DEPARTMENT OF AGRICULTURE

Commercial Fertilizer Usage and Manure Management Practices Associated with Minnesota's 2018 Wheat and Hay Crops

Minnesota Department of Agriculture

6/30/2022

CLEAN WATER LAND & LEGACY AMENDMENT

Information regarding this report contact:
Denton Bruening
Minnesota Department of Agriculture
Pesticide and Fertilizer Management Division
651-201-6399

Table of Contents

Executive Summary

The Minnesota Department of Agriculture (MDA) is responsible for the development and promotion of nitrogen fertilizer Best Management Practices (BMPs). The purpose of the BMPs is to protect water quality while at the same time maintaining farm profitability. These BMPs refer to practices relating to the timing, rate, placement and source of fertilizer application and other practices that increase fertilizer use efficiency and decrease potential loss to the environment. The MDA is also responsible for monitoring the adoption and effectiveness of the BMPs.

Every year the MDA has partnered with NASS to produce a detailed report on fertilizer use and rates used on the state's major crops. The annual survey was designed and conducted in partnership with the United States Department of Agriculture's National Agricultural Statistics Service (NASS) to specifically assess the status of BMP awareness and adoption in relation to fertilizer and manure use on corn, soybeans, wheat, and hay acres.

This year the crops that were surveyed were wheat and hay. NASS developed the survey sample of 7,600 farms. This was done by selecting approximately 93 farms from each of 82 agricultural counties surveyed in this report. This number provided a large pool to reach the desired goal of obtaining approximately 23 farms per county with complete records. Counties not included in the survey are Cook, Lake, Lake of the Woods, Ramsey, and Watonwan Counties.

The general purpose of this survey was to ask farmers about commercial fertilizer and manure applications on wheat and hay. For commercial fertilizer, rates, applications, incorporation, types of fertilizer, and other management decisions were collected through the survey. Fertilizer data was gathered for the major nutrients of nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), and sulfur (SO_4-S).

For manured acres, manure application data was also collected including source of the manure, timing of the manure applications, amounts of manure applied, and nitrogen inputs from the manure applications. Additional nitrogen contributions from commercial fertilizer was also collected for manured acres.

The 2018 report is the first fertilizer and manure use report presenting data that has been weighted by NASS to represent all farmers who planted spring wheat and harvested hay in Minnesota. Statistical weighting of data better represents Minnesota farmers with wheat and hay acres.

The definition of "wheat" for purposes of this report includes spring wheat and excludes durum or winter wheat. In Minnesota, over 99% of the wheat planted was spring wheat in 2018. Hay included all types of hay, including grass, haylage, alfalfa, and grass/alfalfa mix. Hay can be harvested multiple times in a year. Due to these restraints, yields for hay were not collected.

Highlights of the 2018 fertilizer and manure use on wheat acres:

- Wheat yields averaged 55 bushels per acre on non-manured acres
- 95 percent of non-manured wheat fields were fertilized with commercial fertilizer
- An average of 105 pounds of nitrogen were applied to wheat fields treated with nitrogen
- An average of 42 pounds of phosphorus were applied to wheat fields treated with phosphorus
- An average of 40 pounds of potassium were applied to wheat fields treated with potassium
- An average of 9 pounds of sulfur were applied to wheat fields treated with sulfur
- 19 percent of wheat operations applied manure to at least one field
- The main source of manure was beef manure
- A manured wheat field received 104 pounds of nitrogen from both manure and commercial sources.

Highlights of the 2018 fertilizer and manure use on hay acres:

- 37 percent of non-manured hay fields were fertilized with commercial fertilizer only
- An average of 31 pounds of nitrogen were applied to hay fields treated with nitrogen
- An average of 18 pounds of phosphorus were applied to hay fields treated with phosphorus
- An average of 59 pounds of potassium were applied to hay fields treated with potassium
- An average of 8 pounds of sulfur were applied to hay fields treated with sulfur
- 25 percent of hay operations applied manure to at least one field
- The main source of manure was beef manure
- A manured hay field received 93 pounds of nitrogen from both manure and commercial sources.

Introduction

The Minnesota Department of Agriculture (MDA) is responsible for the development and promotion of nitrogen fertilizer Best Management Practices (BMPs). The purpose of the BMPs is to protect water quality while at the same time maintaining farm profitability. These BMPs refer to practices related to the timing, rate, placement, and source of fertilizer application and other practices that increase fertilizer use efficiency and decrease potential loss to the environment. The MDA is also responsible for monitoring the adoption and effectiveness of the BMPs. This survey was designed and conducted in partnership with the United States Department of Agriculture's National Agricultural Statistics Service (NASS) to specifically assess the status of BMP awareness and adoption in relation to the use of nitrogen on wheat and hay acres through the use of commercial nitrogen and manure.

In Minnesota, nitrate is detected frequently in groundwater and surface water resources. Nitrate may exceed the drinking water standards[1] in groundwater in some areas and sometimes exceeds the draft threshold in surface water[2]. The MDA has invested considerable staff time in water monitoring, BMP assessment, and development of BMP education programs including demonstration projects. Nitrogen is the primary focus of this survey and is present in commercial fertilizer and manure. This is the second survey that the MDA is collecting data on nitrogen, phosphorus, potash[3], and sulfur applied to the crops surveyed. In addition to collecting fertilizer information, farmers were asked about manure applications to wheat and hay crops. In past years, only nitrogen information was collected. The NASS developed the survey sample of 7,600 farms. This was done by selecting approximately 93 farms from each of 82 agricultural counties surveyed in this report. All farmers from each county who grew one or both of the target crops (hay and wheat) were eligible to be selected. This number provided a large pool to reach the desired goal of obtaining approximately 23 farms per county with complete records. Counties not included in the survey are Cook, Lake, Lake of the Woods, Ramsey, and Watonwan Counties.

NASS phone enumerators attempted to contact 7,600 producers in early 2019. From this pool, 1,903 farmers who planted wheat or grew hay during the 2018 growing season were interviewed.

The general purpose of this survey was to ask farmers about commercial fertilizer applications and applications of manure on wheat and hay. This included rates, applications, incorporation, types of fertilizer and other

[1] The drinking water standard of 10 mg/L for nitrate has been developed by the Environmental Protection Agency and can be found at: 2018 Edition of the Drinking Water Standards and Health Advisories Tables (EPA 822-F-18-100). In Minnesota, the Department of Health has adopted the federal standard as the value for the state Health Risk Limit of 10 mg/L for nitrate. A health risk limit (HRL) is the concentration of a groundwater contaminant, or a mixture of contaminants, that can be consumed with little or no risk to health.

[2] The Minnesota Pollution Control Agency has published draft nitrate-nitrogen water quality standards to address aquatic life toxicity.

- 3.1 mg/L nitrate-N for class 2A waters
- 4.9 mg/L nitrate-N for class 2B waters

The draft standards can be found at: Water quality standards | Minnesota Pollution Control Agency (state.mn.us) https://www.pca.state.mn.us/sites/default/files/wq-s6-13.pdf

[3] Potash and potassium are used interchangeably in this report.

management decisions based on fertilizer use on wheat and hay acres. Fertilizer inputs refer to soil enriching plant nutrients, primarily nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), and sulfur (SO_4-S). It also includes manure use practices of rates, applications, incorporation, types of manure, and other management decisions for wheat and hay acres. Manure applications are only based on nitrogen. Other nutrients are not collected or reported.

These types of surveys help MDA understand regulatory compliance, adoption of voluntary best management practices, potential informational roadblocks, and opportunities for future technical assistance.

Every year the MDA has partnered with NASS to produce a detailed report on fertilizer use and rates used on the state's major crops. The first nitrogen use survey was conducted in 2009 and was designed for commercial nitrogen use on corn. It was repeated in more detail in 2010 and included wheat acres. In 2012, the survey was expanded to include additional analysis of corn acres applied with manure, while the wheat portion of the survey was not repeated. The fertilizer reports were expanded to include nitrogen, phosphorus, potassium, and sulfur fertilizer rates in 2016, but nitrogen use practices continue to be the primary focus of these reports. Readers are encouraged to visit the five reports from the annual survey: "2009 Survey of Nitrogen Fertilizer Use", the "Fertilizer and Manure Selection and Management Practices Associated with Minnesota's 2010 Corn and Wheat Production", the "Commercial Nitrogen and Manure Fertilizer Selection and Management Practices Associated with Minnesota's 2012 Corn Crop", the "Commercial Nitrogen and Manure Fertilizer Selection and Management Practices Associated with Minnesota's 2014 Corn Crop", and the "Commercial Fertilizer Usage and Management Practices Associated with Minnesota's 2016 Soybean and Wheat Crops" at:

https://www.mda.state.mn.us/nutrient-management-surveys

Each year NASS surveys crop farmers through the Agricultural Resource Management Survey (ARMS). To prevent farmers from being interviewed by both the MDA and the USDA NASS in the same year, the MDA will only interview farmers for crops that are not selected by the USDA NASS. For example, in 2018, the ARMS was conducted for corn and soybean crops and the MDA conducted a survey for wheat and hay. The MDA will continue to survey only crops that are not included in the ARMS for any given year.

Acknowledgements

This survey was a cooperative effort by the Minnesota Department of Agriculture (MDA), the United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS), and the NASS Field Office in Minnesota. The detailed information about fertilizer and manure use could not have been collected without the cooperation of the thousands of farmers who voluntarily responded to the survey in the midst of their busy lives, and for this we are extremely grateful. Special thanks go to Dan Lofthus, the NASS Statistician of the Minnesota Field Office. The MDA is ultimately responsible for the representations of data provided in this report and for the design of the survey mechanism used to collect that data. Excellent participation and good record keeping practices by Minnesota farmers played a vital part in providing complete and detailed fertilizer use information.

2018 Commercial Fertilizer Use Practices Summary and Highlights

The 2018 report is the first fertilizer and manure use report presenting data that have been weighted by NASS to represent all farmers who grew spring wheat and harvested hay in Minnesota. Previous to 2018, reports were

based on non-weighted survey results that could overrepresent or underrepresent counties, depending on participation in those counties. The NASS surveys are designed to statistically represent a non-homogenous population, thus data were "weighted" to account for sample size, county size, crop acreage, and nonresponse, among other factors.[4] [5] By giving a statistical weight to each operation, data can better represent fertilizer and manure use by all Minnesota farmers with wheat and hay acres.

This report summarizes survey results for a number of important practices associated with commercial fertilizer applications on Minnesota's 2018 wheat and hay. There were 21,739 wheat or hay producers represented[6] in the survey and information was statistically weighted for 1,620,892 wheat acres and 1,219,600 hay acres. The NASS surveys are designed to be statistically weighted to account for sample size, county size, crop acreage, nonresponse, etc. By giving a statistical weight to each operation based on standard protocol for NASS, data can better represent all Minnesota farmers for these two crops.[7]

The average yield for wheat by represented farmers in the survey was 55 bushels per acre. Hay includes all varieties of hay, and hay can be harvested multiple times in a year. Due to these restraints, yields for hay were not collected. Wheat yields were slightly less than the USDA reported yield of 59 bushels per acre for the 2018 wheat crop year.

Ninety-five percent of the wheat fields were fertilized, and those fertilized fields received an average rate of 105 pounds of nitrogen, 38 pounds of phosphorus, 30 pounds of potash, and 4 pounds of sulfur.

Thirty-seven percent of the hay fields were fertilized, and those fertilized fields received an average rate of 25 pounds of nitrogen, 10 pounds of phosphorus, 50 pounds of potash, and 3 pounds of sulfur.

Thirteen percent of the wheat operations applied manure on at least one wheat field.

Nineteen percent of the hay operations applied manure on at least one hay field.

---

[4] For an example of survey methods and data quality, visit the NASS website at https://www.nass.gov/Education_and_Outreach/Understanding_Statistics/index.php "Statistical Aspects of Surveys". This site will provide specific details about agricultural chemical use surveys.

[5] Reports available at sections of NASS "Agricultural Chemical Usage – Field Crops" https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Chemical_Use/ and click on "Methodology and Quality Measures".

[6] There were 309 wheat operations that provided information on 97,057 spring wheat acres, and those farmers represented 4,619 operations with 1,620,892 acres of wheat. There were 1,594 hay operations that provided information on 115,296 acres and those farmers represented 17,120 operations with 1,219,600 acres of hay. A total of 21,739 wheat and hay operations representing 2,840,492 acres are analyzed in the 2018 fertilizer and manure use report.

[7] Details on NASS Methodology and Quality Measures are available at: https://www.nass.gov/Surveys/Guide_to_NASS_Surveys /Ag_Resource_Management/. Click on the "Methodology and Quality Measures" tab for more information.

Survey Design and Implementation

Five nitrogen BMP regions (noted as "BMP regions" throughout the report), were previously developed by MDA staff. Counties were clustered based on similarities in geology, soils, and crops. More information about BMP regions can be found at: http://www.mda.state.mn.us/nitrogenbmps. Regional nitrogen use information is used to help design and implement specific water quality monitoring and nitrogen educational programs.

Figure 1. Minnesota Nitrogen BMP regions

For the purpose of this report the Minnesota nitrogen BMP regions will be defined as follows: Northwestern as NW, Irrigated and Non-irrigated Sandy Soils as IRR, Southwestern and West Central as SW, South Central as SC, and Southeastern as SE.

NASS developed a systematic sample of 7,600 farms by randomly drawing from its entire database of all wheat and hay growers in Minnesota. There were 21,739 wheat or hay producers represented in the survey and information was statistically weighted for 1,620,892 wheat acres and 1,219,600 hay acres. The definition of "wheat" for purposes of this report includes spring wheat and excludes durum or winter wheat. In Minnesota over 99% of the wheat harvested was spring wheat in 2018. Hay included all types of hay, including grass, haylage, alfalfa, and grass/alfalfa mix.

Process

Farmers were interviewed over the phone in February 2019. These were 'cold calls', meaning that the farmers did not get any type of direct notification about the survey prior to the contact. However, there were multiple news releases informing farmers of the annual survey. Information collected using this approach was based upon either the participant's memory or records readily available during the interview. If the farmer did not have access to the commercial fertilizer applications, the enumerator asked the farmer if we could contact his fertilizer dealership or applicator for application information. If the farmer gave permission to contact the dealership or applicator, a follow-up call was made. Depending on the complexity of the farm, the interviews would typically last ten to thirty minutes.

Data Reporting and Limitations

The primary purpose of this survey was to obtain an understanding of commercial fertilizer and manure applications associated with wheat and hay production in Minnesota. Hay can be harvested multiple times in a year. Due to these restraints, yields for hay were not collected.

Due to the simplified method used to collect what is typically considered complex data, it is imperative that the reader understand the limitations of the data sets. Farmers that grew wheat or hay were randomly selected from county lists of producers accessed by NASS to participate in the survey. Because NASS surveys are designed to represent a non-homogenous population, data are "weighted" to account for sample size, county size, crop acreage, nonresponse e, etc. By giving statistical weight to each operation based standard protocol for NASS, data can better represent all Minnesota farmers with these two crops.[8]

If there were less than nine responses in any BMP region during the survey process, that BMP region would be combined with another BMP region with the lowest number of responses, or if multiple BMP regions have less than nine response all BMP regions with less than nine responses would be combined. Theses BMP regions are referred to as 'Combined BMPs' in this report.

For each BMP region, if there were less than 5 responses for the 'Number of Responses', then the responses were not published and were represented by '**'. However, the data was still included in the overall statistical analysis. This is why certain columns will be slightly higher in the 'Totals/Averages' row of the relevant tables.

[8] Details on NASS Methodology and Quality Measures are available at: https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Ag_Resource_Management/. Click on the "Methodology and Quality Measures" tab for more information.

Wheat Section

Wheat is not a major crop in the Southeast BMP region, and less than nine farmers reported growing wheat in the Southeast BMP region. Therefore, Southeast BMP region farmers were combined with the farmers from the South Central region and is referred to as the 'Combined BMP Regions' in the following wheat section.

Farmers in the survey were first asked "How many acres of wheat did you plant?" Table 1 details the number of farmers[9] and corresponding wheat acres planted by BMP region for the 2018 crop year (WAQ-1[10]).

Table 1. Summary of respondents and corresponding wheat acres planted by BMP region for the 2018 crop year

BMP Region	Number of Respondents	Number of Wheat Acres
Northwestern	2,393	1,428,196
Irrigated and Non-irrigated Sandy Soils	791	89,427
Southwestern and West Central	1,145	92,983
Combined BMP Regions[11]	291	10,285
Statewide	**4,619**	**1,620,892**

Farmers in the survey were then asked, "Do you have a wheat field without manure?" Table 2 details the percent of farmers who had a wheat field without manure applied by BMP region (WFQ-1). Farmers that answered no to this question applied manure on all their wheat fields for the 2018 growing year.

Table 2. Percent of respondents with a wheat field without manure applied

BMP Region	Wheat Field Without Manure Applied	Percent of Respondents
Northwestern	Yes	88
Northwestern	No	12
Irrigated and Non-irrigated Sandy Soils	Yes	76
Irrigated and Non-irrigated Sandy Soils	No	24
Southwestern and West Central	Yes	72
Southwestern and West Central	No	28
Combined BMP Regions	Yes	66
Combined BMP Regions	No	34
Statewide	**Yes**	**81**
Statewide	**No**	**19**

[9] Farmers and respondents are used interchangeably in this document. The farmer interviewed is the respondent.

[10] WAQ1 is Wheat All Question 1 and can be found at the end of the report in the appendix. All question references will be in this format. WFQ stands for Wheat Fertilizer Question and is in the same appendix.

[11] Due to the low number of wheat farmers without manured applied to their wheat fields in the SC and SE BMP regions, the SC and SE BMP regions are combined for all wheat survey results and published as Combined BMP Regions.

Table 3 details the number of represented respondents and all wheat acres who reported having a field without manure applied to the 2018 wheat crop. Due to the low amount of row crop agriculture in portions of Minnesota, survey results were not listed when there were less than five responses in any category for fertilizer with wheat. Respondents and acres were excluded from Table 3 who applied manure on all of their wheat fields. Farmers with manured acres will be analyzed in the manure section of this report.

Table 3. Summary of respondents and corresponding wheat acres by BMP region for farmers who reported a field without manure applied in the fall of 2017 or anytime in the 2018 crop year

BMP Region	Number of Respondents	Number of Wheat Acres
Northwestern	2,116	1,347,107
Irrigated and Non-irrigated Sandy Soils	599	78,882
Southwestern and West Central	827	76,974
Combined BMP Regions	191	7,084
Statewide	**3,733**	**1,510,047**

All wheat fields without manure applied are included in the analysis for the following tables. There were 3,733 wheat fields represented in the commercial fertilizer analysis.

Farmers were then told by the phone enumerator[12] "I will now ask you about your fertilizer inputs on your wheat acres. First on a wheat field with no manure. Think about your largest wheat field that you planted in 2018 without any manure." Farmers were then asked, "Was this field irrigated?" Farmers were only asked about irrigation on the largest field being surveyed, therefore they could have had a field that was irrigated but not the largest wheat field on their farm.

Table 4 details the percent of farmers who irrigated their largest wheat field, without manure, applied by BMP region (WFQ-2).

Table 4. Percent of respondents who irrigated their largest wheat field

BMP Region	Largest Wheat Field was Irrigated	Percent of Respondents
Northwestern	Yes	1
Northwestern	No	99
Irrigated and Non-irrigated Sandy Soils	Yes	3
Irrigated and Non-irrigated Sandy Soils	No	97
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**1**
Statewide	**No**	**99**

[12] A phone enumerator is a NASS employee who calls on the phone to survey farmers for the Minnesota pesticide and fertilizer survey.

Next, farmers were asked, “What was the crop grown on this field in 2017 before the 2018 wheat crop?” Table 5 details the previous crop planted before the current wheat crop by BMP region and corresponding yield (WFQ-3, WFQ-4, WFQ-5 and WFQ-6). The table includes the next question to the farmers “What was the average wheat yield of this field over the past three wheat crops?” The average wheat yield was 61 bushels per acre in the Northwestern BMP region, 46 bushels per acre in the Irrigated and Non-irrigated Sandy Soils BMP region, 48 bushels per acre in the Southwestern and West Central BMP region, and 44 bushels per acre in the Combined BMP regions. The average wheat yield across all wheat fields in Minnesota was 55 bushels per acre.

Table 5. Percent of fields by previous crop and the corresponding wheat yield in 2018

BMP Region	Previous Crop	Percent of Fields	Average Wheat Yield Bushels per Acre
Northwestern	Soybeans	89	62
Northwestern	Corn	**	**
Northwestern	Small Grains	**	**
Northwestern	Other	8	55
Irrigated and Non-irrigated Sandy Soils	Soybeans	61	52
Irrigated and Non-irrigated Sandy Soils	Corn	**	**
Irrigated and Non-irrigated Sandy Soils	Small Grains	**	**
Irrigated and Non-irrigated Sandy Soils	Other	**	**
Southwestern and West Central	Soybeans	90	48
Southwestern and West Central	Corn	6	47
Southwestern and West Central	Alfalfa	**	**
Southwestern and West Central	Other	**	**
Combined BMP Regions	Soybeans	63	42
Combined BMP Regions	Corn	32	49
Combined BMP Regions	Other	**	**
Statewide	**Soybeans**	**83**	**57**
Statewide	**Corn**	**6**	**51**
Statewide	**Alfalfa**	****	****
Statewide	**Small Grains**	****	****
Statewide	**Other**	**7**	**53**

** Less than five responses

Commercial Fertilizer Applications on Wheat

Farmers were then asked, "Was any commercial fertilizer applied to this wheat field for the 2018 wheat crop?" Table 6 details the percent of non-manured wheat fields applied with commercial fertilizer (WFQ-7).

Table 6. Commercial fertilizer applied to non-manured wheat fields

BMP Region	Fertilizer Applied	Percent of Respondents
Northwestern	Yes	98
Northwestern	No	2
Irrigated and Non-irrigated Sandy Soils	Yes	98
Irrigated and Non-irrigated Sandy Soils	No	2
Southwestern and West Central	Yes	89
Southwestern and West Central	No	11
Combined BMP Regions	Yes	76
Combined BMP Regions	No	24
Statewide	**Yes**	**95**
Statewide	**No**	**5**

Farmers were asked "Was any commercial fertilizer applied to this wheat field with a variable rate or more than one rate such as by management zone or grid?" Table 7 details the percent of respondents using variable rate commercial fertilizer applied by BMP region on their largest wheat field (WFQ-8).

Table 7. Variable rate commercial fertilizer application by BMP region on the farmer's largest wheat field

BMP Region	Variable Rate Fertilizer Application	Percent of Respondents
Northwestern	Variable Rate	22
Northwestern	One Rate	78
Irrigated and Non-irrigated Sandy Soils	Variable Rate	44
Irrigated and Non-irrigated Sandy Soils	One Rate	56
Southwestern and West Central	Variable Rate	12
Southwestern and West Central	One Rate	88
Combined BMP Regions	Variable Rate	20
Combined BMP Regions	One Rate	80
Statewide	**Variable Rate**	**24**
Statewide	**One Rate**	**76**

There were 3,733 wheat fields represented in the commercial fertilizer analysis, and farmers provided complete information for 3,535 wheat fields with fertilizer applied. From these represented farmers, 317 were unable to report actual fertilizer applications. Of the 3,535 farmers that reported complete data, 3,218 farmers reported applying fertilizer that included the nutrient rate and timing on their wheat fields. The following wheat fertilizer tables are based on those 3,218 fields reported by farmers.

Table 8[13] details the percent of all represented wheat fields applied with fertilizer and the percent of fertilized fields treated with nitrogen, phosphorus, potassium, and sulfur by BMP region (WFQ-7 and WFQ-FERT TABLE).

Table 8. The percent of wheat fields applied with commercial fertilizer and the percent of fertilized fields treated with nitrogen, phosphorus, potassium, and sulfur by BMP region

BMP Region	Percent of All Represented Fields Fertilized	Percent of Fertilized Fields Treated with Nitrogen	Percent of Fertilized Fields Treated with Phosphorus	Percent of Fertilized Fields Treated with Potassium	Percent of Fertilized Fields Treated with Sulfur
Northwestern	98	100	94	70	35
Irrigated and Non-irrigated Sandy Soils	97	100	89	95	62
Southwestern and West Central	87	100	80	77	35
Combined BMP Regions	73	100	72	72	53
Statewide	**94**	**100**	**89**	**76**	**40**

Table 9 details the percent of all represented wheat fields with fertilizer and treated with nitrogen, the average nitrogen rate on fields treated with commercial nitrogen fertilizer, and the average nitrogen rate on all fertilized wheat fields by BMP region (WFQ-7 and WFQ-FERT TABLE). All fertilized wheat fields received nitrogen. These are nitrogen rates on all wheat acres treated with commercial fertilizer, regardless of previous crop. Nitrogen rates are for commercial fertilizer only.

