaction, their level of concern about the issue, and their perspectives on common compaction management techniques. The questions were developed in partnership with the ISU Department of Agricultural and Biosystems Engineering. These questions were asked only of farmers who had planted corn, soybeans, or other row crops in 2012.

Size of equipment

Combine and grain cart axle loads are some of the heaviest on row crop land. Axle loads for larger grain carts, for example, can exceed 75,000 lbs. The size of combine headers, the capacity of combine grain tanks, and the capacity of grain carts are indicative of overall equipment weight, so several questions focused on the size of harvest equipment as indicators of potential to cause soil compaction.

Farmers were first asked to report the header size of the largest combine used to harvest corn in 2012 or the last time they harvested corn. Sixty-one percent of farmers indicated that the largest corn header used was fewer than eight rows (table 22). Twenty-seven percent indicated that an 8-row header was used. Ten percent reported that the corn header employed was 12 rows or larger. Two percent reported that they did not know.

Farmers were also asked to estimate the grain tank size of the largest combine used. Sixteen percent estimated that it had a capacity of less than 150 bushels (table 23). Forty-one percent reported capacity between 151 and 250 bushels. Twenty-five percent estimated between 251 and 300 bushels, and 14 percent 301 bushels or more. Five percent did not know.

Table 22. Combine size, as indicated by number of corn header rows

	Percent
Fewer than 8 rows	61
8 rows	27
12 rows	9
16 rows or more.....	1
Don't know	2

Table 23. Combine size, as indicated by grain tank capacity

	Percent
Less than 150 bushels	16
151 to 250 bushels	41
251 to 300 bushels	25
301 bushels or more	14
Don't know	5

Capacity of the largest wagons or carts used to haul grain was also measured. Twenty-eight percent of farmers used carts that hold less than 400 bushels, 33 percent reported cart capacity between 401 and 600, and 19 percent reported between 601 and 800 bushel capacity (table 24). Ten percent reported using grain hauling equipment with between 801 and 1000 bushel capacity, four percent used carts that can haul between 1001 and 1200 bushels, and one percent reported capacity of greater than 1201. Six percent did not know. Thirty-eight percent used semi-trailers to haul grain from their fields.

Table 24. Capacity of largest grain wagons or carts used to haul grain from fields

	Percent
Less than 400 bushels	28
401 to 600 bushels	33
601 to 800 bushels	19
801 to 1000 bushels	10
1001 to 1200 bushels	4
1201 or more bushels	1
Don't know	6

Table 25. Estimated average annual impact of soil compaction on corn yield

	Percent
I do not have soil compaction	16
I have soil compaction but there is little or no effect on yield	33
Yield loss of less than 2 bu/ac	25
Yield loss of between 2 and 5 bu/ac.....	20
Yield loss of between 5 and 10 bu/ac.....	6
Yield loss of greater than 10 bu/ac	2

Impact of soil compaction

Respondents were asked to consider all of the land that they farm and “estimate the average annual impact of soil compaction on corn yield over the past five years.” Sixteen percent reported that they do not have soil compaction, and an additional 33 percent indicated that they have soil compaction issues but that there is negligible effect on yields (table 25). Twenty-five percent estimated yield loss of less than two bushels per acre. Twenty percent estimated

losses of between two and five bushels per acre. Six percent estimated yield loss of between 5 and 10 bushels, and two percent reported annual losses greater than 10 bushels an acre.

Perspectives on management of soil compaction

Most farmers (75 percent) agreed or strongly agreed that they are concerned about the impact of heavy machinery on soil health. A similar proportion (71 percent) agreed that they are

Table 26. Farmer perspectives on soil compaction

	Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
	— Percentage —				
I consider the soil moisture content in fields as I plan fieldwork in order to avoid soil compaction	0	2	7	59	32
I am concerned about the impact of heavy agricultural machinery on soil health	1	8	17	59	16
I am concerned about the impact of soil compaction on the land I farm	2	14	14	55	16
Wheel traffic pattern control is an effective way to reduce soil compaction	1	5	30	58	7
Removal of crop residue increases soil compaction	1	10	29	49	11
No-till is an effective means of reducing soil compaction.....	3	11	30	44	13
Fall tillage is an important soil compaction management strategy for my operation.....	13	18	14	45	10
I consider the weight of agricultural machinery as I make decisions on new equipment purchases	3	17	30	42	9
I believe that winter freeze and thaw and summer shrink and swell are sufficient to address soil compaction on the land I farm	3	21	29	41	6

concerned about soil compaction on the land that they farm. Half of respondents agreed or strongly agreed that they consider the weight of equipment when making purchasing decisions.