Table 9. The percent of all represented wheat fields applied with commercial fertilizer containing nitrogen, the average rate on fields treated with nitrogen, and the average nitrogen rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Nitrogen	Average Commercial Nitrogen Rate On Fields Treated with Nitrogen Pounds per Acre	Average Commercial Nitrogen Rate Across All Fertilized Wheat Fields Pounds per Acre
Northwestern	100	112	112
Irrigated and Non-irrigated Sandy Soils	100	85	85
Southwestern and West Central	100	97	97
Combined BMP Regions	100	98	98
Statewide	**100**	**105**	**105**

[13] Not all farmers who reported fertilizer applied were able to provide complete fertilizer data. Therefore, percent of fields fertilized have slight differences in Table 6 when compared to Table 8.

Table 10 details the percent of all represented wheat fields with fertilizer and treated with phosphorus, the average phosphorus rate on fields treated with commercial phosphorus fertilizer, and the average phosphorus rate on all fertilized wheat fields by BMP region (WFQ-7 and WFQ-FERT TABLE). Statewide, 89% of fertilized wheat fields received phosphorus. These are phosphorus rates on all wheat acres treated with commercial fertilizer, regardless of previous crop. Phosphorus rates are for commercial fertilizer only.

Table 10. The percent of all represented wheat fields applied with commercial fertilizer containing phosphorus, the average rate on fields treated with phosphorus, and the average phosphorus rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Phosphorus	Average Commercial Phosphorus Rate On Fields Treated with Phosphorus Pounds per Acre	Average Commercial Phosphorus Rate Across All Fertilized Wheat Fields Pounds per Acre
Northwestern	94	42	40
Irrigated and Non-irrigated Sandy Soils	89	35	31
Southwestern and West Central	80	45	36
Combined BMP Regions	72	38	27
Statewide	**89**	**42**	**38**

Table 11 details the percent of all represented wheat fields with fertilizer and treated with potassium, the average potassium rate on fields treated with commercial potassium fertilizer, and the average potassium rate on all fertilized wheat fields by BMP region (WFQ-7 and WFQ-FERT TABLE). Statewide, 76% of fertilized wheat fields received potassium. These are potassium rates on all wheat acres treated with commercial fertilizer, regardless of previous crop. Potassium rates are for commercial fertilizer only.

Table 11. The percent of all represented wheat fields applied with commercial fertilizer containing potassium, the average rate on fields treated with potassium, and the average potassium rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Potassium	Average Commercial Potassium Rate On Fields Treated with Potassium Pounds per Acre	Average Commercial Potassium Rate Across All Fertilized Wheat Fields Pounds per Acre
Northwestern	70	39	27
Irrigated and Non-irrigated Sandy Soils	95	47	45
Southwestern and West Central	77	40	31
Combined BMP Regions	72	43	31
Statewide	**76**	**40**	**30**

Table 12 details the percent of all represented wheat fields with fertilizer and treated with sulfur, the average sulfur rate on fields treated with commercial sulfur fertilizer, and the average sulfur rate on all fertilized wheat fields by BMP region (WFQ-7 and WFQ-FERT TABLE). Statewide, 40% of fertilized wheat fields received sulfur. These are sulfur rates on all wheat acres treated with commercial fertilizer, regardless of previous crop. Sulfur rates are for commercial fertilizer only.

Table 12. The percent of all represented wheat fields applied with commercial fertilizer containing sulfur, the average rate on fields treated with sulfur, and the average sulfur rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Sulfur	Average Commercial Sulfur Rate On Fields Treated with Sulfur Pounds per Acre	Average Commercial Sulfur Rate Across All Fertilized Wheat Fields Pounds per Acre
Northwestern	35	10	3
Irrigated and Non-irrigated Sandy Soils	62	10	6
Southwestern and West Central	35	8	3
Combined BMP Regions	53	8	4
Statewide	**40**	**9**	**4**

Table 13 details the nitrogen fertilizer rate and wheat yield by BMP region on wheat following various crops (WFQ-3, WFQ-6 and WFQ-FERT TABLE). These are wheat fields applied with commercial nitrogen fertilizer and no manure applications.

Table 13. Average amount of nitrogen applied and corresponding wheat yield by BMP region and previous crop

BMP Region	Previous Crop	Average Nitrogen Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	Soybeans	115	60
Northwestern	Small Grains	**	**
Northwestern	Other	118	60
Irrigated and Non-irrigated Sandy Soils	Soybeans	87	52
Irrigated and Non-irrigated Sandy Soils	Corn	**	**
Irrigated and Non-irrigated Sandy Soils	Small Grains	**	**
Irrigated and Non-irrigated Sandy Soils	Other	**	**
Southwestern and West Central	Soybeans	94	47
Southwestern and West Central	Corn	**	**
Southwestern and West Central	Alfalfa	**	**
Southwestern and West Central	Small Grains	**	**
Combined BMP Regions	Soybeans	98	45
Combined BMP Regions	Corn	**	**
Combined BMP Regions	Small Grains	**	**
Statewide	**Soybeans**	**106**	**56**
Statewide	**Corn**	**85**	**49**
Statewide	**Alfalfa**	**	**
Statewide	**Small Grains**	**	**
Statewide	**Other**	**104**	**52**

** Less than five responses

Table 14 details the phosphorus fertilizer rate and wheat yield by BMP region on wheat following various crops (WFQ-3, WFQ-6 and WFQ-FERT TABLE). These are wheat fields applied with commercial phosphorus fertilizer and no manure applications.

Table 14. Average amount of phosphorus applied and corresponding wheat yield by BMP region and previous crop

BMP Region	Previous Crop	Average Phosphorus Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	Soybeans	42	61
Northwestern	Small Grains	**	**
Northwestern	Other	45	60
Irrigated and Non-irrigated Sandy Soils	Soybeans	30	50
Irrigated and Non-irrigated Sandy Soils	Corn	**	**
Irrigated and Non-irrigated Sandy Soils	Small Grains	**	**
Irrigated and Non-irrigated Sandy Soils	Other	**	**
Southwestern and West Central	Soybeans	45	47
Southwestern and West Central	Corn	**	**
Southwestern and West Central	Small Grains	**	**
Combined BMP Regions	Soybeans	33	45
Combined BMP Regions	Corn	**	**
Combined BMP Regions	Small Grains	**	**
Statewide	**Soybeans**	**41**	**57**
Statewide	**Corn**	**	**
Statewide	**Small Grains**	**	**
Statewide	**Other**	**40**	**52**

** Less than five responses

Table 15 details the potassium fertilizer rate and wheat yield by BMP region on wheat following various crops (WFQ-3, WFQ-6 and WFQ-FERT TABLE). These are wheat fields applied with commercial potassium fertilizer and no manure applications.

Table 15. Average amount of potassium applied and corresponding wheat yield by BMP region and previous crop

BMP Region	Previous Crop	Average Potassium Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	Soybeans	40	60
Northwestern	Small Grains	**	**
Northwestern	Other	29	61
Irrigated and Non-irrigated Sandy Soils	Soybeans	48	53
Irrigated and Non-irrigated Sandy Soils	Corn	**	**
Irrigated and Non-irrigated Sandy Soils	Small Grains	**	**
Irrigated and Non-irrigated Sandy Soils	Other	45	43
Southwestern and West Central	Soybeans	41	46
Southwestern and West Central	Corn	**	**
Southwestern and West Central	Small Grains	**	**
Combined BMP Regions	Soybeans	35	45
Combined BMP Regions	Corn	**	**
Combined BMP Regions	Small Grains	**	**
Statewide	**Soybeans**	**41**	**55**
Statewide	**Corn**	****	****
Statewide	**Small Grains**	****	****
Statewide	**Other**	**36**	**52**

** Less than five responses

Table 16 details the sulfur fertilizer rate and wheat yield by BMP region on wheat following various crops (WFQ-3, WFQ-6 and WFQ-FERT TABLE). These are wheat fields applied with commercial sulfur fertilizer and no manure applications.

Table 16. Average amount of sulfur applied and corresponding wheat yield by BMP region and previous crop

BMP Region	Previous Crop	Average Sulfur Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	Soybeans	8	64
Northwestern	Other	**	**
Irrigated and Non-irrigated Sandy Soils	Soybeans	8	56
Irrigated and Non-irrigated Sandy Soils	Small Grains	**	**
Irrigated and Non-irrigated Sandy Soils	Other	**	**
Southwestern and West Central	Soybeans	8	50
Southwestern and West Central	Corn	**	**
Combined BMP Regions	Soybeans	**	**
Combined BMP Regions	Corn	**	**
Combined BMP Regions	Other	**	**
Statewide	**Soybeans**	**9**	**59**
Statewide	**Corn**	****	****
Statewide	**Small Grains**	****	****
Statewide	**Other**	**9**	**53**

** Less than five responses

Fertilizer Sources and Timing

Table 17 details the respondents and corresponding wheat acres by BMP region for all farmers in this study who fall applied nitrogen on the largest wheat field (WFQ-FERT TABLE). This table includes all sources of fall applied nitrogen from commercial fertilizer.

Table 17. Average amount of fall applied nitrogen and corresponding wheat yield by BMP region

BMP Region	Percent of Respondents: Fall Applied Nitrogen	Average Fall Nitrogen Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	19	101	67
Irrigated and Non-irrigated Sandy Soils	**	**	**
Southwestern and West Central	16	85	47
Combined BMP Regions	**	**	**
Statewide	**15**	**95**	**62**

** Less than five responses

Table 18 details the respondents and corresponding wheat acres by BMP region for all farmers in this study who fall applied phosphorus on the largest wheat field (WFQ-FERT TABLE). This table includes all sources of fall applied phosphorus from commercial fertilizer.

Table 18. Average amount of fall applied phosphorus and corresponding wheat yield by BMP region

BMP Region	Percent of Respondents: Fall Applied Phosphorus	Average Fall Phosphorus Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	9	38	70
Irrigated and Non-irrigated Sandy Soils	**	**	**
Southwestern and West Central	11	49	49
Combined BMP Regions	**	**	**
Statewide	**8**	**41**	**63**

** Less than five responses

Table 19 details the respondents and corresponding wheat acres by BMP region for all farmers in this study who fall applied potassium on the largest wheat field (WFQ-FERT TABLE). This table includes all sources of fall applied potassium from commercial fertilizer.

Table 19. Average amount of fall applied potassium and corresponding wheat yield by BMP region

BMP Region	Percent of Respondents: Fall Applied Potassium	Average Fall Potassium Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	11	45	67
Irrigated and Non-irrigated Sandy Soils	**	**	**
Southwestern and West Central	9	41	48
Statewide	**9**	**46**	**63**

** Less than five responses

Table 20 details the percent of respondents and corresponding wheat acres by BMP region for all farmers in this study who fall applied sulfur on the largest wheat field (WFQ-FERT TABLE). This table includes all sources of fall applied sulfur from commercial fertilizer.

Table 20. Average amount of fall applied sulfur and corresponding wheat yield by BMP region

BMP Region	Percent of Respondents: Fall Applied Sulfur	Average Fall Sulfur Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	**	**	**
Southwestern and West Central	**	**	**
Combined BMP Regions	**	**	**
Statewide	**8**	**9**	**55**

** Less than five responses

Table 21 details the major form of nitrogen fertilizer applied in each BMP region and statewide along with the percent of respondents for those forms (WFQ-9b). 'Other' forms of fertilizer containing nitrogen would include sources of phosphorus, such as MAP or DAP, and sulfur, such as AMS[14], on represented wheat fields.

Table 21. The major form of nitrogen applied to the field

BMP Region	Major Form of Nitrogen Applied	Percent of Respondents
Northwestern	Anhydrous	15
Northwestern	Urea	83
Northwestern	Liquid Nitrogen	0
Northwestern	Other	2
Northwestern	Unknown	0
Irrigated and Non-irrigated Sandy Soils	Anhydrous	0
Irrigated and Non-irrigated Sandy Soils	Urea	93
Irrigated and Non-irrigated Sandy Soils	Liquid Nitrogen	0
Irrigated and Non-irrigated Sandy Soils	Other	0
Irrigated and Non-irrigated Sandy Soils	Unknown	7
Southwestern and West Central	Anhydrous	6
Southwestern and West Central	Urea	92
Southwestern and West Central	Liquid Nitrogen	1
Southwestern and West Central	Other	0
Southwestern and West Central	Unknown	1
Combined BMP Regions	Anhydrous	7
Combined BMP Regions	Urea	93
Combined BMP Regions	Liquid Nitrogen	0
Combined BMP Regions	Other	0
Combined BMP Regions	Unknown	0
Statewide	**Anhydrous**	**11**
Statewide	**Urea**	**86**
Statewide	**Liquid**	**1**

[14] AMS is the acronym for ammonium sulfate, MAP is monoammonium phosphate, and DAP is diammonium phosphate.

BMP Region	Major Form of Nitrogen Applied	Percent of Respondents
Statewide	**Other**	**1**
Statewide	**Unknown**	**1**

Table 22 details the major form of nitrogen used, average nitrogen rate from all sources, and average wheat yield of the 2018 wheat crop (WFQ-6, WFQ-9 and WFQ-9b).

Table 22. Average amount of nitrogen applied and corresponding yield by BMP region and type of nitrogen

BMP Region	Major Form of Nitrogen Applied	Average Nitrogen Rate Pounds per Acre	Average Wheat Yield Bushels per Acre
Northwestern	Anhydrous	119	69
Northwestern	Urea	115	58
Northwestern	Other	**	**
Irrigated and Non-irrigated Sandy Soils	Urea	80	45
Irrigated and Non-irrigated Sandy Soils	Unknown	**	**
Southwestern and West Central	Anhydrous	**	**
Southwestern and West Central	Urea	93	47
Southwestern and West Central	Liquid Nitrogen	**	**
Southwestern and West Central	Unknown	**	**
Combined BMP Regions	Anhydrous	**	**
Combined BMP Regions	Urea	96	47
Statewide	**Anhydrous**	**116**	**66**
Statewide	**Urea**	**104**	**54**
Statewide	**Liquid**	**	**
Statewide	**Other**	**	**
Statewide	**Unknown**	**	**

** Less than five responses

Table 23 details any commercial fertilizer applied in the fall of 2017 for the 2018 wheat crop across all fertilized fields (WFQ-FERT TABLE).

Table 23. Commerical fertilizer applied in the fall of 2017 for the 2018 wheat crop

BMP Region	Any Commercial Fertilizer Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	23
Northwestern	No	77
Irrigated and Non-irrigated Sandy Soils	Yes	5
Irrigated and Non-irrigated Sandy Soils	No	95
Southwestern and West Central	Yes	15
Southwestern and West Central	No	85
Combined BMP Regions	Yes	7
Combined BMP Regions	No	93
Statewide	**Yes**	**18**
Statewide	**No**	**82**

Table 24 details anhydrous ammonia applied in the fall of 2017 for the 2018 wheat crop (WFQ-FERT TABLE).

Table 24. Anhydrous ammonia applied in the fall of 2017 for the 2018 wheat crop

BMP Region	Anhydrous Ammonia Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	4
Northwestern	No	96
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	5
Southwestern and West Central	No	95
Combined BMP Regions	Yes	7
Combined BMP Regions	No	93
Statewide	**Yes**	**4**
Statewide	**No**	**96**

Table 25 details urea applied in the fall of 2017 for the 2018 wheat crop (WFQ-FERT TABLE).

Table 25. Urea applied in the fall of 2017 for the 2018 wheat crop

BMP Region	Urea Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	11
Northwestern	No	89
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	3
Southwestern and West Central	No	97
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**7**
Statewide	**No**	**93**

No liquid nitrogen (28%, 32%) was reported to be applied in the fall of 2017 for the 2018 wheat crop (WFQ-FERT TABLE).

Table 26 details other fertilizers containing nitrogen applied in the fall of 2017 for the 2018 wheat crop (WFQ-FERT TABLE).

Table 26. Other fertilizers containing nitrogen applied in the fall of 2017 for the 2018 wheat crop

BMP Region	Other Sources of Fertilizer Containing Nitrogen in the Fall of 2017	Percent of Respondents
Northwestern	Yes	3
Northwestern	No	97
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	6
Southwestern and West Central	No	94
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**3**
Statewide	**No**	**97**

Table 27 details phosphorus fertilizer, such as MAP or DAP, applied in the fall of 2017 for the 2018 wheat crop (WFQ-FERT TABLE).

Table 27. Fertilizer containing phosphorus applied in the fall of 2017 for the 2018 wheat crop

BMP Region	Phosphorus Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	9
Northwestern	No	91
Irrigated and Non-irrigated Sandy Soils	Yes	2
Irrigated and Non-irrigated Sandy Soils	No	98
Southwestern and West Central	Yes	11
Southwestern and West Central	No	89
Combined BMP Regions	Yes	7
Combined BMP Regions	No	93
Statewide	**Yes**	**9**
Statewide	**No**	**91**

Table 28 details potassium fertilizer applied in the fall of 2017 for the 2018 wheat crop (WFQ-FERT TABLE).[15]

Table 28. Fertilizer containing potassium applied in the fall of 2017 for the 2018 wheat crop

BMP Region	Potassium Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	11
Northwestern	No	89
Irrigated and Non-irrigated Sandy Soils	Yes	5
Irrigated and Non-irrigated Sandy Soils	No	95
Southwestern and West Central	Yes	9
Southwestern and West Central	No	91
Combined BMP Regions	Yes	7
Combined BMP Regions	No	93
Statewide	**Yes**	**9**
Statewide	**No**	**91**

Table 29 details sulfur fertilizer, such as AMS[16], applied in the fall of 2017 for the 2018 wheat crop (WFQ-FERT TABLE).

Table 29. Fertilizer containing sulfur applied in the fall of 2017 for the 2018 wheat crop

BMP Region	Sulfur Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	2
Northwestern	No	98
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	8
Southwestern and West Central	No	92
Combined BMP Regions	Yes	7
Combined BMP Regions	No	93
Statewide	**Yes**	**3**
Statewide	**No**	**97**

[15] Potassium, also known as potash (0-0-60), does not contain nitrogen.

[16] AMS is an example of a fertilizer that contains sulfur. There are many fertilizers that contain sulfur.

Table 30 details commercial fertilizer applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 30. Commercial fertilizer in the spring applied as a preplant for the 2018 wheat crop

BMP Region	Any Commercial Fertilizer Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	82
Northwestern	No	18
Irrigated and Non-irrigated Sandy Soils	Yes	88
Irrigated and Non-irrigated Sandy Soils	No	12
Southwestern and West Central	Yes	92
Southwestern and West Central	No	8
Combined BMP Regions	Yes	100
Combined BMP Regions	No	0
Statewide	**Yes**	**86**
Statewide	**No**	**14**

Table 31 details anhydrous ammonia applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 31. Anhydrous ammonia applied in the spring as a preplant for the 2018 wheat crop

BMP Region	Anhydrous Ammonia Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	4
Northwestern	No	96
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	5
Southwestern and West Central	No	95
Combined BMP Regions	Yes	7
Combined BMP Regions	No	93
Statewide	**Yes**	**4**
Statewide	**No**	**96**

Table 32 details urea applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 32. Urea applied in the spring as a preplant for the 2018 wheat crop

BMP Region	Urea Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	70
Northwestern	No	30
Irrigated and Non-irrigated Sandy Soils	Yes	85
Irrigated and Non-irrigated Sandy Soils	No	15
Southwestern and West Central	Yes	80
Southwestern and West Central	No	20
Combined BMP Regions	Yes	93
Combined BMP Regions	No	7
Statewide	**Yes**	**75**
Statewide	**No**	**25**

Table 33 details liquid nitrogen fertilizer applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 33. Liquid nitrogen fertilizer applied in the spring as a preplant for the 2018 wheat crop

BMP Region	Liquid Nitrogen (28%, 32%) Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 34 details other nitrogen fertilizer sources applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 34. Other nitrogen sources applied in the spring as a preplant for the 2018 wheat crop

BMP Region	Other Sources of Nitrogen Fertilizer as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	2
Northwestern	No	98
Irrigated and Non-irrigated Sandy Soils	Yes	3
Irrigated and Non-irrigated Sandy Soils	No	97
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**2**
Statewide	**No**	**98**

Table 35 details phosphorus fertilizer, such as MAP or DAP, applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 35. Fertilizer containing phosphorus applied in the spring as a preplant for the 2018 wheat crop

BMP Region	Phosphorus Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	77
Northwestern	No	23
Irrigated and Non-irrigated Sandy Soils	Yes	76
Irrigated and Non-irrigated Sandy Soils	No	24
Southwestern and West Central	Yes	66
Southwestern and West Central	No	34
Combined BMP Regions	Yes	62
Combined BMP Regions	No	38
Statewide	**Yes**	**74**
Statewide	**No**	**26**

Table 36 details potassium fertilizer applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 36. Fertilizer containing potassium applied in the spring as a preplant for the 2018 wheat crop

BMP Region	Potassium Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	51
Northwestern	No	49
Irrigated and Non-irrigated Sandy Soils	Yes	83
Irrigated and Non-irrigated Sandy Soils	No	17
Southwestern and West Central	Yes	66
Southwestern and West Central	No	34
Combined BMP Regions	Yes	62
Combined BMP Regions	No	38
Statewide	**Yes**	**60**
Statewide	**No**	**40**

Table 37 details sulfur fertilizer, such as AMS, applied in the spring as a preplant for the 2018 wheat crop (WFQ-FERT TABLE).

Table 37. Fertilizer containing sulfur applied in the spring as a preplant for the 2018 wheat crop

BMP Region	Sulfur Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	26
Northwestern	No	74
Irrigated and Non-irrigated Sandy Soils	Yes	47
Irrigated and Non-irrigated Sandy Soils	No	53
Southwestern and West Central	Yes	29
Southwestern and West Central	No	71
Combined BMP Regions	Yes	53
Combined BMP Regions	No	47
Statewide	**Yes**	**31**
Statewide	**No**	**69**

Table 38 details commercial fertilizer applied in the spring as a starter or at planting for the 2018 wheat crop (WFQ-FERT TABLE). No anhydrous ammonia was applied as a starter or at planting.

Table 38. Commercial fertilizer applied in the spring at planting for the 2018 wheat crop

BMP Region	Any Commercial Fertilizer Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	11
Northwestern	No	89
Irrigated and Non-irrigated Sandy Soils	Yes	13
Irrigated and Non-irrigated Sandy Soils	No	87
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	10
Combined BMP Regions	No	90
Statewide	**Yes**	**9**
Statewide	**No**	**91**

Table 39 details urea applied in the spring as a starter or at planting for the 2018 wheat crop (WFQ-FERT TABLE).

Table 39. Urea applied in the spring at planting for the 2018 wheat crop

BMP Region	Urea Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	2
Northwestern	No	98
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**1**
Statewide	**No**	**99**

Table 40 details liquid nitrogen fertilizer applied in the spring as a starter or at planting for the 2018 wheat crop (WFQ-FERT TABLE).

Table 40. Liquid nitrogen fertilizer applied in the spring at planting for the 2018 wheat crop

BMP Region	Liquid Nitrogen (28%, 32%) Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	1
Northwestern	No	99
Irrigated and Non-irrigated Sandy Soils	Yes	4
Irrigated and Non-irrigated Sandy Soils	No	96
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	10
Combined BMP Regions	No	90
Statewide	**Yes**	**2**
Statewide	**No**	**98**

Table 41 details other nitrogen fertilizers applied in the spring or at planting for the 2018 wheat crop (WFQ-FERT TABLE).

Table 41. Other nitrogen fertilizers applied in the spring at planting for the 2018 wheat crop

BMP Region	Other Nitrogen Fertilizers as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	4
Northwestern	No	96
Irrigated and Non-irrigated Sandy Soils	Yes	6
Irrigated and Non-irrigated Sandy Soils	No	94
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**3**
Statewide	**No**	**97**

Table 42 details phosphorus fertilizer, such as MAP or DAP, applied in the spring at planting for the 2018 wheat crop (WFQ-FERT TABLE).

Table 42. Fertilizer containing phosphorus applied in the spring at planting for the 2018 wheat crop

BMP Region	Phosphorus Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	9
Northwestern	No	91
Irrigated and Non-irrigated Sandy Soils	Yes	10
Irrigated and Non-irrigated Sandy Soils	No	90
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	10
Combined BMP Regions	No	90
Statewide	**Yes**	**7**
Statewide	**No**	**93**

Table 43 details potassium fertilizer applied in the spring at planting for the 2018 wheat crop (WFQ-FERT TABLE).

Table 43. Fertilizer containing potassium applied in the spring at planting for the 2018 wheat crop

BMP Region	Potassium Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	6
Northwestern	No	94
Irrigated and Non-irrigated Sandy Soils	Yes	7
Irrigated and Non-irrigated Sandy Soils	No	93
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	10
Combined BMP Regions	No	90
Statewide	**Yes**	**5**
Statewide	**No**	**95**

Table 44 details sulfur fertilizer, such as AMS, applied in the spring at planting for the 2018 wheat crop (WFQ-FERT TABLE).

Table 44. Fertilizer containing sulfur applied in the spring at planting for the 2018 wheat crop

BMP Region	Sulfur Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	7
Northwestern	No	93
Irrigated and Non-irrigated Sandy Soils	Yes	5
Irrigated and Non-irrigated Sandy Soils	No	95
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**5**
Statewide	**No**	**95**

Table 45 details commercial fertilizers applied as a post planting or sidedress for the 2018 wheat crop (WFQ-FERT TABLE).

Table 45. Commercial fertilizers applied as a post planting or sidedress for the 2018 wheat crop

BMP Region	Any Commercial Fertilizer Application After Planting such as a Sidedress	Percent of Respondents
Northwestern	Yes	4
Northwestern	No	96
Irrigated and Non-irrigated Sandy Soils	Yes	11
Irrigated and Non-irrigated Sandy Soils	No	89
Southwestern and West Central	Yes	5
Southwestern and West Central	No	95
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**5**
Statewide	**No**	**95**

No anhydrous ammonia was reported to be applied on wheat after planting such as a sidedress for the 2018 wheat crop (WFQ-FERT TABLE).

Table 46 details urea applied as a post planting or sidedress for the 2018 wheat crop (WFQ-FERT TABLE).

Table 46. Urea applied as a post planting or sidedress for the 2018 wheat crop

BMP Region	Urea Application After Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	2
Northwestern	No	98
Irrigated and Non-irrigated Sandy Soils	Yes	10
Irrigated and Non-irrigated Sandy Soils	No	90
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**3**
Statewide	**No**	**97**

Table 47 details liquid nitrogen fertilizer applied as a post planting or sidedress for the 2018 wheat crop (WFQ-FERT TABLE).

Table 47. Liquid nitrogen fertilizer (28%, 32%) applied as a post planting or sidedress for the 2018 wheat crop

BMP Region	Liquid Nitrogen (28%, 32%) Application After Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	1
Irrigated and Non-irrigated Sandy Soils	No	99
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 48 details other nitrogen fertilizers applied as a post planting or sidedress the 2018 wheat crop (WFQ-FERT TABLE).

Table 48. Other nitrogen fertilizers applied in the spring at planting for the 2018 wheat crop

BMP Region	Other Nitrogen Fertilizers After Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	1
Northwestern	No	99
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 49 details phosphorus fertilizer, such as MAP or DAP, applied as a post planting or sidedress for the 2018 wheat crop (WFQ-FERT TABLE).

Table 49. Fertilizer containing phosphorus applied as a post planting or sidedress for the 2018 wheat crop

BMP Region	Phosphorus Application After Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	1
Northwestern	No	99
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	5
Southwestern and West Central	No	95
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**2**
Statewide	**No**	**98**

Table 50 details potassium fertilizer applied as a post planting or sidedress for the 2018 wheat crop (WFQ-FERT TABLE).

Table 50. Fertilizer containing potassium applied as a post planting or sidedress for the 2018 wheat crop

BMP Region	Potassium Application After Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	1
Northwestern	No	99
Irrigated and Non-irrigated Sandy Soils	Yes	4
Irrigated and Non-irrigated Sandy Soils	No	96
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**1**
Statewide	**No**	**99**

Table 51 details sulfur fertilizer, such as AMS, applied as a post planting or sidedress for the 2018 wheat crop (WFQ-FERT TABLE).

Table 51. Fertilizer containing sulfur applied as a post planting or sidedress for the 2018 wheat crop

BMP Region	Sulfur Application after Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	1
Northwestern	No	99
Irrigated and Non-irrigated Sandy Soils	Yes	10
Irrigated and Non-irrigated Sandy Soils	No	90
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
Combined BMP Regions	Yes	0
Combined BMP Regions	No	100
Statewide	**Yes**	**2**
Statewide	**No**	**98**

Figure 2 details the form of nitrogen that was applied to wheat acres statewide based on total pounds of nitrogen applied (WFQ-FERT TABLE).

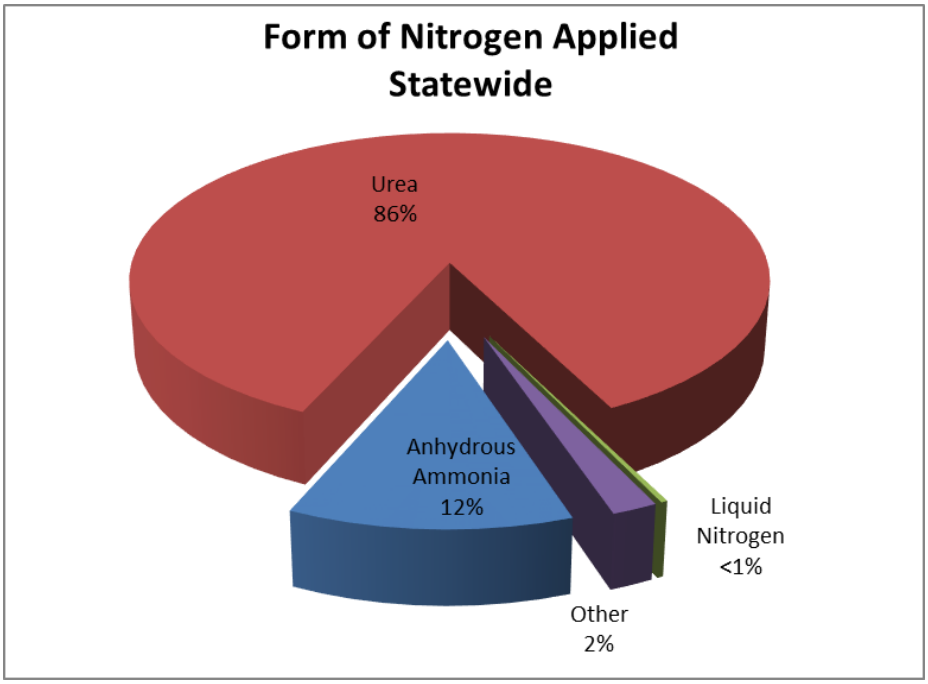

Figure 2. The form of the nitrogen applied to wheat acres in state for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 3 details the form of nitrogen that was applied to wheat acres in the SW BMP region based on total pounds of nitrogen applied (WFQ-FERT TABLE).

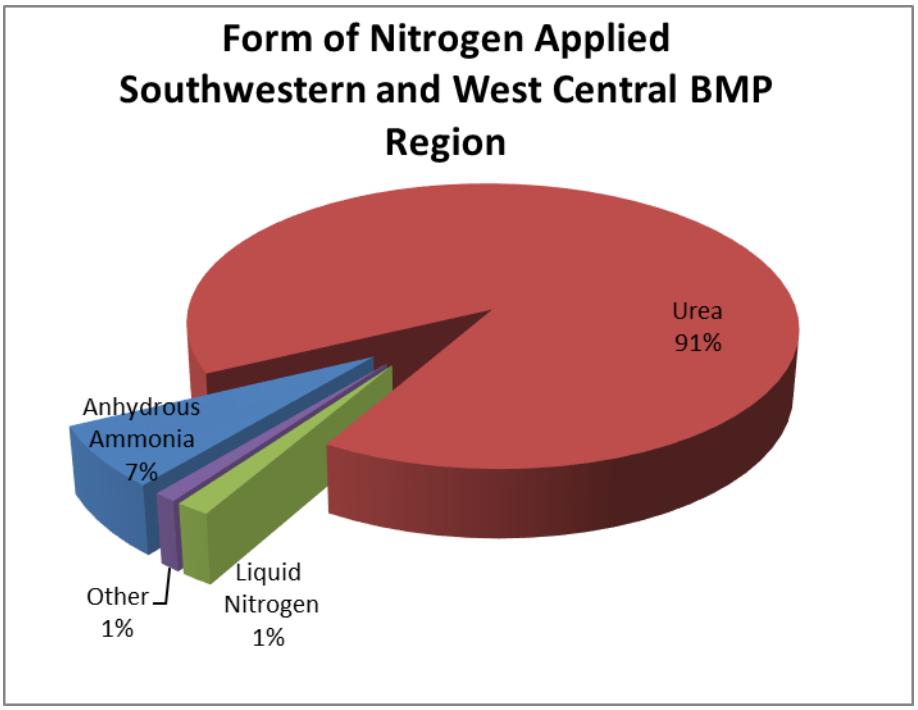

Figure 3. The form of the nitrogen applied to wheat acres in the SW BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 4 details the form of nitrogen that was applied to wheat acres in the NW BMP region based on total pounds of nitrogen applied (WFQ-FERT TABLE).

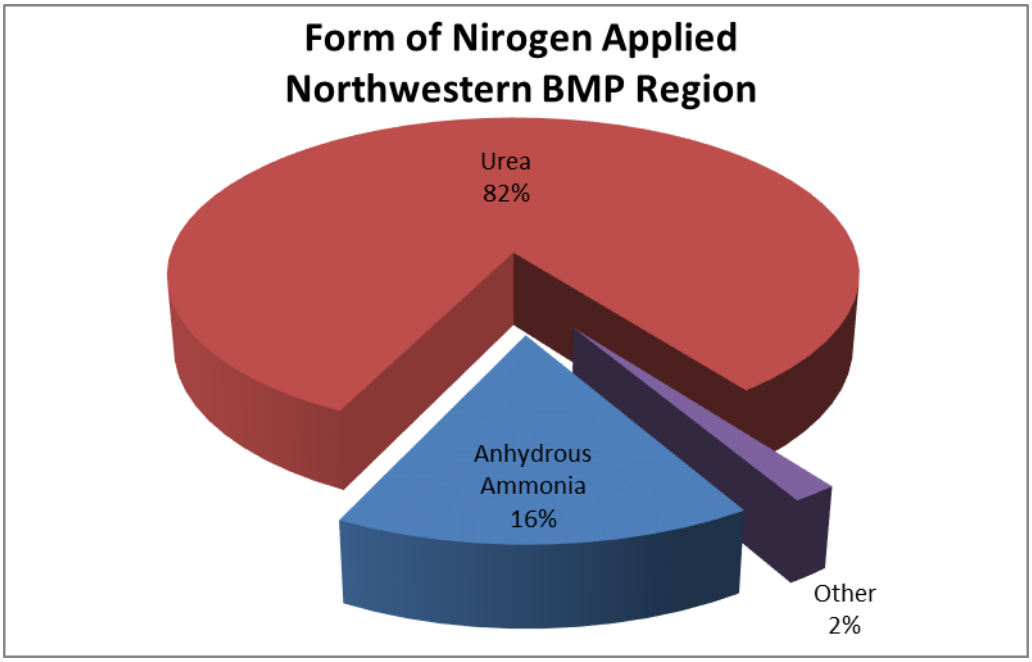

Figure 4. The form of the nitrogen applied to wheat acres in the NW BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 5 details the form of nitrogen that was applied to wheat acres in the IRR BMP region based on total pounds of nitrogen applied (WFQ-FERT TABLE).

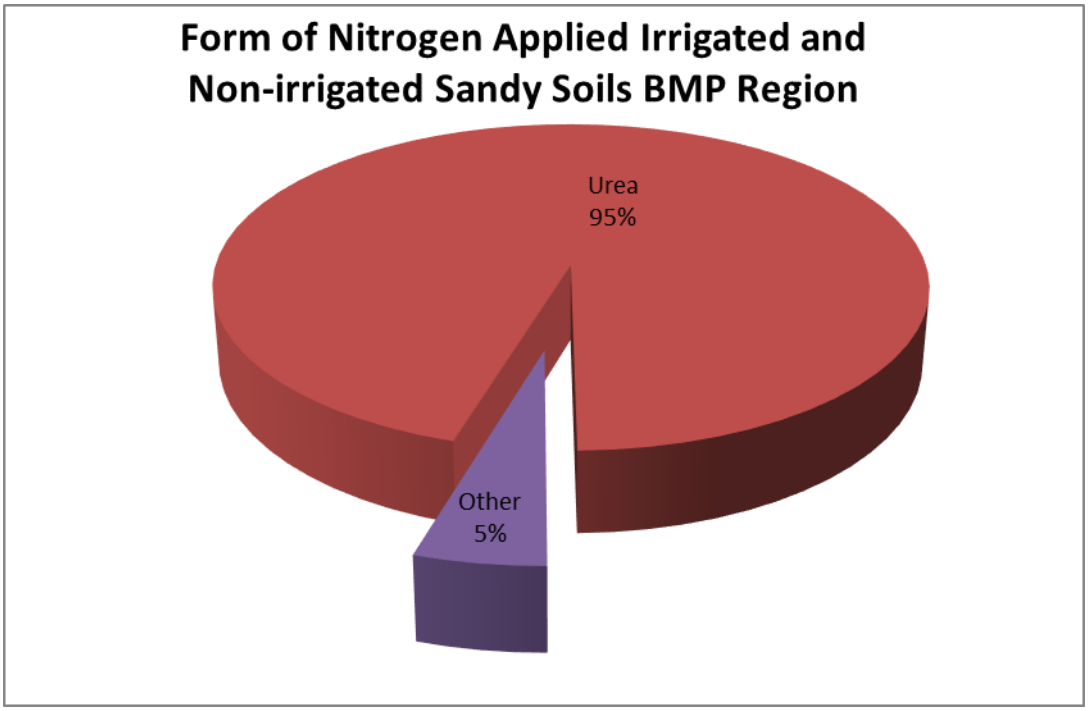

Figure 5. The form of the nitrogen applied to wheat acres in the IRR BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 6 details the form of nitrogen that was applied to wheat acres in the Combined BMP regions based on total pounds of nitrogen applied (WFQ-FERT TABLE).

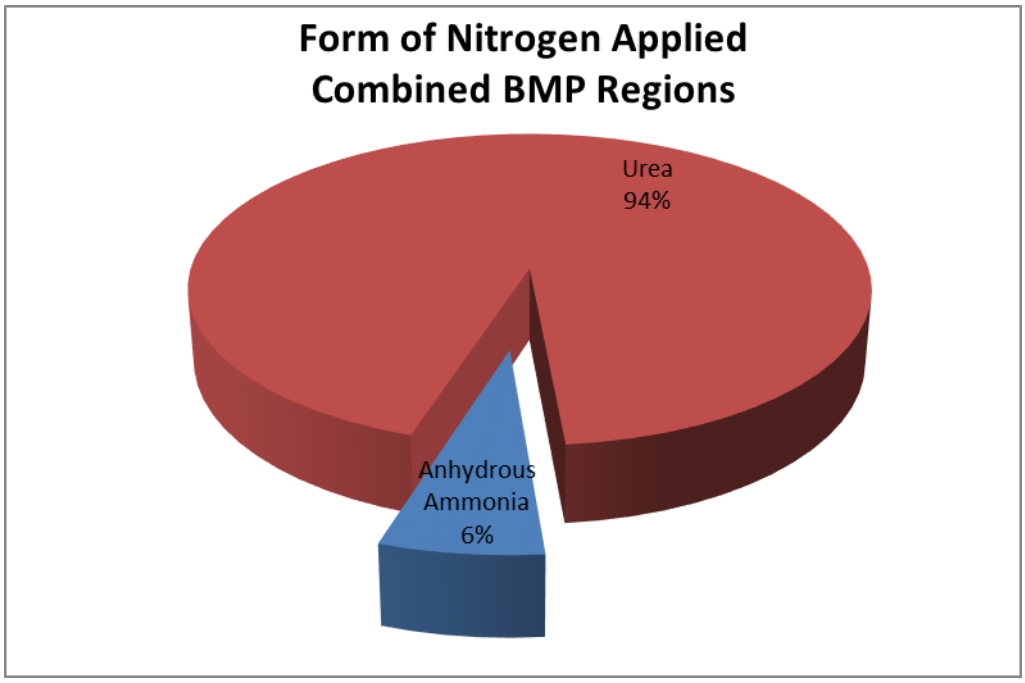

Figure 6. The form of the nitrogen applied to wheat acres in the Combined BMP regions for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 7 details the application timing of anhydrous ammonia on wheat acres in Minnesota for the largest field by pounds of nitrogen applied (WFQ-FERT TABLE).

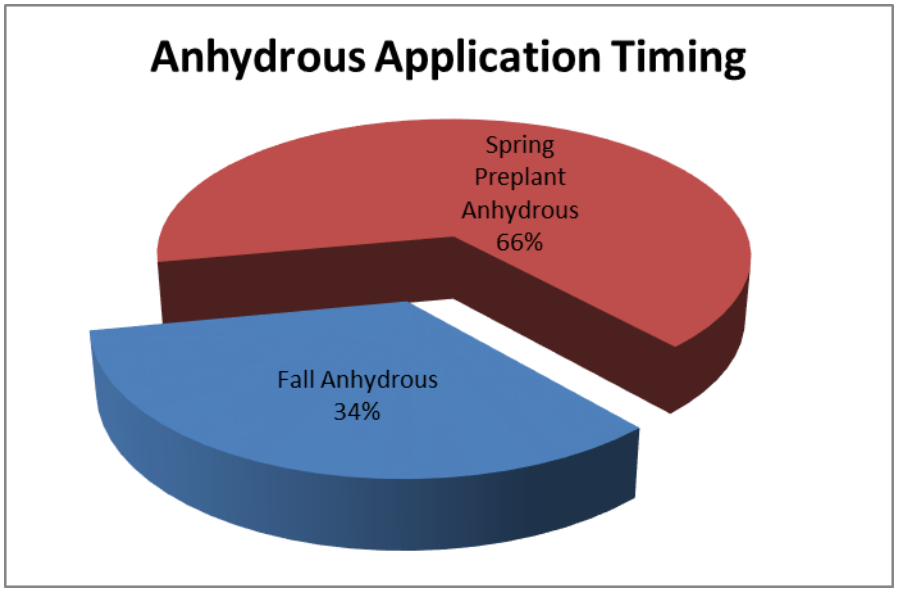

Figure 7. The application timing of anhydrous ammonia to wheat acres in Minnesota by pounds of nitrogen applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 8 details the application timing of urea on wheat acres in Minnesota for the largest field by pounds of nitrogen applied (WFQ-FERT TABLE).

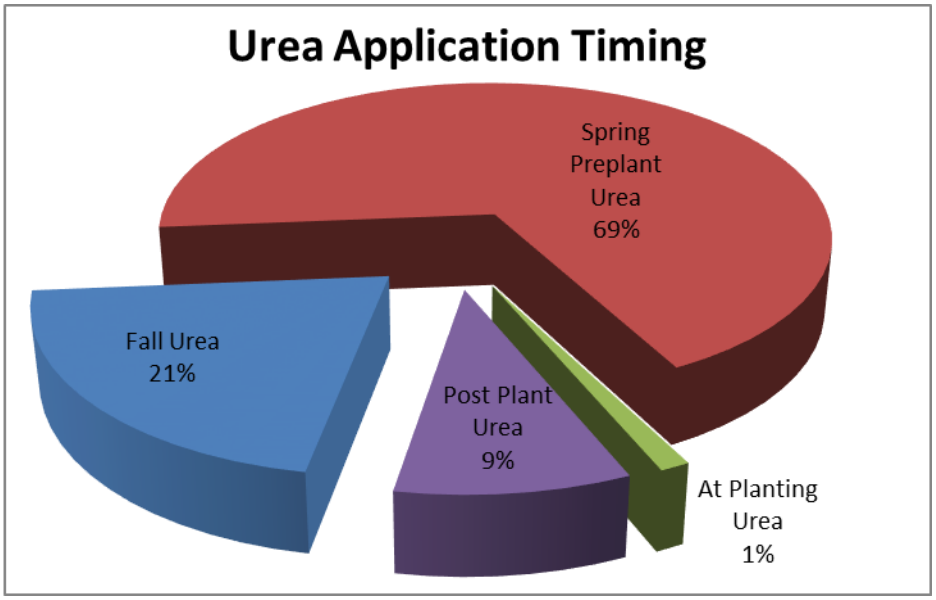

Figure 8. The application timing of urea to wheat acres in Minnesota by pounds of nitrogen applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 9 details the application timing of liquid nitrogen fertilizer on wheat acres in Minnesota for the largest field by pounds of nitrogen applied (WFQ-FERT TABLE).

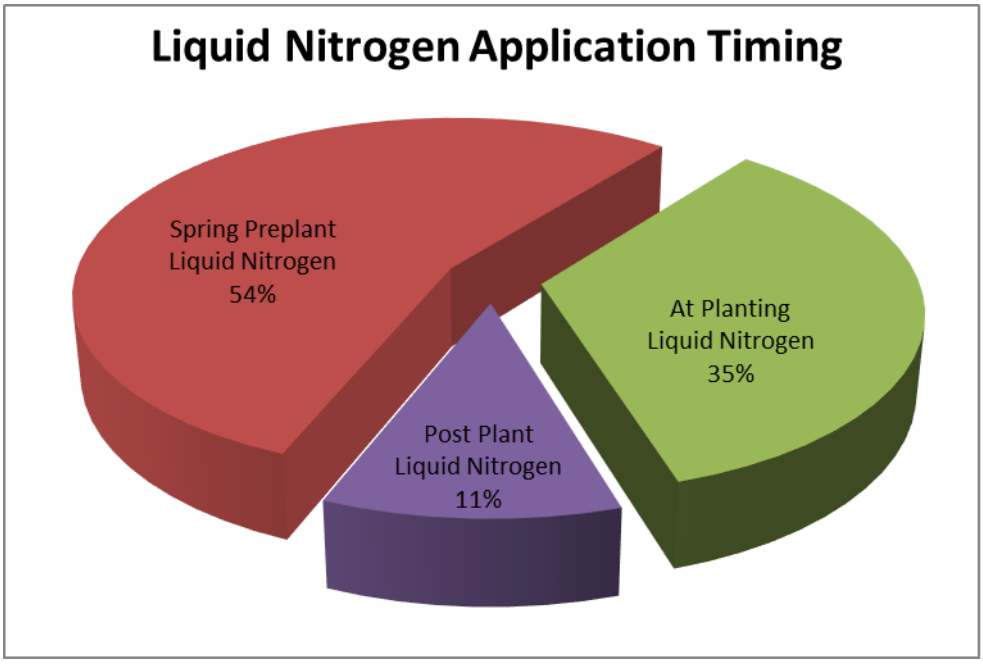

Figure 9. The application timing of liquid nitrogen fertilizer to wheat acres in Minnesota by pounds of nitrogen applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 10 details the application timing of other nitrogen sources on wheat acres in Minnesota for the largest field by pounds of nitrogen applied (WFQ-FERT TABLE).

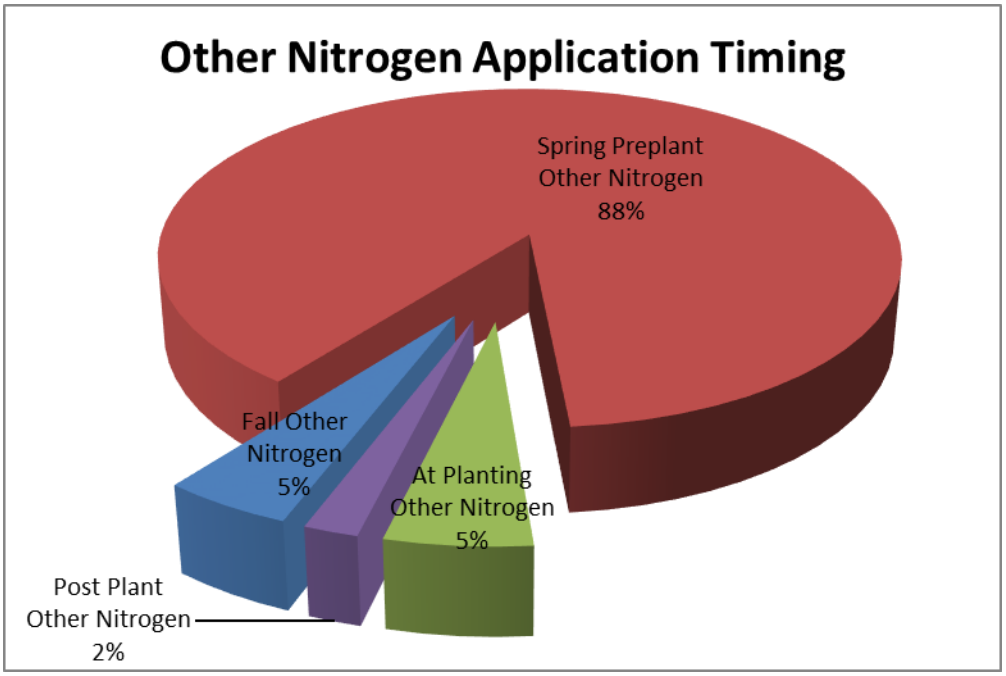

Figure 10. The application timing of other nitrogen sources to wheat acres in Minnesota by pounds of nitrogen applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 11 details the application timing of phosphorus on wheat acres in Minnesota for the largest field by pounds of phosphorus applied (WFQ-FERT TABLE).