Several questions focused on potential compaction management strategies. The amount of moisture in the soil is a major soil compaction mediating factor, and 91 percent of farmers indicated that they attempt to avoid compaction by taking soil moisture content into account as they plan fieldwork (table 26). Sixty-five percent agreed that the best management practice “wheel traffic pattern

Table 27. Methods used to determine presence of soil compaction issues

	% ✓'ed
Simple observation	75
Evaluation of plant growth during the growing season	59
Dig the root system	24
Use a penetrometer or other metal rod to determine soil resistance.....	21

control” is an effective means of reducing soil compaction. Sixty percent of respondents agreed that removal of crop residue can lead to increased soil compaction. Fifty-seven percent agreed that no-till is an effective way to reduce compaction. On the other hand, 55 percent of farmers indicated that fall tillage is an important compaction management strategy for their operation. Forty-seven percent indicated that winter freeze and thaw and summer shrink and swell are sufficient to address soil compaction on the land they farm.

Finally, farmers were asked to indicate if they use any or all of several methods that can be employed to determine whether soil compaction is an issue. Seventy-five percent report that they use “simple observation” (table 27). Fifty-nine percent use evaluation of plant growth as an indicator of soil compaction. Twenty-four percent reported that they dig the root system, and 21 percent use a penetrometer or other metal rod to measure soil resistance.

References

- ¹ Rogovska, N. and R.M. Cruse. 2011. "Climate Change Consequences for Agriculture in Iowa." in *Climate Change Impacts on Iowa 2010*. Des Moines, IA: Office of Energy Independence. Available at http://www.iowadnr.gov/portals/idnr/uploads/air/environment/climatechange/complete_report.pdf
- ² Hatfield, J. L., D. Ort, A. M. Thomson, D. Wolfe, R. C. Izaurralde, K. J. Boote, B. A. Kimball, and L. H. Ziska. 2011. "Climate Impacts on Agriculture: Implications for Crop Production." *Agronomy Journal* 103:351-370. Available at <https://www.agronomy.org/publications/aj/pdfs/103/2/351>
- ³ Walthal, C.L., J. Hatfield, P. Backlund, L. Lengnick, E. Marshall, M. Walsh, S. Adkins, M. Aillery, E.A. Ainsworth, C. Ammann, C.J. Anderson, I. Bartomeus, L.H. Baumgard, F. Booker, B. Bradley, D.M. Blumenthal, J. Bunce, K. Burkey, S.M. Dabney, J.A. Delgado, J. Dukes, A. Funk, K. Garrett, M. Glenn, D.A. Grantz, D. Goodrich, S. Hu, R.C. Izaurralde, R.A.C. Jones, S-H. Kim, A.D.B. Leaky, K. Lewers, T.L. Mader, A. McClung, J. Morgan, D.J. Muth, M. Nearing, D.M. Oosterhuis, D. Ort, C. Parmesan, W.T. Pettigrew, W. Polley, R. Rader, C. Rice, M. Rivington, E. Rosskopf, W.A. Salas, L.E. Sollenberger, R. Srygley, C. Stockle, E.S. Takle, D. Timlin, J.W. White, R. Winfree, L. Wright Morton, and L.H. Ziska. 2012. *Climate Change and Agriculture in the United States: Effects and Adaptation*. Washington, D.C.: USDA. Available at http://www.usda.gov/oce/climate_change
- ⁴ Statistical significance is the probability that differences between group averages are due to chance. Unless otherwise indicated, the threshold level of significance used in this report is .05, meaning that there is a five percent or less probability that differences are due to chance.
- ⁵ USEPA. (2013). *Inventory of U.S. greenhouse gas emissions and sinks: 1990-2011*. Washington, DC: US Environmental Protection Agency. Available at <http://www.epa.gov/climatechange/ghgemissions/>
- ⁶ Iowa Department of Natural Resources. 2012. *2011 Iowa statewide greenhouse gas emissions inventory report*. Des Moines: Iowa Department of Natural Resources. Available at http://www.iowadnr.gov/portals/idnr/uploads/air/insidednr/ghgemissions/2011_ghg_inv.pdf
- ⁷ The Farmland Ownership and Tenure in Iowa survey is one of the few research efforts that focuses on rented land. The 2007 report can be found at: <http://www.extension.iastate.edu/publications/pm1983.pdf>
- ⁸ For comprehensive resources on weed management, please visit <http://www.weeds.iastate.edu/>.
- ⁹ For more information on western corn rootworm, see <http://www.ent.iastate.edu/dept/faculty/hodgson/files/ul/CRW%20management%202012%20final.pdf>
- ¹⁰ For more information on soil health, see <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/>
- ¹¹ For more information on management of soil compaction, see <http://www.extension.iastate.edu/publications/pm1901b.pdf>

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