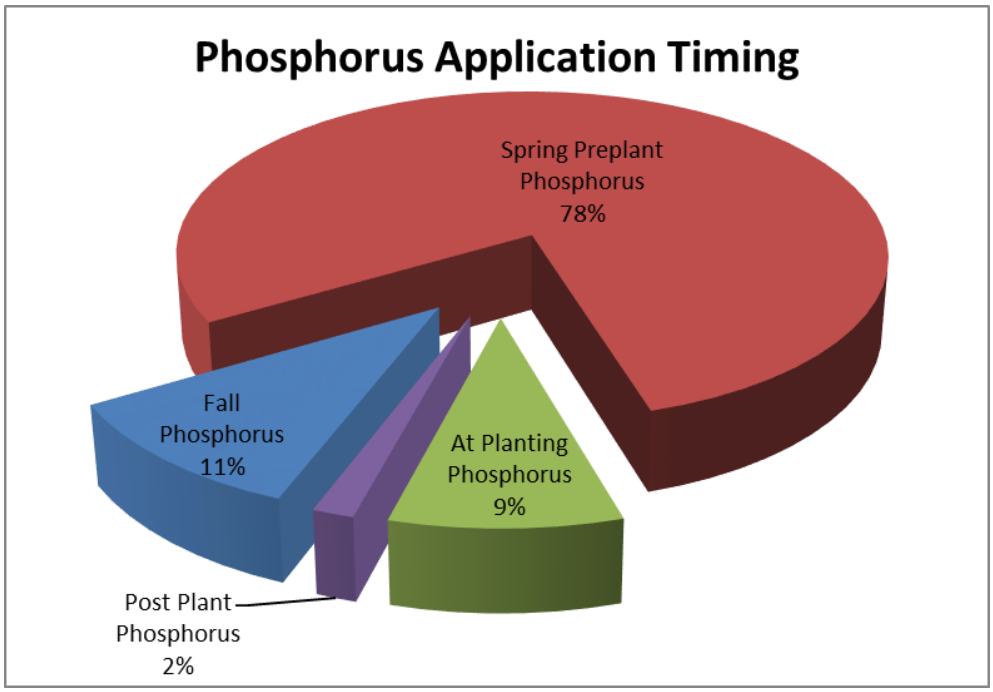

Figure 11. The application timing of phosphorus to wheat acres in Minnesota by pounds of phosphorus applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 12 details the application timing of potassium on wheat acres in Minnesota for the largest field by pounds of potassium applied (WFQ-FERT TABLE).

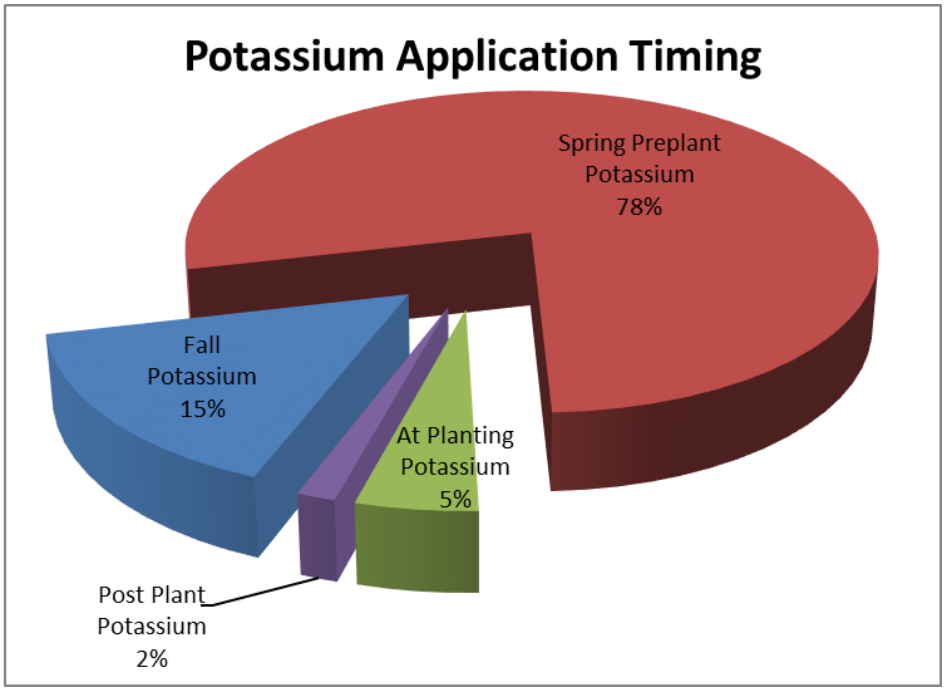

Figure 12. The application timing of potassium to wheat acres in Minnesota by pounds of potassium applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 13 details the application timing of sulfur on wheat acres in Minnesota for the largest field by pounds of sulfur applied (WFQ-FERT TABLE).

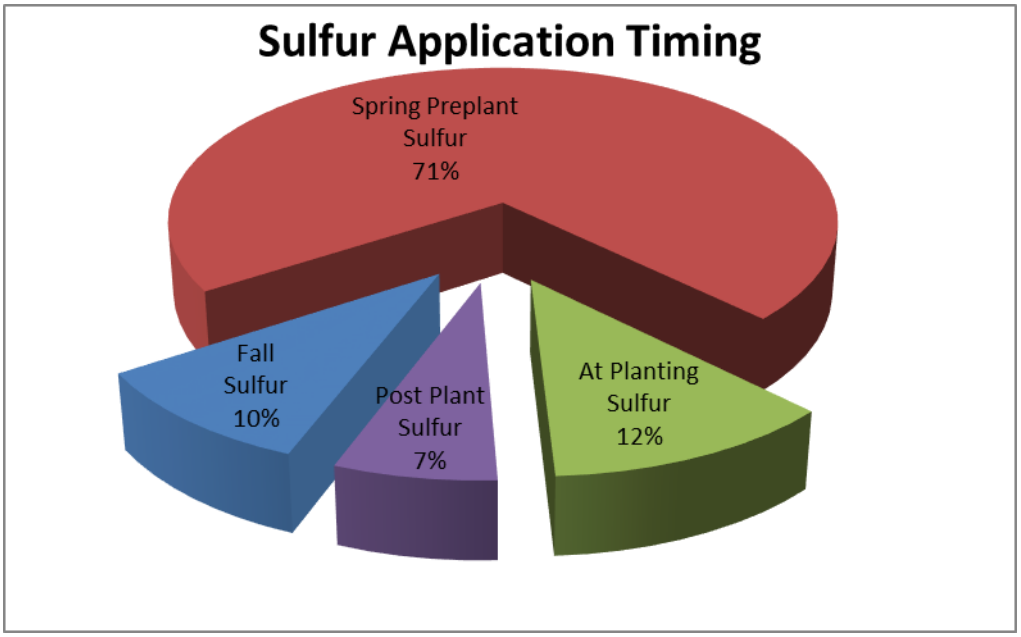

Figure 13. The application timing of sulfur to wheat acres in Minnesota by pounds of sulfur applied in the 2018 survey (Based on total pounds applied to the largest field)

Farmers were asked “Did you use a nitrogen inhibitor or stabilizer on this field?”

Table 52 details the percent of respondents that used a nitrogen inhibitor or stabilizer in 2017 or 2018 for the 2018 wheat crop on the farmer’s largest field (WFQ-6 and WFQ-10).

Table 52. Nitrogen inhibitor or stabilizer use for the 2018 wheat crop

BMP Region	Nitrogen Inhibitor or Stabilizer Use	Percent of Respondents	Average Wheat Yield Bushels per Acre
Northwestern	Yes	12	62
Northwestern	No	88	60
Northwestern	Don’t Know	**	**
Irrigated and Non-irrigated Sandy Soils	Yes	31	44
Irrigated and Non-irrigated Sandy Soils	No	69	47
Irrigated and Non-irrigated Sandy Soils	Don’t Know	**	**
Southwestern and West Central	Yes	18	43
Southwestern and West Central	No	80	48
Southwestern and West Central	Don’t Know	**	**
Combined BMP Regions	Yes	**	**
Combined BMP Regions	No	93	47
Combined BMP Regions	Don’t Know	**	**
Statewide	**Yes**	**22**	**50**
Statewide	**No**	**77**	**56**
Statewide	**Don’t Know**	****	****

** Less than five responses

The following tables and figures in the remaining wheat section represent the 3,218 statistically weighted respondents that reported on their largest wheat field including fertilizer rate, timing, and previous crop planted. Fertilizer rates are based on the rate for each nutrient applied (nitrogen rate for fields fertilized with nitrogen, phosphorus rate for fields fertilized with phosphorus, potassium rate for fields fertilized with potassium, and sulfur rate for fields fertilized with sulfur). Nutrient rates are only published if there are more than five responses.

Statewide: Wheat Following Soybeans

Statewide, eighty seven percent of the represented fields reported were wheat following soybeans. Figure 14 details the BMP regions where farmers reported on fields with wheat following soybeans. There were 2,796 fields represented in Minnesota.[17]

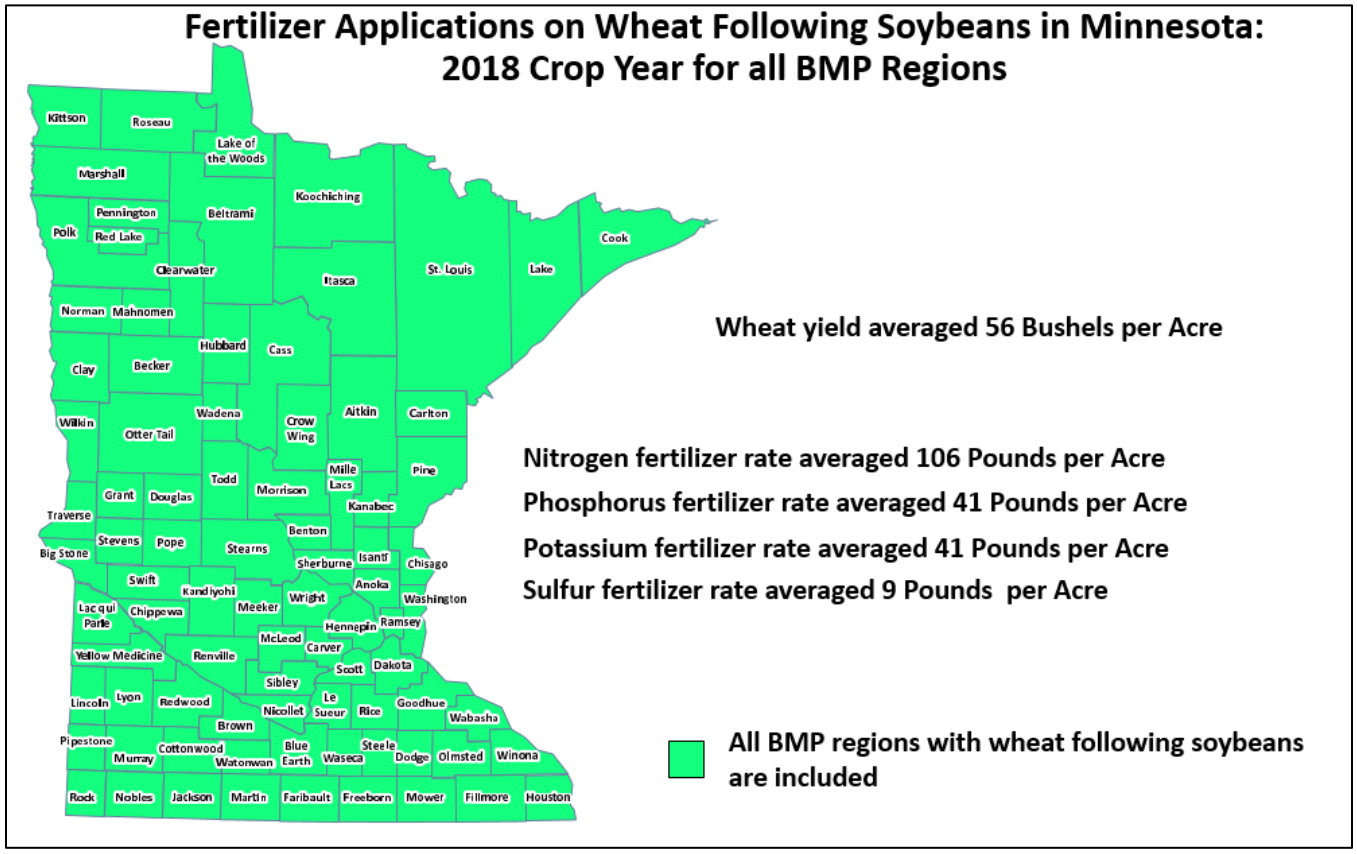

Figure 14. The average wheat yield and average fertilizer rate for wheat following soybeans in Minnesota

[17] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 90% applied phosphorus, 75% applied potassium, and 39% applied sulfur on fields with wheat following soybeans.

Figure 15 provides the distribution of average nitrogen fertilizer rate in Minnesota for wheat following soybeans; the corresponding wheat yield is detailed in red. Nitrogen rates are only from commercial fertilizer.

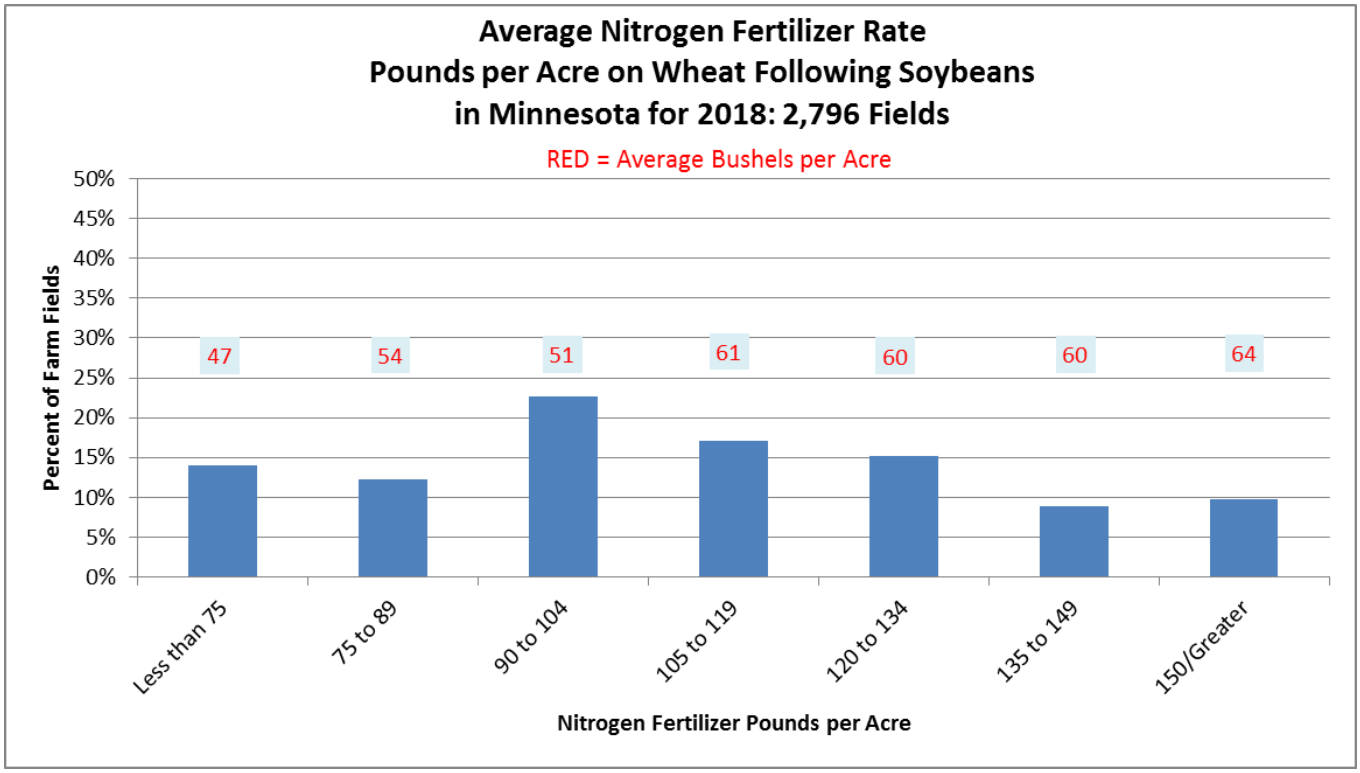

Figure 15. Average nitrogen fertilizer rate and yield on wheat following soybeans in Minnesota for 2018: 2,796 fields

In Minnesota, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; corresponding yield; and the average nutrient rate across all fertilized fields of wheat following soybeans are shown in Table 53.

Table 53. Average fertilizer rate and yield on fertilized wheat fields in Minnesota for wheat following soybeans

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient[18] Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields[19] Pounds per Acre
Nitrogen	100	106	56	106
Phosphorus	90	41	57	37
Potassium	75	41	55	31
Sulfur	39	9	59	3

[18] Represents the average rate of a nutrient on fields receiving the same nutrient. For example, 41 pounds per acre of phosphorus was applied on fields receiving phosphorus. Fields not receiving phosphorus were not included.

[19] Represents the average rate of a nutrient on all fields receiving fertilizer. For example, 31 pounds per acre of phosphorus was applied on fields receiving fertilizer. This could include MAP, DAP, urea, anhydrous ammonia, etc.

Combined BMP Regions: Wheat Following Soybeans

There were 64 fields that were represented in the Combined BMP regions for the wheat following soybeans analysis. Figure 16 details the location, average rate of nitrogen, phosphorus, potassium, sulfur, and average yield for wheat following soybeans in the Combined BMP regions.[20]

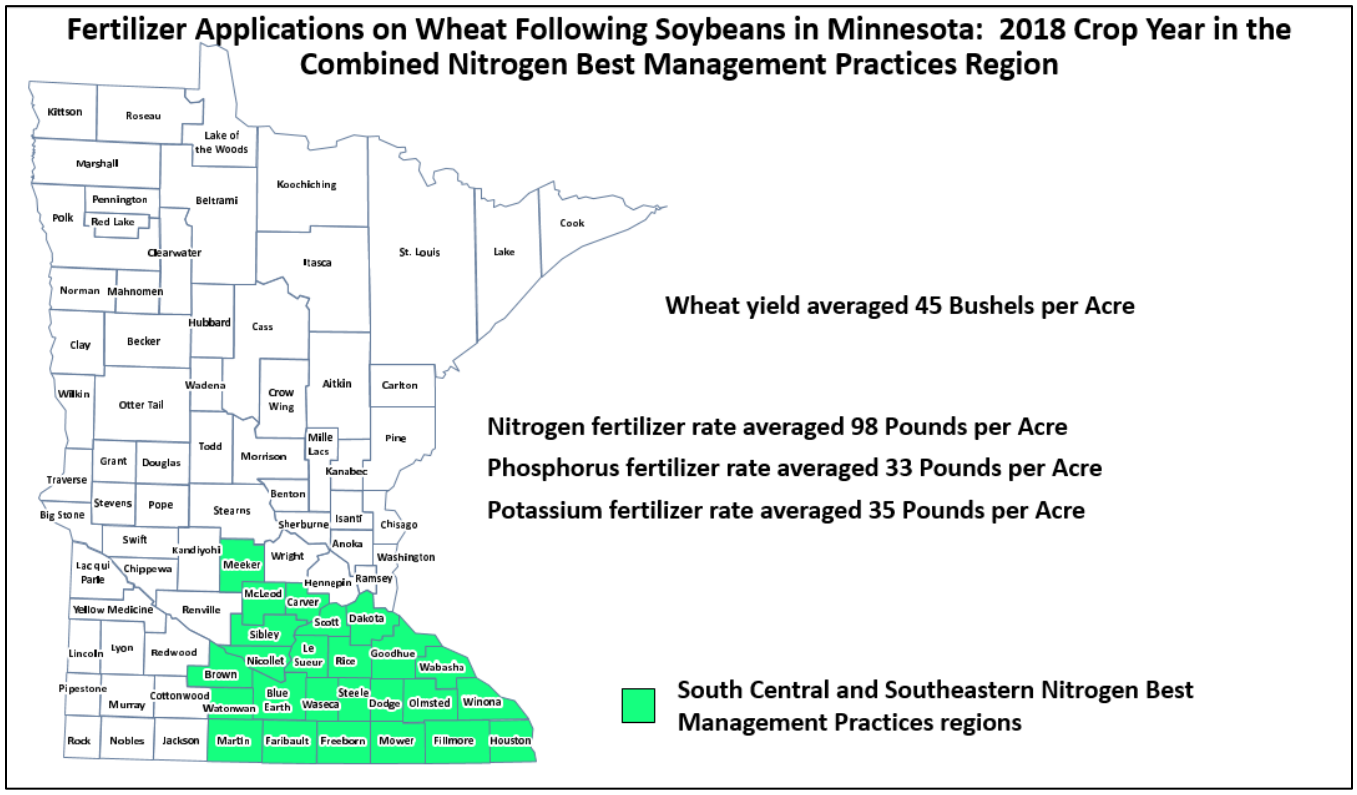

Figure 16. The average wheat yield and average fertilizer rate for wheat following soybeans in the Combined BMP regions

[20] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 100% applied phosphorus, and 100% applied potassium. Less than five respondents surveyed reported applied sulfur on fields with wheat following soybeans.

Figure 17 provides the distribution of nitrogen fertilizer rate in the Combined BMP regions for wheat following soybeans; the corresponding wheat yield are detailed in red.[21] Nitrogen rates are only from commercial fertilizer.

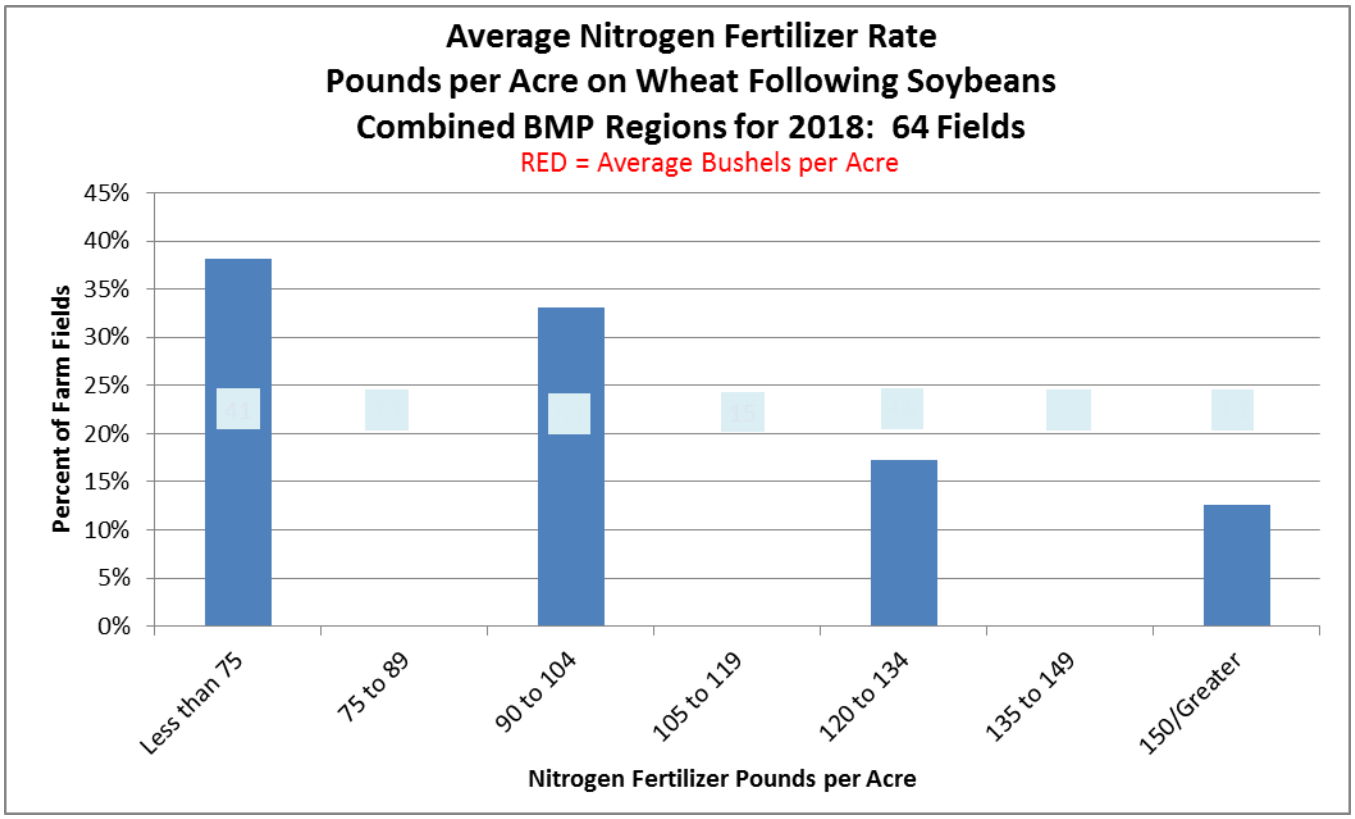

Figure 17. Average nitrogen fertilizer rate and yield on wheat following soybeans in the Combined BMP regions for 2018: 64 fields

In the Combined BMP regions, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; corresponding yield; and the average nutrient rate across all fertilized fields of wheat following soybeans are shown in Table 54.

Table 54. Average fertilizer rate and yield in the Combined BMP regions for wheat following soybeans

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields Pounds per Acre
Nitrogen	100	98	45	98
Phosphorus	100	33	45	33
Potassium	100	35	45	35
Sulfur	**	**	**	**

** Less than five responses

[21] Yields are not published if there are less than five responses.

Southwestern and West Central BMP Region: Wheat Following Soybeans

There were 594 fields that were represented in the SW BMP region for the wheat following soybeans analysis. Figure 18 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer and average yield for wheat following soybeans in the SW BMP region.[22]

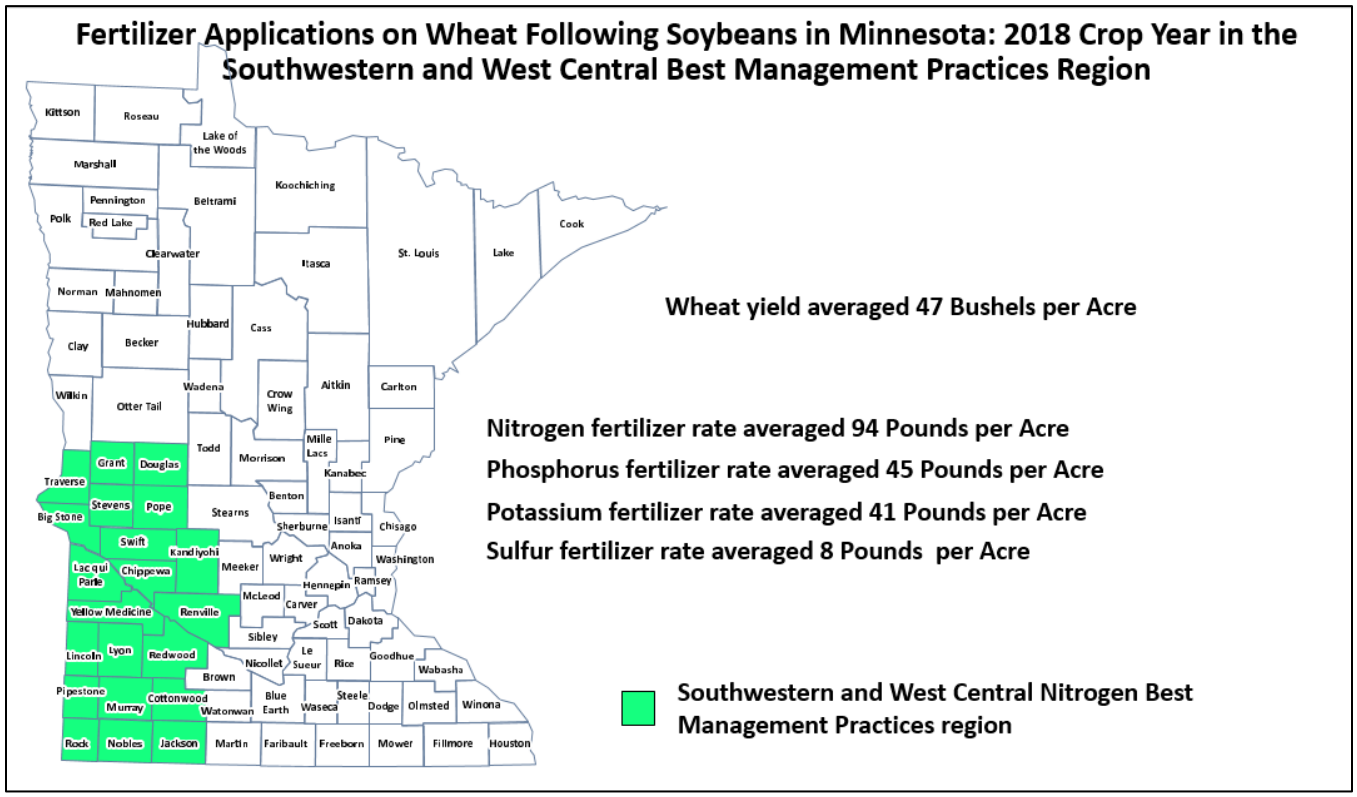

Figure 18. The average wheat yield and average fertilizer rate for wheat following soybeans in the SW BMP region

[22] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 82% applied phosphorus, 79% applied potassium, and 37% applied sulfur on fields with wheat following soybeans.

Figure 19 provides the distribution of nitrogen fertilizer rate in the SW BMP region for wheat following soybeans; the corresponding wheat yield is detailed in red.[23] Nitrogen rates are only from commercial fertilizer.

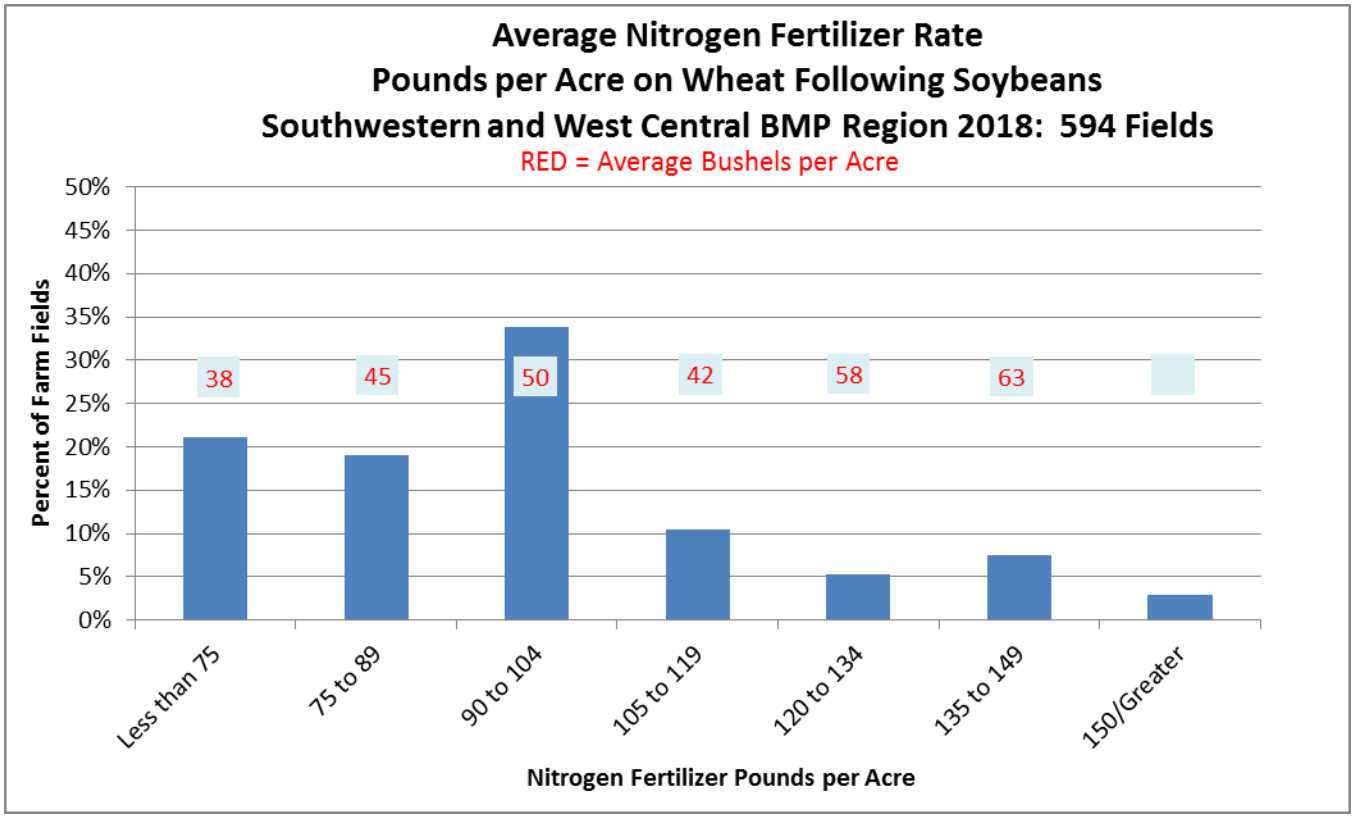

Figure 19. Average nitrogen fertilizer rate and yield on wheat following soybeans in the SW BMP region for 2018: 594 fields

In the SW BMP region, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; corresponding yield; and the average nutrient rate across all fertilized fields of wheat following soybeans are shown in Table 55.

Table 55. Average fertilizer rate and wheat yield in the SW BMP region for wheat following soybeans

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields Pounds per Acre
Nitrogen	100	94	47	94
Phosphorus	82	45	47	37
Potassium	79	41	46	32
Sulfur	37	8	50	3

[23] Yields are not published if there are less than five responses.

Northwestern BMP Region: Wheat Following Soybeans

There were 1,789 fields that were represented in the NW BMP region for the wheat following soybean analysis. Figure 20 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer and average yield for wheat following soybeans in the NW BMP region.[24]

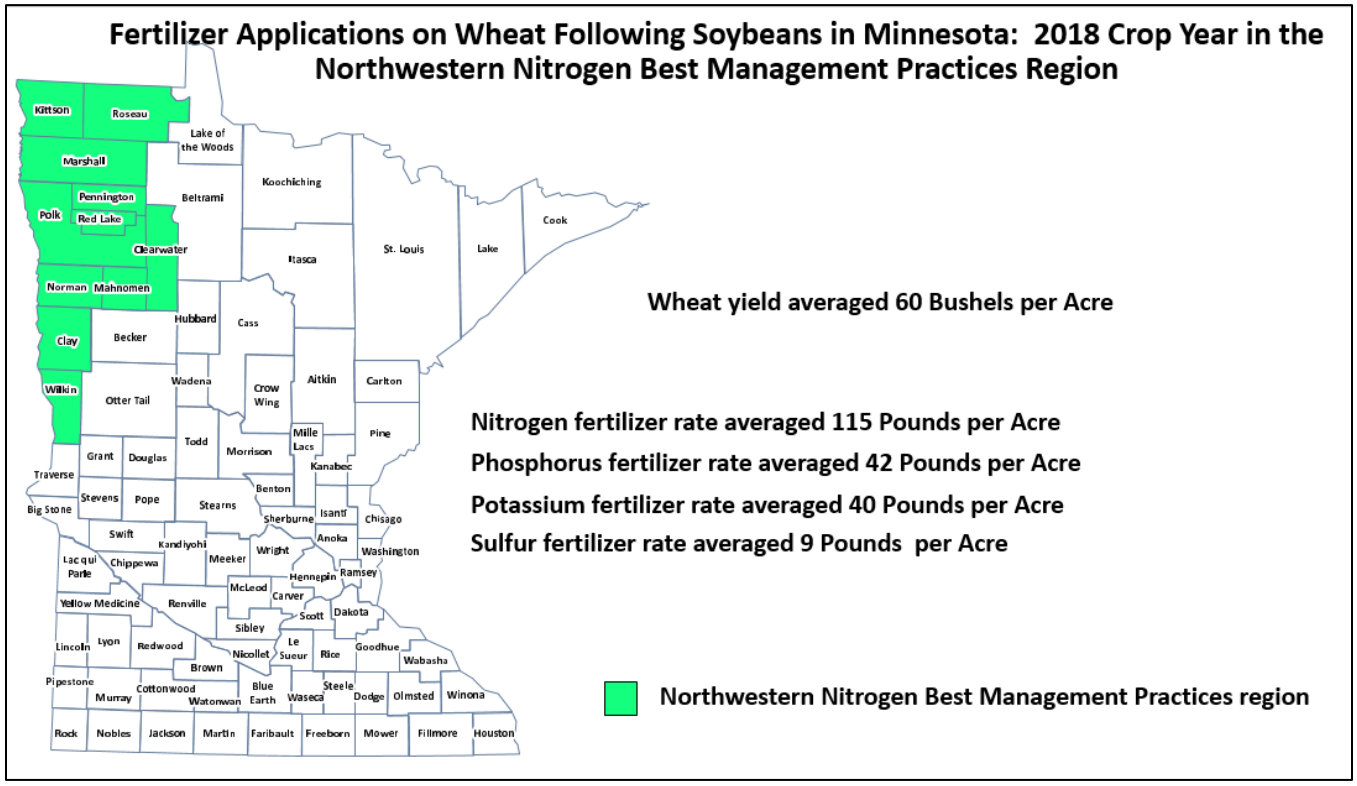

Figure 20. The average wheat yield and average fertilizer rate for wheat following soybeans in the NW BMP region

[24] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 94% applied phosphorus, 70% applied potassium, and 35% applied sulfur on fields with wheat following soybeans.

Figure 21 provides the distribution of nitrogen fertilizer rate in the NW BMP region for wheat following soybeans; the corresponding wheat yield is detailed in red. Nitrogen rates are only from commercial fertilizer.

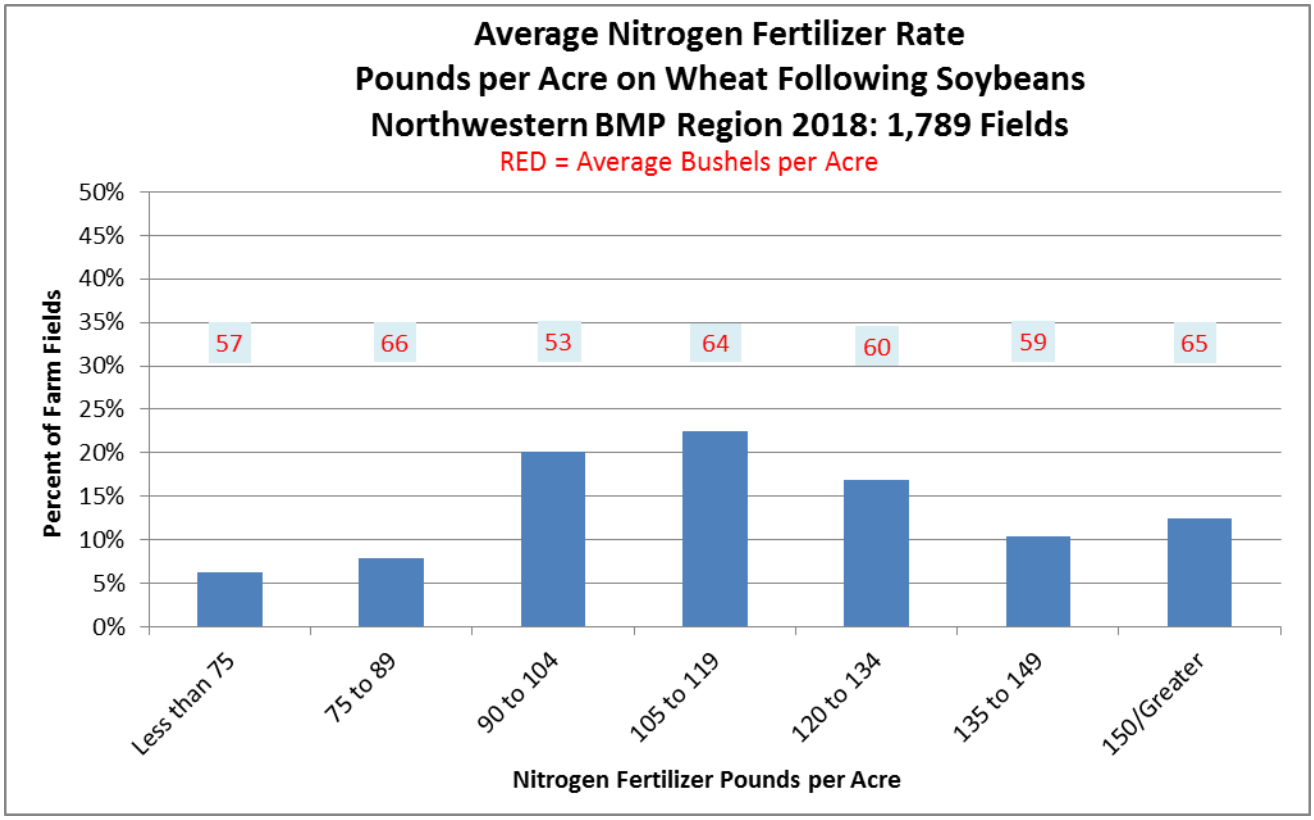

Figure 21. Average nitrogen fertilizer rate and yield on wheat following soybeans in the NW BMP region for 2018: 1,789 fields

In the NW BMP region, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur, pounds per acre of actual nutrients, corresponding yield, and the average nutrient rate across all fertilized fields of wheat following soybeans are shown in Table 56.

Table 56. Average fertilizer rate and wheat yield in the NW BMP region for wheat following soybeans

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields Pounds per Acre
Nitrogen	100	115	60	115
Phosphorus	94	42	61	40
Potassium	70	40	60	28
Sulfur	35	9	64	3

Irrigated and Non-irrigated Sandy Soils BMP Region: Wheat Following Soybeans

There were 349 fields that were represented in the IRR BMP region for the wheat following soybean analysis. Figure 22 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer and average yield for wheat following soybeans in the IRR BMP region.[25]

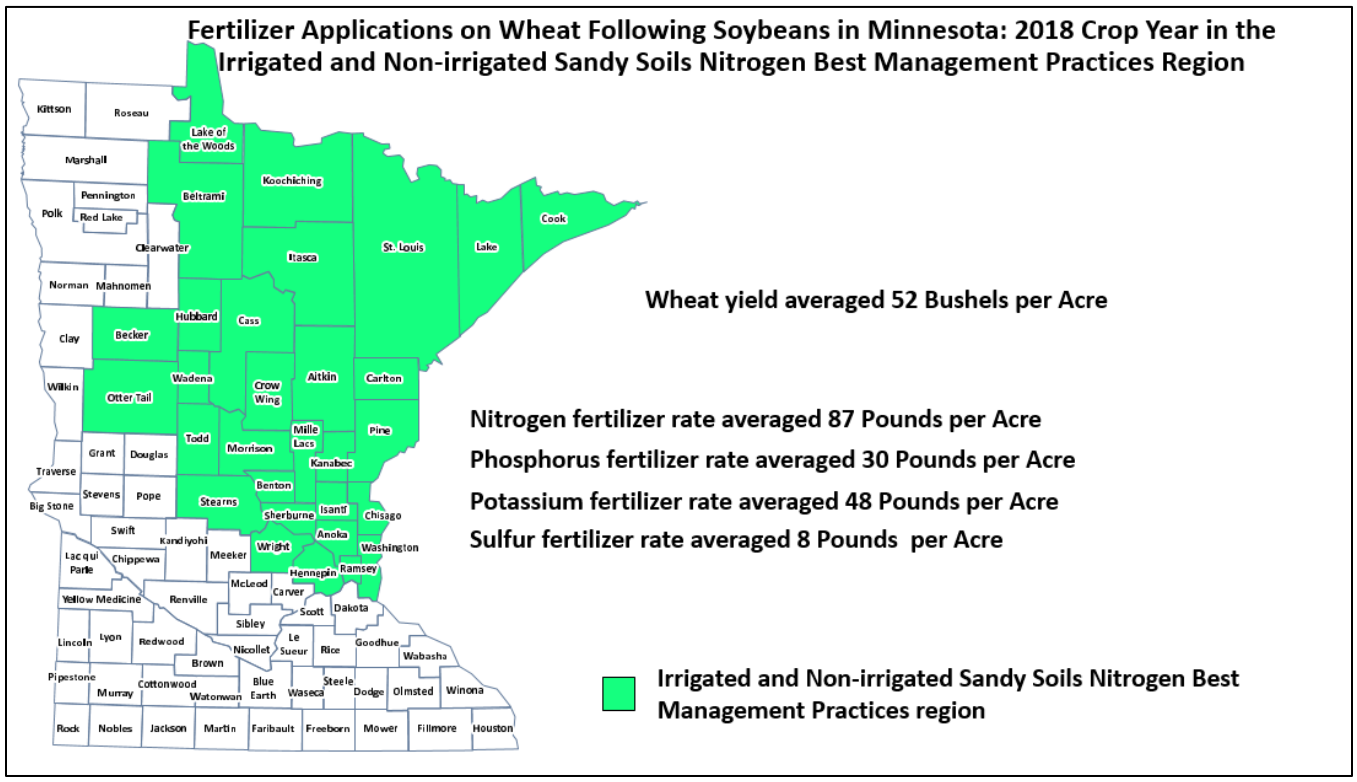

Figure 22. The average wheat yield and average fertilizer rate for wheat following soybeans in the IRR BMP region

[25] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 84% applied phosphorus, 93% applied potassium, and 52% applied sulfur on fields with wheat following soybeans.

Figure 23 provides the distribution of nitrogen fertilizer rate in the IRR BMP region for wheat following soybeans; the corresponding wheat yield is detailed in red.[26] Nitrogen rates are only from commercial fertilizer.

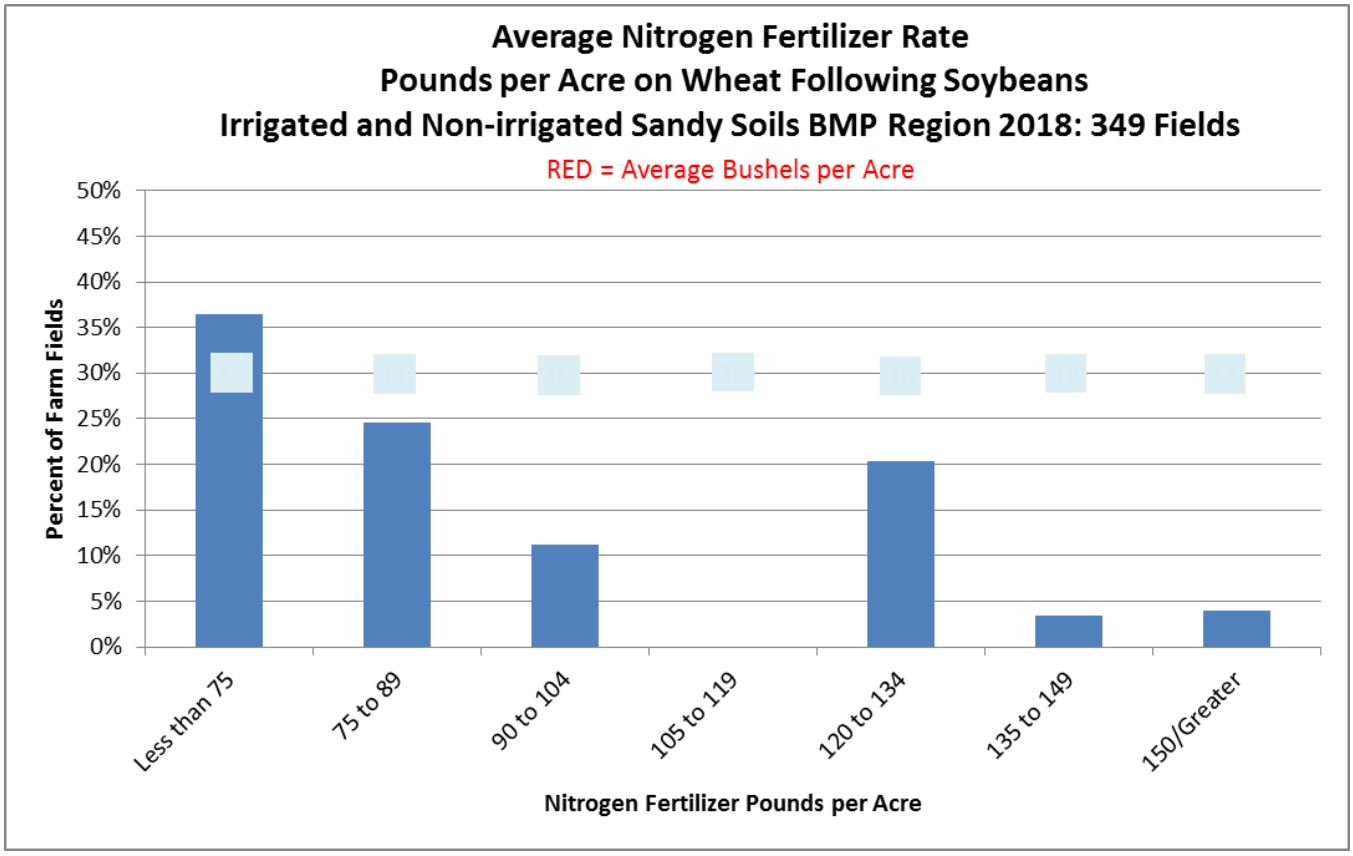

Figure 23. Average nitrogen fertilizer rate and yield on wheat following soybeans in the IRR BMP region for 2018: 349 fields

In the IRR BMP region, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; corresponding yield; and the average nutrient rate across all fertilized fields of wheat following soybeans are shown in Table 57.

Table 57. Average fertilizer rate and wheat yield in the IRR BMP region for wheat following soybeans

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields Pounds per Acre
Nitrogen	100	87	52	87
Phosphorus	84	30	50	25
Potassium	93	48	53	45
Sulfur	52	8	56	4

[26] Yields are not published if there are less than five responses.

Statewide: Wheat Following Corn

Statewide, three percent of the fields reported were wheat following corn. Figure 24 details the BMP regions where farmers reported on fields with wheat following corn. There were 98 fields represented in Minnesota.[27]

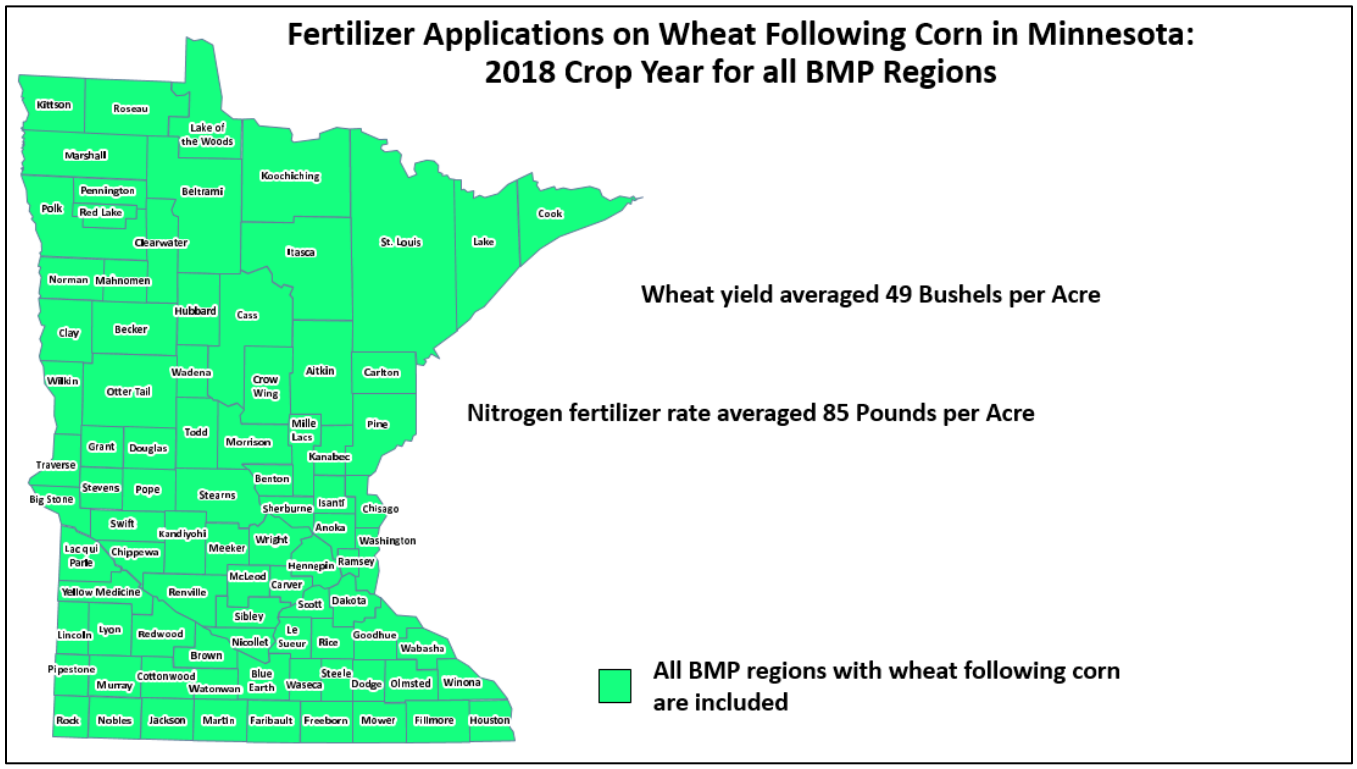

Figure 24. The average wheat yield and average fertilizer rate for wheat following corn in Minnesota

[27] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen. Less than five respondents reported applying phosphorus, potassium, and sulfur.

Figure 25 provides the distribution of average nitrogen fertilizer rate in Minnesota for wheat following corn; the corresponding wheat yield is detailed in red.[28] Nitrogen rates are only from commercial fertilizer.

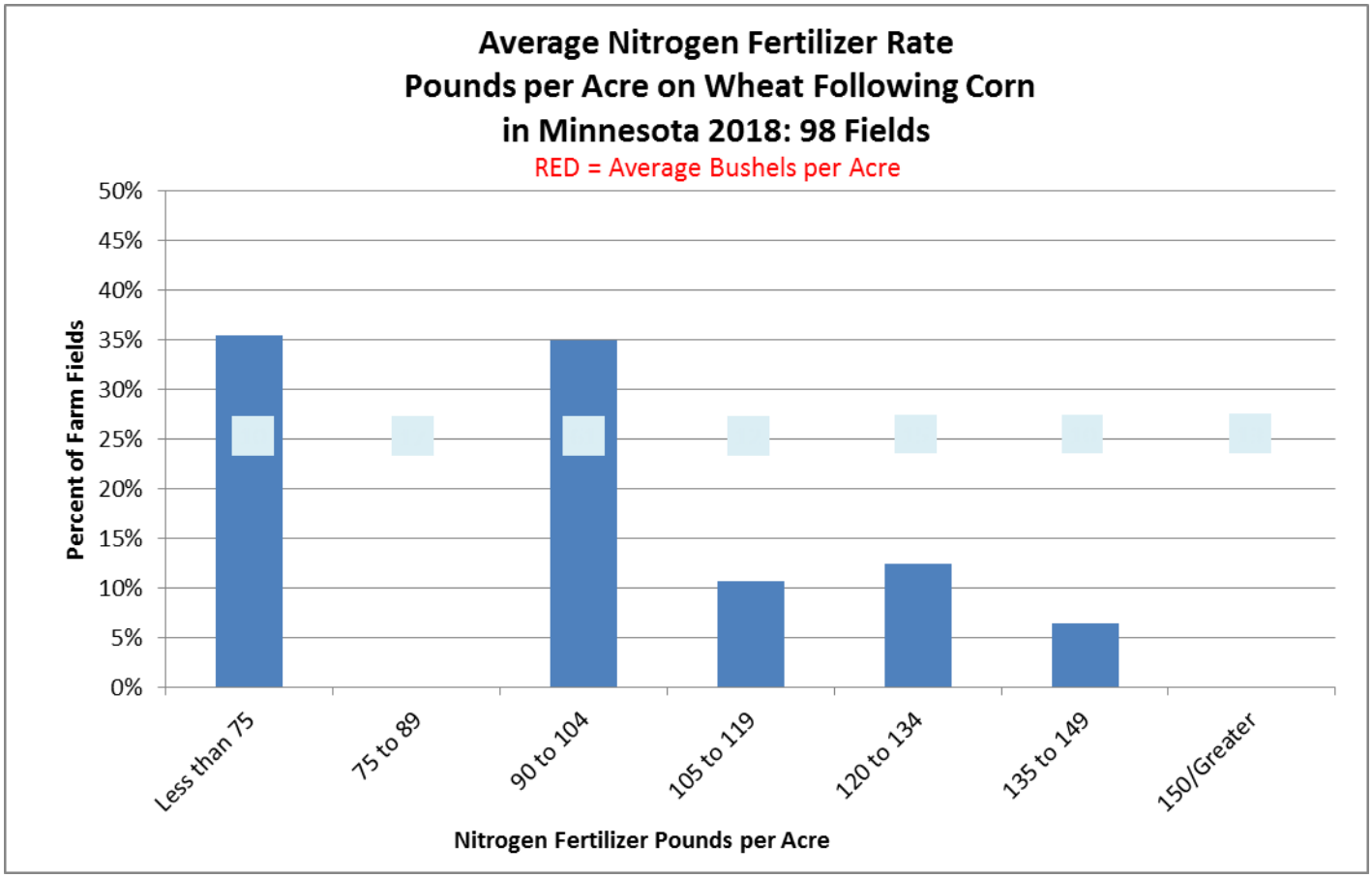

Figure 25. Average nitrogen fertilizer rate and yield on wheat following corn in Minnesota for 2018: 98 fields

In Minnesota, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; corresponding yield; and the average nutrient rate across all fertilized fields of wheat following corn are shown in Table 58.

Table 58. Average fertilizer rate and wheat yield in Minnesota for wheat following corn

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields Pounds per Acre
Nitrogen	100	85	49	85
Phosphorus	**	**	**	**
Potassium	**	**	**	**
Sulfur	**	**	**	**

** Less than five responses

[28] Yields are not published if there are less than five responses.

Combined BMP Regions: Wheat Following Corn

The Combined BMP regions had less than five responses for wheat following corn.

Southwestern and West Central BMP Region: Wheat Following Corn

The SW BMP region had less than five responses for wheat following corn.

Northwestern BMP Region: Wheat Following Corn

The NW BMP region had less than five responses for wheat following corn.

Irrigated and Non-irrigated Sandy Soils BMP Region: Wheat Following Corn

The IRR BMP region had less than five responses for wheat following corn.

Statewide: Wheat Following Corn Following Alfalfa

Statewide, no responses were reported for wheat following alfalfa.

Statewide: Wheat Following Alfalfa

Statewide, less than five responses were reported for wheat following alfalfa.

Statewide: Wheat Following Small Grains

Statewide, less than five responses were reported for wheat following small grains.

Statewide: Wheat Following Other Crops

Statewide, six percent of the fields represented were wheat following other crops. Figure 26 details the BMP regions where farmers reported on fields with wheat following other crops. There were 193 fields represented in Minnesota.[29]

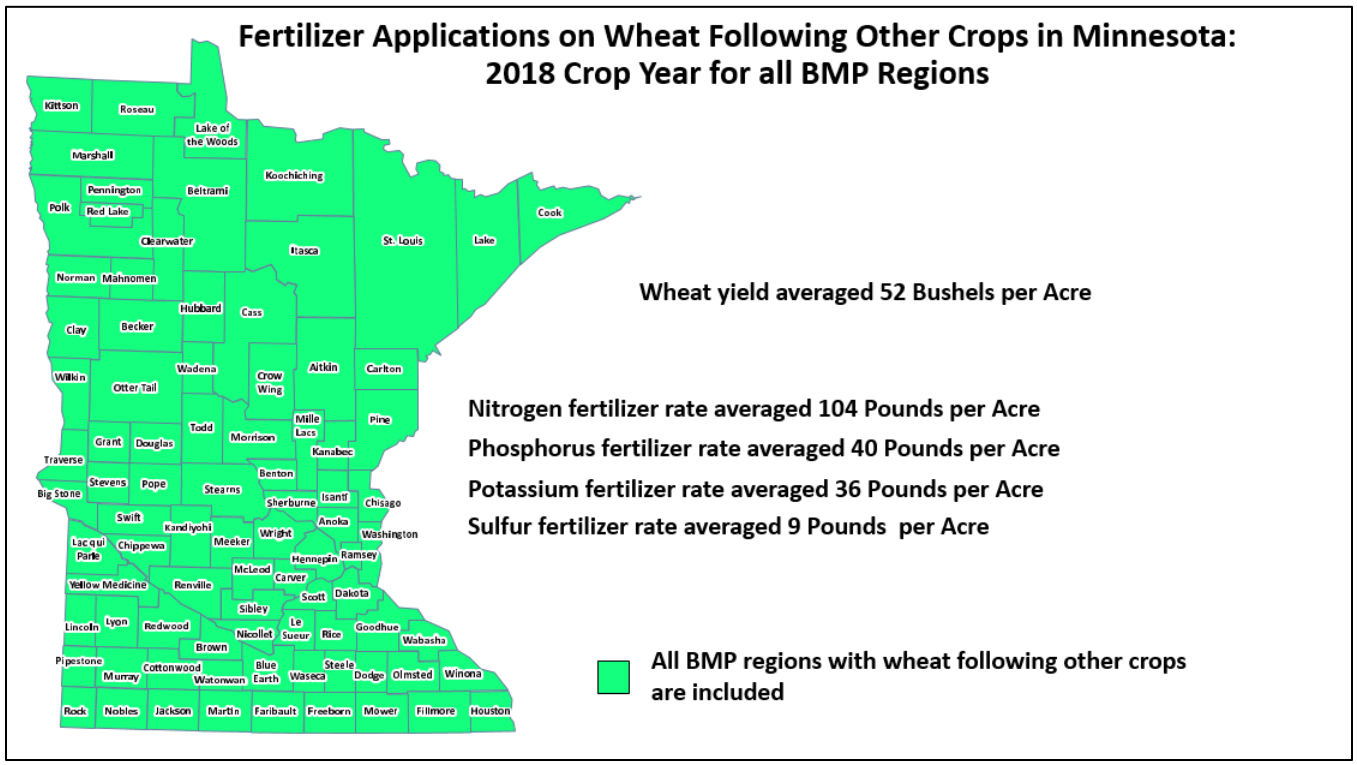

Figure 26. The average wheat yield and average fertilizer rate for wheat following other crops in Minnesota

[29] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 100% applied phosphorus, 88% applied potassium, and 55% applied sulfur on fields with wheat following other crops.

Figure 27 provides the distribution of average nitrogen fertilizer rate in Minnesota for wheat following other crops; the corresponding wheat yield is detailed in red.[30] Nitrogen rates are only from commercial fertilizer.

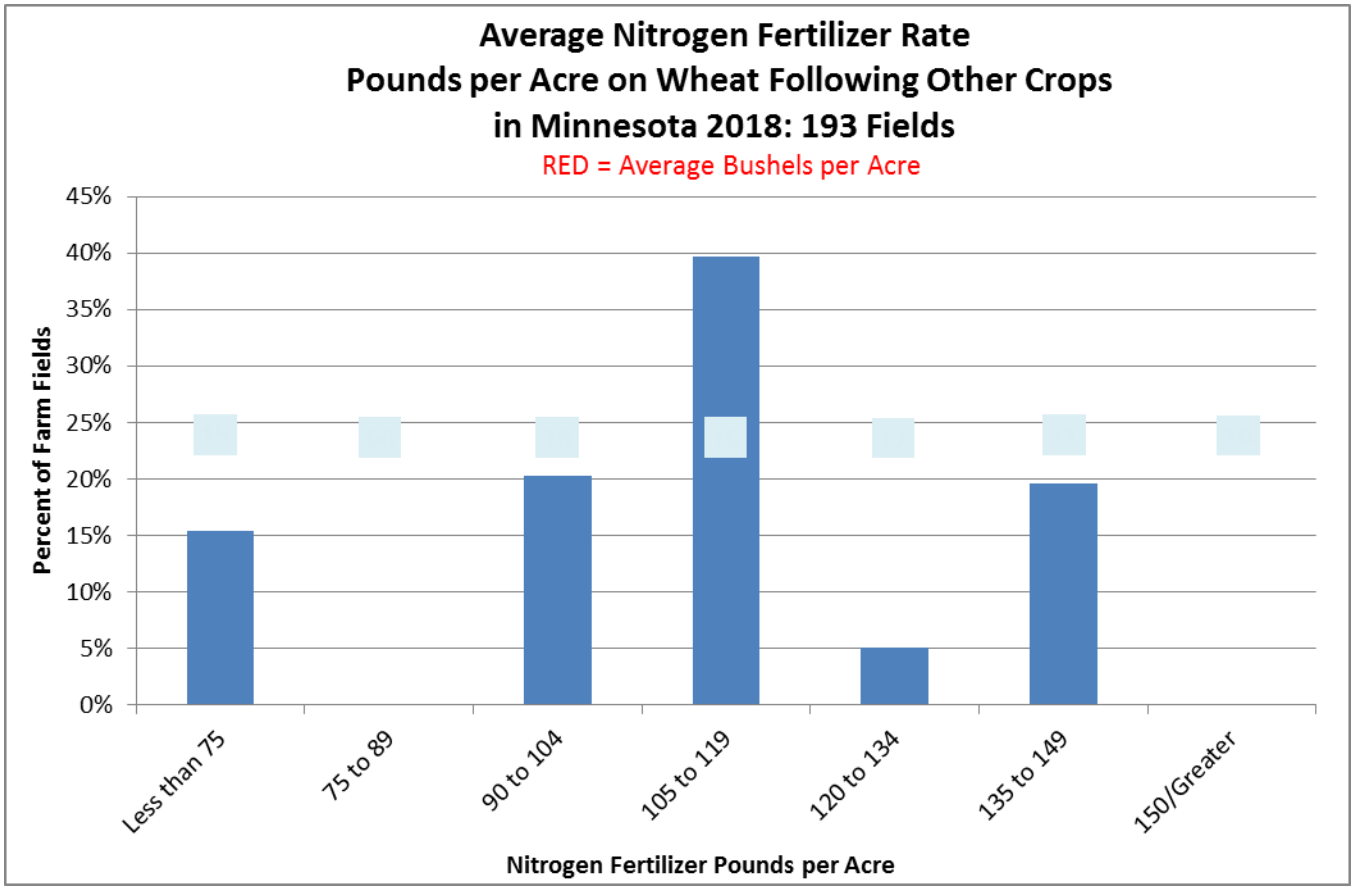

Figure 27. Average nitrogen fertilizer rate and yield on wheat following other crops in Minnesota for 2018: 193 fields

In Minnesota, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; corresponding yield; and the average nutrient rate across all fertilized fields of wheat following other crops are shown in Table 59.

Table 59. Average fertilizer rate and wheat yield in Minnesota for wheat following other crops

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields Pounds per Acre
Nitrogen	100	104	52	104
Phosphorus	100	40	52	40
Potassium	88	36	52	32
Sulfur	55	9	53	5

** Less than five responses

[30] Yields are not published if there are less than five responses.

Combined BMP Regions: Wheat Following Other Crops

The Combined BMP regions had no responses for wheat following other crops.

Southwestern and West Central BMP Region: Wheat Following Other Crops

The SW BMP region had no responses for wheat following other crops.

Northwestern BMP Region: Wheat Following Other Crops

There were 118 fields that were included in the NW BMP region for wheat following other crops analysis. Figure 28 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer and average yield for wheat following other crops in the NW BMP region.[31]

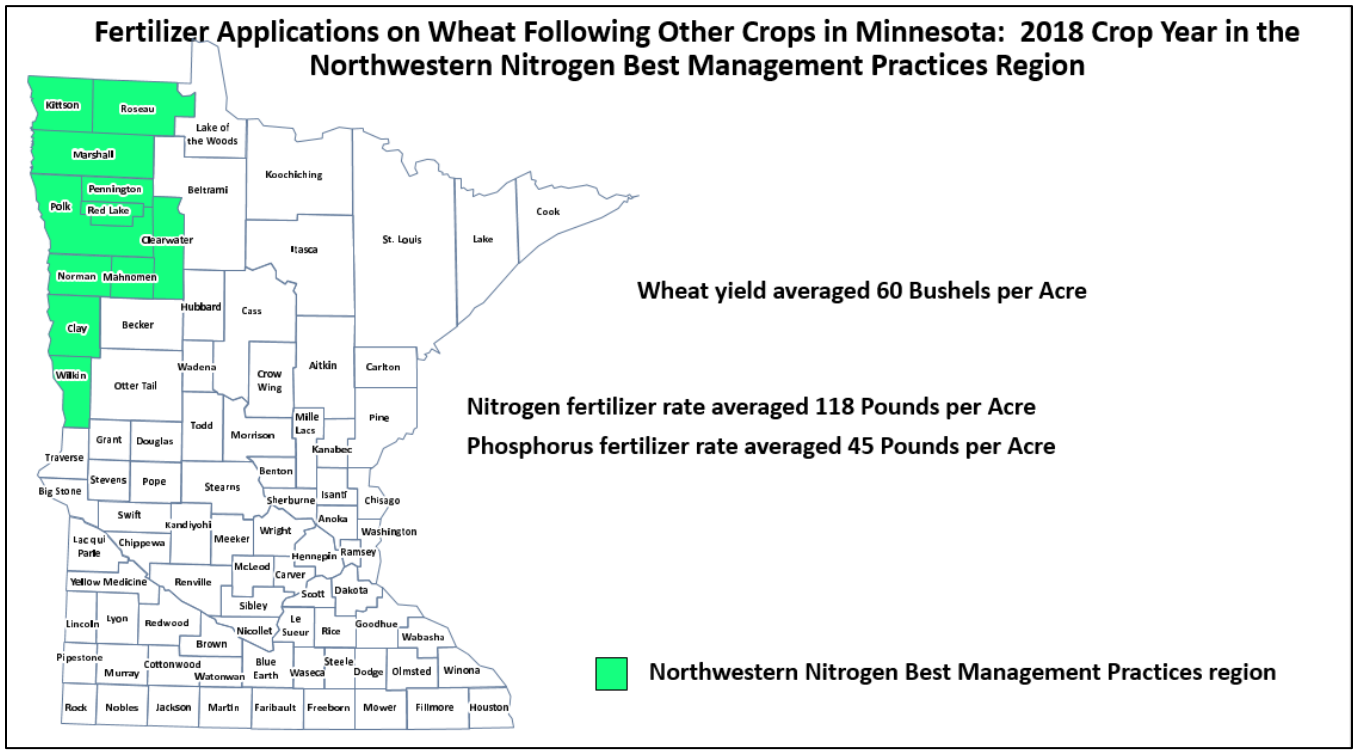

Figure 28. The average wheat yield and average fertilizer rate for wheat following other crops in the NW BMP region

[31] The published averages are for respondents that applied commercial fertilizer on wheat fields without manure to the 2018 wheat crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen and 100% applied phosphorus on fields with wheat following other crops. Less than five respondents reported applying potassium or sulfur.

Figure 29 provides the distribution of average nitrogen fertilizer rate in the NW BMP region for wheat following other crops; the corresponding wheat yield is detailed in red.[32] Nitrogen rates are only from commercial fertilizer.

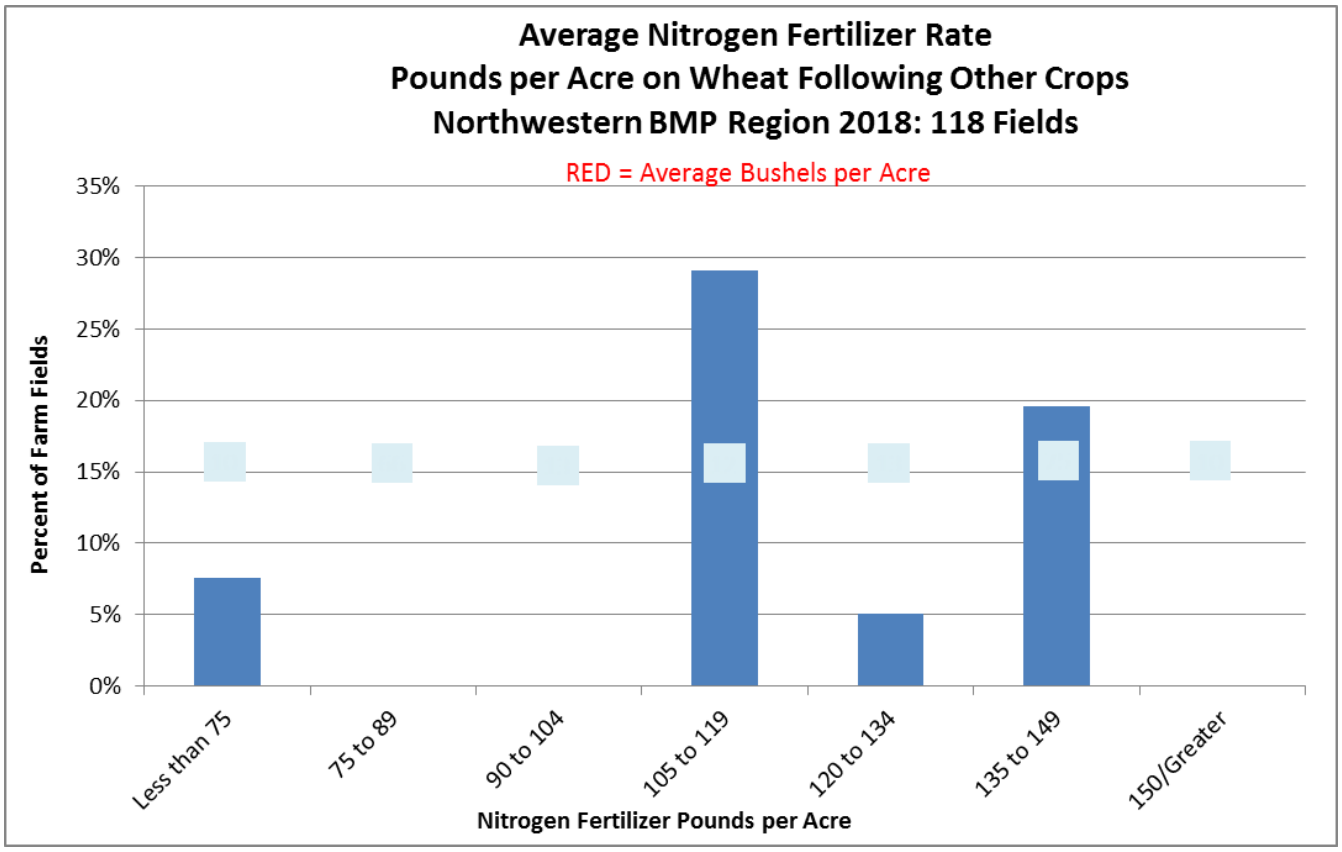

Figure 29. Average nitrogen fertilizer rate and yield on wheat following other crops in the NW BMP region for 2018: 118 fields

In the NW BMP region, the percent of fertilized wheat fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; corresponding yield; and the average nutrient rate across all fertilized fields of wheat following other crops are shown in Table 60.

Table 60. Average fertilizer rate and wheat yield in the NW BMP region for wheat following other crops

Nutrients Applied	Percent of Fertilized Wheat Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Wheat Yield Bushels per Acre	Average Commercial Nutrient Rate Across All Fertilized Wheat Fields Pounds per Acre
Nitrogen	100	118	60	118
Phosphorus	100	45	60	45
Potassium	**	**	**	**
Sulfur	**	**	**	**

** Less than five responses

[32] Yields are not published if there are less than five responses.

Irrigated and Non-irrigated Sandy Soils BMP Region: Wheat Following Other Crops

The IRR BMP region had less than five responses for wheat following other crops.

Hay Section

Hay can be harvested multiple times in a year. Due to these restraints, yields for hay were not collected.

Farmers in the survey were first asked "How many acres of hay were harvested in the 2018 crop year?" Table 61 details the number of farmers and corresponding hay acres planted by BMP region for the 2018 crop year (HAQ-1)[33].

Table 61. Summary of respondents and corresponding hay acres planted by BMP region for the 2018 crop year

BMP Region	Number of Respondents	Number of Hay Acres
Northwestern	1,365	191,701
Irrigated and Non-irrigated Sandy Soils	8,097	700,920
Southwestern and West Central	2,725	87,196
South Central	2,271	117,762
Southeastern	2,662	122,022
Statewide	**17,120**	**1,219,600**

Farmers in the survey were then asked, "Do you have a hay field without manure?" Table 62 details the percent of farmers who had a hay field without manure applied by BMP region (HFQ-1). Farmers that answered no to this question applied manure on all their hay fields for the 2018 growing year.

Table 62. Percent of respondents with a hay field without manure applied

BMP Region	Hay Field Without Manure Applied	Percent of Respondents
Northwestern	Yes	74
Northwestern	No	26
Irrigated and Non-irrigated Sandy Soils	Yes	75
Irrigated and Non-irrigated Sandy Soils	No	25
Southwestern and West Central	Yes	77
Southwestern and West Central	No	23
South Central	Yes	73
South Central	No	27
Southeastern	Yes	75
Southeastern	No	25
Statewide	**Yes**	**75**
Statewide	**No**	**25**

[33] HAQ1 is Hay All Question 1 and can be found at the end of the report in the appendix. All question references will be in this format. HFQ stands for Hay Fertilizer Question and is in the same appendix.

Table 63 details the number of represented respondents and all hay acres who reported having a field without manure applied to the 2018 hay crop. Due to the low amount of row crop agriculture in portions of Minnesota, survey results were not listed when there were less than five responses in any category for fertilizer with hay. Respondents and acres were excluded from Table 63 who applied manure on all of their hay fields. Farmers with manured acres will be analyzed in the manure section of this report.

Table 63. Summary of respondents and corresponding hay acres by BMP region for all fields without manure applied in the fall of 2017 or anytime in the 2018 crop year

BMP Region	Number of Respondents	Number of Hay Acres
Northwestern	986	156,838
Irrigated and Non-irrigated Sandy Soils	6,026	538,414
Southwestern and West Central	2,041	97,207
South Central	1,993	62,762
Southeastern	1,714	90,009
Statewide	**12,760**	**945,230**

All hay fields without manure applied are included in the analysis for the following table. Of the 12,760 represented hay farmers, there were 12,706[34] hay fields represented in the commercial fertilizer analysis.

Farmers were then told by the phone enumerator[35] "I will now ask you about your fertilizer inputs on your hay acres. First on a hay field with no manure. Think about your largest hay field that you planted in 2018 without any manure." Farmers were then asked, "Was this field irrigated?" Farmers were only asked about irrigation on the largest field being surveyed, therefore they could have had a field that was irrigated but not the largest hay field on their farm.

Table 64 details the percent of farmers who had irrigated their largest hay field without manure applied by BMP region (HFQ-2).

Table 64. Percent of respondents who irrigated their hay field

BMP Region	Largest Hay Field was Irrigated	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	1
Irrigated and Non-irrigated Sandy Soils	No	99
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
South Central	Yes	1
South Central	No	99
Southeastern	Yes	1
Southeastern	No	99
Statewide	**Yes**	**1**
Statewide	**No**	**99**

[34] There were 54 represented farmers that were unable to complete the hay portion of the survey.
[35] A phone enumerator is a NASS employee who calls on the phone to survey farmers for the Minnesota pesticide and fertilizer survey.

Next, farmers were asked, “What was the crop grown on this field in 2017 before the 2018 hay crop?” Table 65 details the previous crop planted before the current hay crop by BMP region (HFQ-3 and HFQ-4). For the previous crop of corn/alfalfa, the definition would be hay in 2018, corn in 2017 and alfalfa in 2016.

Table 65. Percent of hay fields by previous crop in 2018

BMP Region	Previous Crop	Percent of Fields
Northwestern	Soybeans	**
Northwestern	Corn	**
Northwestern	Alfalfa	43
Northwestern	Small Grains	**
Northwestern	Other	46
Irrigated and Non-irrigated Sandy Soils	Soybeans	**
Irrigated and Non-irrigated Sandy Soils	Corn	6
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	2
Irrigated and Non-irrigated Sandy Soils	Alfalfa	34
Irrigated and Non-irrigated Sandy Soils	Small Grains	5
Irrigated and Non-irrigated Sandy Soils	Other	52
Southwestern and West Central	Soybeans	4
Southwestern and West Central	Corn	7
Southwestern and West Central	Alfalfa	51
Southwestern and West Central	Small Grains	**
Southwestern and West Central	Other	36
South Central	Soybeans	6
South Central	Corn	7
South Central	Alfalfa	44
South Central	Small Grains	2
South Central	Other	41
Southeastern	Soybeans	**
Southeastern	Corn	13
Southeastern	Corn/Alfalfa	**
Southeastern	Alfalfa	36
Southeastern	Small Grains	5
Southeastern	Other	42
Statewide	**Soybeans**	**3**
Statewide	**Corn**	**7**
Statewide	**Corn/Alfalfa**	**1**
Statewide	**Alfalfa**	**40**
Statewide	**Small Grains**	**4**
Statewide	**Other**	**45**

** Less than five responses

Commercial Fertilizer Applications on Hay

Farmers were then asked, "Was any commercial fertilizer applied to this hay field for the 2018 hay crop?" Table 66 details the percent of non-manured hay fields applied with commercial fertilizer (HFQ-6).

Table 66. Commercial fertilizer applied to non-manured hay fields

BMP Region	Fertilizer Applied	Percent of Respondents
Northwestern	Yes	42
Northwestern	No	58
Irrigated and Non-irrigated Sandy Soils	Yes	35
Irrigated and Non-irrigated Sandy Soils	No	65
Southwestern and West Central	Yes	38
Southwestern and West Central	No	62
South Central	Yes	31
South Central	No	69
Southeastern	Yes	46
Southeastern	No	54
Statewide	**Yes**	**37**
Statewide	**No**	**63**

Farmers were asked "Was any commercial fertilizer applied to this hay field with a variable rate or more than one rate such as by management zone or grid?" Table 67 details the percent of respondents using variable rate commercial fertilizer applied by BMP region on their largest hay field (HFQ-7).

Table 67. Variable rate commercial fertilizer application by BMP region on the farmer's largest hay field

BMP Region	Variable Rate Fertilizer Application	Percent of Respondents
Northwestern	Variable Rate	21
Northwestern	One Rate	79
Irrigated and Non-irrigated Sandy Soils	Variable Rate	16
Irrigated and Non-irrigated Sandy Soils	One Rate	84
Southwestern and West Central	Variable Rate	14
Southwestern and West Central	One Rate	86
South Central	Variable Rate	17
South Central	One Rate	83
Southeastern	Variable Rate	25
Southeastern	One Rate	75
Statewide	**Variable Rate**	**18**
Statewide	**One Rate**	**82**

There were 12,706 hay fields represented in the commercial fertilizer analysis, and farmers provided complete information for 4,677 hay fields with fertilizer applied. From these represented farmers, 1,150 were unable to report actual fertilizer applications. Of the 4,677 farmers represented that reported complete data, 3,527 farmers reported applying fertilizer that included the nutrient rate and timing on their hay fields. The following hay fertilizer tables are based on those 3,527 fields.

Table 68 details the percent of all represented hay fields with fertilizer applications and the percent of fertilized fields treated with nitrogen, phosphorus, potassium, and sulfur by BMP region (HFQ-6 and HFQ-FERT TABLE).

Table 68. The percent of hay fields applied with commercial fertilizer and the percent of fertilized fields treated with nitrogen, phosphorus, potassium, and sulfur by BMP region

BMP Region	Percent of All Represented Fields Fertilized	Percent of Fertilized Fields Treated with Nitrogen	Percent of Fertilized Fields Treated with Phosphorus	Percent of Fertilized Fields Treated with Potassium	Percent of Fertilized Fields Treated with Sulfur
Northwestern	33	99	84	83	37
Irrigated and Non-irrigated Sandy Soils	27	75	42	88	36
Southwestern and West Central	26	93	78	88	45
South Central	23	80	63	79	44
Southeastern	36	81	50	80	46
Statewide	**28**	**82**	**55**	**85**	**40**

Table 69 details the percent of all represented hay fields with fertilizer and treated with nitrogen, the average nitrogen rate on fields treated with commercial nitrogen fertilizer, and the average nitrogen rate on all fertilized hay fields by BMP region (HFQ-6 and HFQ-FERT TABLE). Statewide, 82% of fertilized hay fields received nitrogen. These are nitrogen rates on all hay acres treated with commercial fertilizer, regardless of previous crop. Nitrogen rates are for commercial fertilizer only.

Table 69. The percent of all represented hay fields applied with commercial fertilizer containing nitrogen, the average rate on fields treated with nitrogen, and the average nitrogen rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Nitrogen	Average Commercial Nitrogen Rate On Fields Treated with Nitrogen Pounds per Acre	Average Commercial Nitrogen Rate Across All Fertilized Hay Fields Pounds per Acre
Northwestern	99	31	31
Irrigated and Non-irrigated Sandy Soils	75	36	27
Southwestern and West Central	93	26	24
South Central	80	27	21
Southeastern	81	27	22
Statewide	**82**	**31**	**25**

Table 70 details the percent of all represented hay fields with fertilizer and treated with phosphorus, the average phosphorus rate on fields treated with commercial phosphorus fertilizer, and the average phosphorus rate on all fertilized hay fields by BMP region (HFQ-6 and HFQ-FERT TABLE). Statewide, 55% of fertilized hay fields received phosphorus. These are phosphorus rates on all hay acres treated with commercial fertilizer, regardless of previous crop. Phosphorus rates are for commercial fertilizer only.

Table 70. The percent of all represented hay fields applied with commercial fertilizer containing phosphorus, the average rate on fields treated with phosphorus, and the average phosphorus rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Phosphorus	Average Commercial Phosphorus Rate On Fields Treated with Phosphorus Pounds per Acre	Average Commercial Phosphorus Rate Across All Fertilized Hay Fields Pounds per Acre
Northwestern	84	29	25
Irrigated and Non-irrigated Sandy Soils	42	12	5
Southwestern and West Central	78	29	23
South Central	63	20	13
Southeastern	50	16	8
Statewide	**55**	**18**	**10**

Table 71 details the percent of all represented hay fields with fertilizer and treated with potassium, the average potassium rate on fields treated with commercial potassium fertilizer, and the average potassium rate on all fertilized hay fields by BMP region (HFQ-6 and HFQ-FERT TABLE). Statewide, 85% of all fertilized hay fields received potassium. These are potassium rates on all hay acres treated with commercial fertilizer, regardless of previous crop. Potassium rates are for commercial fertilizer only.

Table 71. The percent of all represented hay fields applied with commercial fertilizer containing potassium, the average rate on fields treated with potassium, and the average potassium rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Potassium	Average Commercial Potassium Rate On Fields Treated with Potassium Pounds per Acre	Average Commercial Potassium Rate Across All Fertilized Hay Fields Pounds per Acre
Northwestern	83	44	37
Irrigated and Non-irrigated Sandy Soils	88	60	52
Southwestern and West Central	88	54	47
South Central	79	58	46
Southeastern	80	70	56
Statewide	**85**	**59**	**50**

Table 72 details the percent of all represented hay fields with fertilizer and treated with sulfur, the average sulfur rate on fields treated with commercial sulfur fertilizer, and the average sulfur rate on all fertilized hay fields by BMP region (HFQ-6 and HFQ-FERT TABLE). Statewide, 40% of all fertilized hay fields received sulfur. These are sulfur rates on all hay acres treated with commercial fertilizer, regardless of previous crop. Sulfur rates are for commercial fertilizer only.

Table 72. The percent of all represented hay fields applied with commercial fertilizer containing sulfur, the average rate on fields treated with sulfur, and the average sulfur rate on all fertilized fields by BMP region

BMP Region	Percent of Fertilized Fields Treated with Sulfur	Average Commercial Sulfur Rate On Fields Treated with Sulfur Pounds per Acre	Average Commercial Sulfur Rate Across All Fertilized Hay Fields Pounds per Acre
Northwestern	37	10	4
Irrigated and Non-irrigated Sandy Soils	36	8	3
Southwestern and West Central	45	7	3
South Central	44	8	3
Southeastern	46	9	4
Statewide	**40**	**8**	**3**

Table 73 details the nitrogen fertilizer rate by BMP region on hay following various crops (HFQ-3, HQF-4, and HFQ-FERT TABLE). These are hay fields applied with commercial nitrogen fertilizer and no manure applications. For the previous crop of corn/alfalfa, the definition would be hay in 2018, corn in 2017 and alfalfa in 2016.

Table 73. Average amount of nitrogen applied by BMP region and previous crop

BMP Region	Previous Crop	Average Nitrogen Rate Pounds per Acre
Northwestern	Soybeans	**
Northwestern	Corn	**
Northwestern	Alfalfa	26
Northwestern	Other	30
Irrigated and Non-irrigated Sandy Soils	Soybeans	**
Irrigated and Non-irrigated Sandy Soils	Corn	**
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	31
Irrigated and Non-irrigated Sandy Soils	Small Grains	**
Irrigated and Non-irrigated Sandy Soils	Other	41
Southwestern and West Central	Soybeans	**
Southwestern and West Central	Corn	**
Southwestern and West Central	Alfalfa	25
Southwestern and West Central	Small Grains	**
Southwestern and West Central	Other	25
South Central	Soybeans	**
South Central	Corn	**
South Central	Alfalfa	33
South Central	Small Grains	**
South Central	Other	26
Southeastern	Soybeans	**
Southeastern	Corn	**
Southeastern	Alfalfa	45
Southeastern	Small Grains	**
Southeastern	Other	14
Statewide	**Soybeans**	**39**
Statewide	**Corn**	**26**
Statewide	**Corn/Alfalfa**	****
Statewide	**Alfalfa**	**32**
Statewide	**Small Grains**	**31**
Statewide	**Other**	**31**

** Less than five responses

Table 74 details the phosphorus fertilizer rate by BMP region on hay following various crops (HFQ-3, HQF-4, and HFQ-FERT TABLE). These are hay fields applied with commercial phosphorus fertilizer and no manure applications. For the previous crop of corn/alfalfa, the definition would be hay in 2018, corn in 2017 and alfalfa in 2016.

Table 74. Average amount of phosphorus applied by BMP region and previous crop

BMP Region	Previous Crop	Average Phosphorus Rate Pounds per Acre
Northwestern	Soybeans	**
Northwestern	Corn	**
Northwestern	Alfalfa	33
Northwestern	Other	38
Irrigated and Non-irrigated Sandy Soils	Soybeans	**
Irrigated and Non-irrigated Sandy Soils	Corn	**
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	27
Irrigated and Non-irrigated Sandy Soils	Other	27
Southwestern and West Central	Soybeans	**
Southwestern and West Central	Corn	**
Southwestern and West Central	Alfalfa	41
Southwestern and West Central	Small Grains	**
Southwestern and West Central	Other	33
South Central	Soybeans	**
South Central	Corn	**
South Central	Alfalfa	31
South Central	Small Grains	**
South Central	Other	**
Southeastern	Corn	**
Southeastern	Alfalfa	33
Southeastern	Small Grains	**
Southeastern	Other	26
Statewide	**Soybeans**	**37**
Statewide	**Corn**	**34**
Statewide	**Corn/Alfalfa**	****
Statewide	**Alfalfa**	**32**
Statewide	**Small Grains**	**33**
Statewide	**Other**	**31**

** Less than five responses

Table 75 details the potassium fertilizer rate by BMP region on hay following various crops (HFQ-3, HQF-4, and HFQ-FERT TABLE). These are hay fields applied with commercial potassium fertilizer and no manure applications. For the previous crop of corn/alfalfa, the definition would be hay in 2018, corn in 2017 and alfalfa in 2016.

Table 75. Average amount of potassium applied by BMP region and previous crop

BMP Region	Previous Crop	Average Potassium Rate Pounds per Acre
Northwestern	Corn	**
Northwestern	Alfalfa	41
Northwestern	Other	48
Irrigated and Non-irrigated Sandy Soils	Soybeans	**
Irrigated and Non-irrigated Sandy Soils	Corn	**
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	64
Irrigated and Non-irrigated Sandy Soils	Small Grains	**
Irrigated and Non-irrigated Sandy Soils	Other	45
Southwestern and West Central	Soybeans	**
Southwestern and West Central	Corn	**
Southwestern and West Central	Alfalfa	59
Southwestern and West Central	Small Grains	**
Southwestern and West Central	Other	52
South Central	Soybeans	**
South Central	Corn	**
South Central	Alfalfa	58
South Central	Small Grains	**
South Central	Other	63
Southeastern	Soybeans	**
Southeastern	Corn	**
Southeastern	Alfalfa	70
Southeastern	Small Grains	**
Southeastern	Other	73
Statewide	**Soybeans**	**66**
Statewide	**Corn**	**58**
Statewide	**Corn/Alfalfa**	****
Statewide	**Alfalfa**	**61**
Statewide	**Small Grains**	**70**
Statewide	**Other**	**54**

** Less than five responses

Table 76 details the sulfur fertilizer rate by BMP region on hay following various crops (HFQ-3, HQF-4, and HFQ-FERT TABLE). These are hay fields applied with commercial sulfur fertilizer and no manure applications. For the previous crop of corn/alfalfa, the definition would be hay in 2018, corn in 2017 and alfalfa in 2016.

Table 76. Average amount of sulfur applied by BMP region and previous crop

BMP Region	Previous Crop	Average Sulfur Rate Pounds per Acre
Northwestern	Soybeans	**
Northwestern	Corn	**
Northwestern	Alfalfa	8
Northwestern	Other	**
Irrigated and Non-irrigated Sandy Soils	Soybeans	**
Irrigated and Non-irrigated Sandy Soils	Corn	**
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	9
Irrigated and Non-irrigated Sandy Soils	Small Grains	**
Irrigated and Non-irrigated Sandy Soils	Other	10
Southwestern and West Central	Soybeans	**
Southwestern and West Central	Corn	**
Southwestern and West Central	Alfalfa	8
Southwestern and West Central	Other	6
South Central	Soybeans	**
South Central	Corn	**
South Central	Alfalfa	9
South Central	Small Grains	**
South Central	Other	10
Southeastern	Soybeans	**
Southeastern	Corn	**
Southeastern	Alfalfa	6
Southeastern	Small Grains	**
Southeastern	Other	11
Statewide	**Soybeans**	**10**
Statewide	**Corn**	**7**
Statewide	**Corn/Alfalfa**	****
Statewide	**Alfalfa**	**8**
Statewide	**Small Grains**	****
Statewide	**Other**	**9**

** Less than five responses

Fertilizer Sources and Timing

Table 77 details the respondents and corresponding hay acres by BMP region for all farmers in this study who fall applied nitrogen on the largest hay field (HFQ-FERT TABLE). This table includes all sources of fall applied nitrogen from commercial fertilizer applications.

Table 77. Average amount of nitrogen fall applied by BMP region

BMP Region	Percent of Respondents: Fall Applied Nitrogen	Average Fall Nitrogen Rate Pounds per Acre
Northwestern	**	**
Irrigated and Non-irrigated Sandy Soils	8	22
Southwestern and West Central	17	24
South Central	19	15
Southeastern	16	26
Statewide	**12**	**21**

** Less than five responses

Table 78 details the respondents and corresponding hay acres by BMP region for all farmers in this study who fall applied phosphorus on the largest hay field (HFQ-FERT TABLE). This table includes all sources of fall applied phosphorus from commercial fertilizer applications.

Table 78. Average amount of phosphorus fall applied by BMP region

BMP Region	Percent of Respondents: Fall Applied Phosphorus	Average Fall Phosphorus Rate Pounds per Acre
Northwestern	**	**
Irrigated and Non-irrigated Sandy Soils	**	**
Southwestern and West Central	14	45
South Central	17	26
Southeastern	14	29
Statewide	**9**	**33**

** Less than five responses

Table 79 details the respondents and corresponding hay acres by BMP region for all farmers in this study who fall applied potassium on the largest hay field (HFQ-FERT TABLE). This table includes all sources of fall applied potassium from commercial fertilizer applications.

Table 79. Average amount of potassium fall applied by BMP region

BMP Region	Percent of Respondents: Fall Applied Potassium	Average Fall Potassium Rate Pounds per Acre
Northwestern	**	**
Irrigated and Non-irrigated Sandy Soils	12	74
Southwestern and West Central	16	61
South Central	15	46
Southeastern	27	78
Statewide	**15**	**69**

** Less than five responses

Table 80 details the respondents and corresponding hay acres by BMP region for all farmers in this study who fall applied sulfur on the largest hay field (HFQ-FERT TABLE). This table includes all sources of fall applied sulfur from commercial fertilizer applications.

Table 80. Average amount of sulfur fall applied by BMP region

BMP Region	Percent of Respondents: Fall Applied Sulfur	Average Fall Sulfur Rate Pounds per Acre
Northwestern	**	**
Irrigated and Non-irrigated Sandy Soils	8	9
Southwestern and West Central	8	6
South Central	**	**
Southeastern	**	**
Statewide	**7**	**7**

** Less than five responses

Table 81 details the major form of nitrogen fertilizer applied in each BMP region and statewide and the percent of respondents for those forms (HFQ-8b). 'Other' forms of fertilizer containing nitrogen would include sources of phosphorus, such as MAP or DAP, and sulfur, such as AMS, on represented hay fields.

Table 81. The major form of nitrogen applied to the field

BMP Region	Major Form of Fertilizer Containing Nitrogen Applied	Percent of Fertilized Fields
Northwestern	Anhydrous	0
Northwestern	Urea	49
Northwestern	Liquid Nitrogen	0
Northwestern	Other	51
Northwestern	Unknown	0
Irrigated and Non-irrigated Sandy Soils	Anhydrous	0
Irrigated and Non-irrigated Sandy Soils	Urea	53
Irrigated and Non-irrigated Sandy Soils	Liquid Nitrogen	0
Irrigated and Non-irrigated Sandy Soils	Other	47
Irrigated and Non-irrigated Sandy Soils	Unknown	0
Southwestern and West Central	Anhydrous	0
Southwestern and West Central	Urea	39
Southwestern and West Central	Liquid Nitrogen	0
Southwestern and West Central	Other	61
Southwestern and West Central	Unknown	0
South Central	Anhydrous	0
South Central	Urea	35
South Central	Liquid Nitrogen	0
South Central	Other	65
South Central	Unknown	0
Southeastern	Anhydrous	0
Southeastern	Urea	30
Southeastern	Liquid Nitrogen	0
Southeastern	Other	70
Southeastern	Unknown	0
Statewide	**Anhydrous**	**0**
Statewide	**Urea**	**44**
Statewide	**Liquid**	**0**
Statewide	**Other**	**56**
Statewide	**Unknown**	**0**

No anhydrous ammonia was applied on hay and therefore will not be included in any other analysis in this report.

Table 82 details the major form of nitrogen and average nitrogen rate of the 2018 hay crop (HFQ-8 and HFQ-8b).

Table 82. Average amount of nitrogen applied by BMP region and type of nitrogen

BMP Region	Major Form of Nitrogen Applied	Average Nitrogen Rate Pounds per Acre
Northwestern	Urea	44
Northwestern	Other	19
Irrigated and Non-irrigated Sandy Soils	Urea	51
Irrigated and Non-irrigated Sandy Soils	Other	19
Southwestern and West Central	Urea	39
Southwestern and West Central	Other	17
South Central	Urea	51
South Central	Other	13
Southeastern	Urea	65
Southeastern	Other	12
Statewide	**Urea**	**50**
Statewide	**Other**	**17**

** Less than five responses

Table 83 details any commercial fertilizer applied in the fall of 2017 for the 2018 hay crop (HFQ-FERT TABLE).

Table 83. Commerical fertilizer applied in the fall of 2017 for the 2018 hay crop

BMP Region	Any Commercial Fertilizer Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	6
Northwestern	No	94
Irrigated and Non-irrigated Sandy Soils	Yes	12
Irrigated and Non-irrigated Sandy Soils	No	88
Southwestern and West Central	Yes	17
Southwestern and West Central	No	83
South Central	Yes	22
South Central	No	78
Southeastern	Yes	27
Southeastern	No	73
Statewide	**Yes**	**16**
Statewide	**No**	**84**

Table 84 details the urea applied in the fall of 2017 for the 2018 hay crop (HFQ-FERT TABLE).

Table 84. Urea applied in the fall of 2017 for the 2018 hay crop

BMP Region	Urea Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	1
Irrigated and Non-irrigated Sandy Soils	No	99
Southwestern and West Central	Yes	3
Southwestern and West Central	No	97
South Central	Yes	5
South Central	No	95
Southeastern	Yes	4
Southeastern	No	96
Statewide	**Yes**	**2**
Statewide	**No**	**98**

No liquid nitrogen (28%, 32%) was reported to be applied on hay in the fall of 2017 for the 2018 hay crop (HFQ-FERT TABLE).

Table 85 details other fertilizers containing nitrogen applied in the fall of 2017 for the 2018 hay crop (HFQ-FERT TABLE).

Table 85. Other fertilizers containing nitrogen applied in the fall of 2017 for the 2018 hay crop

BMP Region	Other Sources of Fertilizer Containing Nitrogen in the Fall of 2017	Percent of Respondents
Northwestern	Yes	6
Northwestern	No	94
Irrigated and Non-irrigated Sandy Soils	Yes	7
Irrigated and Non-irrigated Sandy Soils	No	93
Southwestern and West Central	Yes	14
Southwestern and West Central	No	86
South Central	Yes	13
South Central	No	87
Southeastern	Yes	12
Southeastern	No	88
Statewide	**Yes**	**10**
Statewide	**No**	**90**

Table 86 details phosphorus fertilizer, such as MAP or DAP, applied in the fall of 2017 for the 2018 hay crop (HFQ-FERT TABLE).

Table 86. Fertilizer containing phosphorus applied in the fall of 2017 for the 2018 hay crop

BMP Region	Phosphorus Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	6
Northwestern	No	94
Irrigated and Non-irrigated Sandy Soils	Yes	3
Irrigated and Non-irrigated Sandy Soils	No	97
Southwestern and West Central	Yes	14
Southwestern and West Central	No	86
South Central	Yes	17
South Central	No	83
Southeastern	Yes	14
Southeastern	No	86
Statewide	**Yes**	**9**
Statewide	**No**	**91**

Table 87 details potassium fertilizer applied in the fall of 2017 for the 2018 hay crop (HFQ-FERT TABLE).[36]

Table 87. Fertilizer containing potassium applied in the fall of 2017 for the 2018 hay crop

BMP Region	Potassium Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	6
Northwestern	No	94
Irrigated and Non-irrigated Sandy Soils	Yes	12
Irrigated and Non-irrigated Sandy Soils	No	88
Southwestern and West Central	Yes	16
Southwestern and West Central	No	84
South Central	Yes	15
South Central	No	85
Southeastern	Yes	27
Southeastern	No	73
Statewide	**Yes**	**15**
Statewide	**No**	**85**

Table 88 details sulfur fertilizer, such as AMS, applied in the fall of 2017 for the 2018 hay crop (HFQ-FERT TABLE).

Table 88. Fertilizer containing sulfur applied in the fall of 2017 for the 2018 hay crop.

BMP Region	Sulfur Application in the Fall of 2017	Percent of Respondents
Northwestern	Yes	3
Northwestern	No	97
Irrigated and Non-irrigated Sandy Soils	Yes	8
Irrigated and Non-irrigated Sandy Soils	No	92
Southwestern and West Central	Yes	8
Southwestern and West Central	No	92
South Central	Yes	4
South Central	No	96
Southeastern	Yes	7
Southeastern	No	93
Statewide	**Yes**	**7**
Statewide	**No**	**93**

[36] Potassium, also known as potash (0-0-60), does not contain nitrogen.

Table 89 details commercial fertilizer applied in the spring as a preplant for the 2018 hay crop (HFQ-FERT TABLE).

Table 89. Commercial fertilizer applied in the spring as a preplant for the 2018 hay crop

BMP Region	Any Commercial Fertilizer Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	<1
Irrigated and Non-irrigated Sandy Soils	No	>99
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
South Central	Yes	1
South Central	No	99
Southeastern	Yes	3
Southeastern	No	97
Statewide	**Yes**	**1**
Statewide	**No**	**99**

Table 90 details urea applied in the spring as a preplant for the 2018 hay crop (HFQ-FERT TABLE).

Table 90. Urea applied in the spring as a preplant for the 2018 hay crop

BMP Region	Urea Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	<1
Irrigated and Non-irrigated Sandy Soils	No	>99
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
South Central	Yes	1
South Central	No	99
Southeastern	Yes	3
Southeastern	No	97
Statewide	**Yes**	**1**
Statewide	**No**	**99**

Table 91 details liquid nitrogen fertilizer applied in the spring as a preplant for the 2018 hay crop (HFQ-FERT TABLE).

Table 91. Liquid nitrogen fertilizer applied in the spring as a preplant for the 2018 hay crop

BMP Region	Liquid Nitrogen (28%, 32%) Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
South Central	Yes	0
South Central	No	100
Southeastern	Yes	0
Southeastern	No	100
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 92 details other nitrogen sources applied in the spring as a preplant for the 2018 hay crop (HFQ-FERT TABLE).

Table 92. Other nitrogen sources applied in the spring as a preplant for the 2018 hay crop

BMP Region	Other Sources of Nitrogen Fertilizer as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	<1
Irrigated and Non-irrigated Sandy Soils	No	>99
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
South Central	Yes	0
South Central	No	100
Southeastern	Yes	0
Southeastern	No	100
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 93 details phosphorus, such as MAP or DAP, applied in the spring as a preplant for the 2018 hay crop (HFQ-FERT TABLE).

Table 93. Fertilizer containing phosphorus applied in the spring as a preplant for the 2018 hay crop

BMP Region	Phosphorus Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	<1
Irrigated and Non-irrigated Sandy Soils	No	>99
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
South Central	Yes	0
South Central	No	100
Southeastern	Yes	0
Southeastern	No	100
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 94 details potassium applied in the spring as a preplant for the 2018 hay crop (HFQ-FERT TABLE).

Table 94. Fertilizer containing potassium applied in the spring as a preplant for the 2018 hay crop

BMP Region	Potassium Application as a Preplant in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	<1
Irrigated and Non-irrigated Sandy Soils	No	>99
Southwestern and West Central	Yes	1
Southwestern and West Central	No	99
South Central	Yes	1
South Central	No	99
Southeastern	Yes	3
Southeastern	No	97
Statewide	**Yes**	**1**
Statewide	**No**	**99**

No sulfur fertilizer, such as AMS, was reported to be applied in the spring on hay as a preplant for the 2018 hay crop.

Table 95 details commercial fertilizer applied in the spring as a starter or at planting for the 2018 hay crop (HFQ-FERT TABLE).

Table 95. Commercial fertilizer applied in the spring at planting for the 2018 hay crop

BMP Region	Any Commercial Fertilizer in the Spring as a Starter or at Planting of 2018	Percent of Respondents
Northwestern	Yes	46
Northwestern	No	54
Irrigated and Non-irrigated Sandy Soils	Yes	40
Irrigated and Non-irrigated Sandy Soils	No	60
Southwestern and West Central	Yes	34
Southwestern and West Central	No	66
South Central	Yes	21
South Central	No	79
Southeastern	Yes	18
Southeastern	No	82
Statewide	**Yes**	**34**
Statewide	**No**	**66**

Table 96 details urea applied in the spring as a starter or at planting for the 2018 hay crop (HFQ-FERT TABLE).

Table 96. Urea applied in the spring at planting for the 2018 hay crop

BMP Region	Urea Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	23
Northwestern	No	77
Irrigated and Non-irrigated Sandy Soils	Yes	14
Irrigated and Non-irrigated Sandy Soils	No	86
Southwestern and West Central	Yes	18
Southwestern and West Central	No	82
South Central	Yes	4
South Central	No	96
Southeastern	Yes	11
Southeastern	No	89
Statewide	**Yes**	**13**
Statewide	**No**	**87**

Table 97 details liquid nitrogen fertilizer applied in the spring as a starter or at planting for the 2018 hay crop (HFQ-FERT TABLE).

Table 97. Liquid nitrogen fertilizer applied in the spring at planting for the 2018 hay crop

BMP Region	Liquid Nitrogen (28%, 32%) Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
South Central	Yes	1
South Central	No	99
Southeastern	Yes	0
Southeastern	No	100
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 98 details other nitrogen fertilizers applied in the spring at planting for the 2018 hay crop (HFQ-FERT TABLE).

Table 98. Other nitrogen fertilizers applied in the spring at planting for the 2018 hay crop

BMP Region	Other Nitrogen Fertilizers as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	23
Northwestern	No	77
Irrigated and Non-irrigated Sandy Soils	Yes	17
Irrigated and Non-irrigated Sandy Soils	No	83
Southwestern and West Central	Yes	14
Southwestern and West Central	No	86
South Central	Yes	13
South Central	No	87
Southeastern	Yes	13
Southeastern	No	87
Statewide	**Yes**	**16**
Statewide	**No**	**84**

Table 99 details phosphorus, such as MAP or DAP, fertilizer applied in the spring at planting for the 2018 hay crop (HFQ-FERT TABLE).

Table 99. Fertilizer containing phosphorus applied in the spring at planting for the 2018 hay crop

BMP Region	Phosphorus Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	42
Northwestern	No	58
Irrigated and Non-irrigated Sandy Soils	Yes	18
Irrigated and Non-irrigated Sandy Soils	No	82
Southwestern and West Central	Yes	27
Southwestern and West Central	No	73
South Central	Yes	13
South Central	No	87
Southeastern	Yes	12
Southeastern	No	88
Statewide	**Yes**	**20**
Statewide	**No**	**80**

Table 100 details potassium fertilizer applied in the spring at planting for the 2018 hay crop (HFQ-FERT TABLE).

Table 100. Fertilizer containing potassium applied in the spring at planting for the 2018 hay crop

BMP Region	Potassium Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	37
Northwestern	No	63
Irrigated and Non-irrigated Sandy Soils	Yes	34
Irrigated and Non-irrigated Sandy Soils	No	66
Southwestern and West Central	Yes	28
Southwestern and West Central	No	72
South Central	Yes	13
South Central	No	87
Southeastern	Yes	12
Southeastern	No	88
Statewide	**Yes**	**27**
Statewide	**No**	**73**

Table 101 details sulfur fertilizer, such as AMS, applied in the spring at planting for the 2018 hay crop (HFQ-FERT TABLE).

Table 101. Fertilizer containing sulfur applied in the spring at planting for the 2018 hay crop

BMP Region	Sulfur Application as a Starter or at Planting in the Spring of 2018	Percent of Respondents
Northwestern	Yes	7
Northwestern	No	93
Irrigated and Non-irrigated Sandy Soils	Yes	16
Irrigated and Non-irrigated Sandy Soils	No	84
Southwestern and West Central	Yes	14
Southwestern and West Central	No	86
South Central	Yes	8
South Central	No	92
Southeastern	Yes	13
Southeastern	No	87
Statewide	**Yes**	**13**
Statewide	**No**	**87**

Table 102 details commercial fertilizer applied post planting or sidedress for the 2018 hay crop (HFQ-FERT TABLE).

Table 102. Commercial fertilizer applied post planting or sidedress for the 2018 hay crop

BMP Region	Any Commercial Fertilizer Application After Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	13
Northwestern	No	87
Irrigated and Non-irrigated Sandy Soils	Yes	5
Irrigated and Non-irrigated Sandy Soils	No	95
Southwestern and West Central	Yes	7
Southwestern and West Central	No	93
South Central	Yes	4
South Central	No	96
Southeastern	Yes	6
Southeastern	No	94
Statewide	**Yes**	**6**
Statewide	**No**	**94**

Table 103 details urea applied as a post planting or sidedress for the 2018 hay crop (HFQ-FERT TABLE).

Table 103. Urea applied as a post planting or sidedress for the 2018 hay crop

BMP Region	Urea Application after Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	11
Northwestern	No	89
Irrigated and Non-irrigated Sandy Soils	Yes	3
Irrigated and Non-irrigated Sandy Soils	No	97
Southwestern and West Central	Yes	5
Southwestern and West Central	No	95
South Central	Yes	0
South Central	No	100
Southeastern	Yes	2
Southeastern	No	98
Statewide	**Yes**	**4**
Statewide	**No**	**96**

Table 104 details liquid nitrogen fertilizer applied as a post planting or sidedress for the 2018 hay crop (HFQ-FERT TABLE).

Table 104. Liquid nitrogen fertilizer applied as a post planting or sidedress for the 2018 hay crop

BMP Region	Liquid Nitrogen (28%, 32%) Application after Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	0
Northwestern	No	100
Irrigated and Non-irrigated Sandy Soils	Yes	0
Irrigated and Non-irrigated Sandy Soils	No	100
Southwestern and West Central	Yes	0
Southwestern and West Central	No	100
South Central	Yes	0
South Central	No	100
Southeastern	Yes	1
Southeastern	No	99
Statewide	**Yes**	**<1**
Statewide	**No**	**>99**

Table 105 details other nitrogen fertilizers applied as a post planting or sidedress the 2018 hay crop (HFQ-FERT TABLE).

Table 105. Other nitrogen fertilizers applied as a post planting or sidedress for the 2018 hay crop

BMP Region	Other Nitrogen Fertilizers after Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	2
Northwestern	No	98
Irrigated and Non-irrigated Sandy Soils	Yes	2
Irrigated and Non-irrigated Sandy Soils	No	98
Southwestern and West Central	Yes	4
Southwestern and West Central	No	96
South Central	Yes	4
South Central	No	96
Southeastern	Yes	10
Southeastern	No	90
Statewide	**Yes**	**4**
Statewide	**No**	**96**

Table 106 details phosphorus fertilizer, such as MAP or DAP, applied as a post planting or sidedress for the 2018 hay crop (HFQ-FERT TABLE).

Table 106. Fertilizer containing phosphorus applied as a post planting or sidedress for the 2018 hay crop

BMP Region	Phosphorus Application after Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	6
Northwestern	No	94
Irrigated and Non-irrigated Sandy Soils	Yes	4
Irrigated and Non-irrigated Sandy Soils	No	96
Southwestern and West Central	Yes	7
Southwestern and West Central	No	93
South Central	Yes	2
South Central	No	98
Southeastern	Yes	2
Southeastern	No	98
Statewide	**Yes**	**4**
Statewide	**No**	**96**

Table 107 details potassium fertilizer applied as a post planting or sidedress of the 2018 hay crop (HFQ-FERT TABLE).

Table 107. Fertilizer containing potassium applied as a post planting or sidedress for the 2018 hay crop

BMP Region	Potassium Application after Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	6
Northwestern	No	94
Irrigated and Non-irrigated Sandy Soils	Yes	5
Irrigated and Non-irrigated Sandy Soils	No	95
Southwestern and West Central	Yes	7
Southwestern and West Central	No	93
South Central	Yes	4
South Central	No	96
Southeastern	Yes	6
Southeastern	No	94
Statewide	**Yes**	**5**
Statewide	**No**	**95**

Table 108 details sulfur fertilizer, such as AMS, applied as a post planting or sidedress for the 2018 hay crop (HFQ-FERT TABLE).

Table 108. Fertilizer containing sulfur applied as a post planting or sidedress for the 2018 hay crop

BMP Region	Sulfur Application after Planting such as a Sidedress in 2018	Percent of Respondents
Northwestern	Yes	11
Northwestern	No	89
Irrigated and Non-irrigated Sandy Soils	Yes	4
Irrigated and Non-irrigated Sandy Soils	No	96
Southwestern and West Central	Yes	3
Southwestern and West Central	No	97
South Central	Yes	0
South Central	No	100
Southeastern	Yes	6
Southeastern	No	94
Statewide	**Yes**	**4**
Statewide	**No**	**96**

Figure 30 details the form of nitrogen that was applied to hay acres statewide based on total pounds of nitrogen applied (HFQ-FERT TABLE).

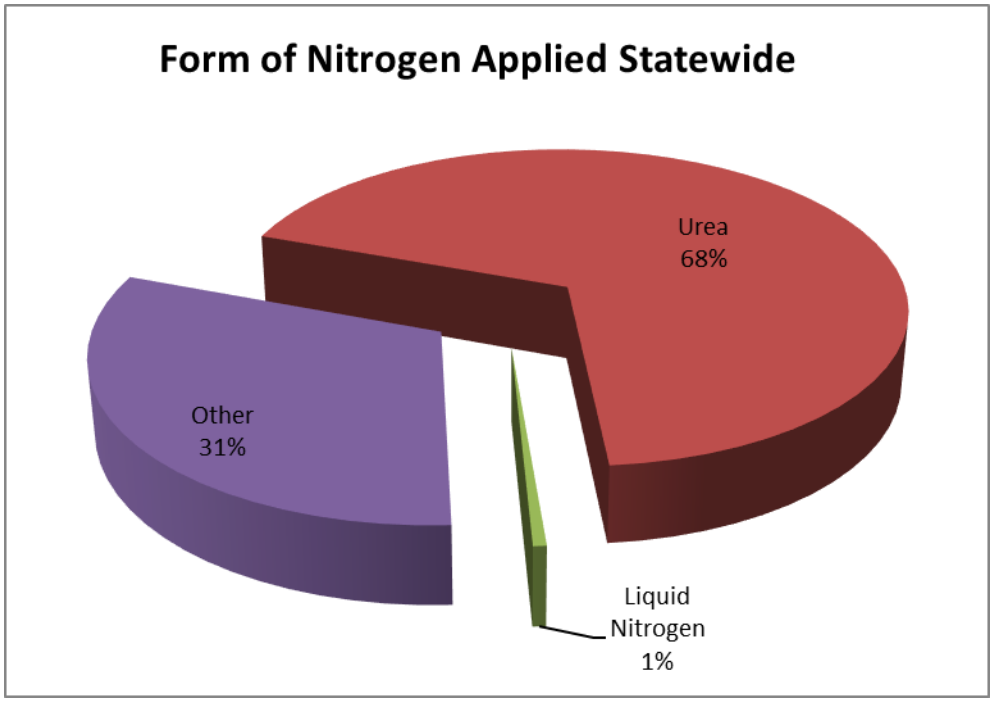

Figure 30. The form of the nitrogen applied to hay acres in state for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 31 details the form of nitrogen that was applied to hay acres in the SE BMP region based (HFQ-FERT TABLE).

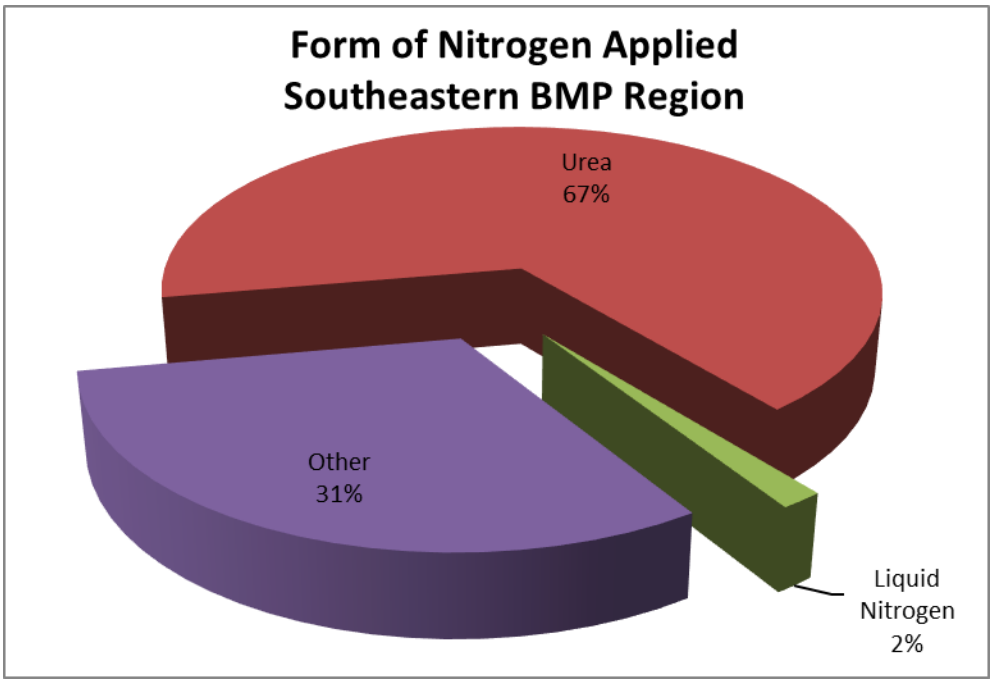

Figure 31. The form of the nitrogen applied to hay acres in the SE BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 32 details the form of nitrogen that was applied to hay acres in the SC BMP region based (HFQ-FERT TABLE).

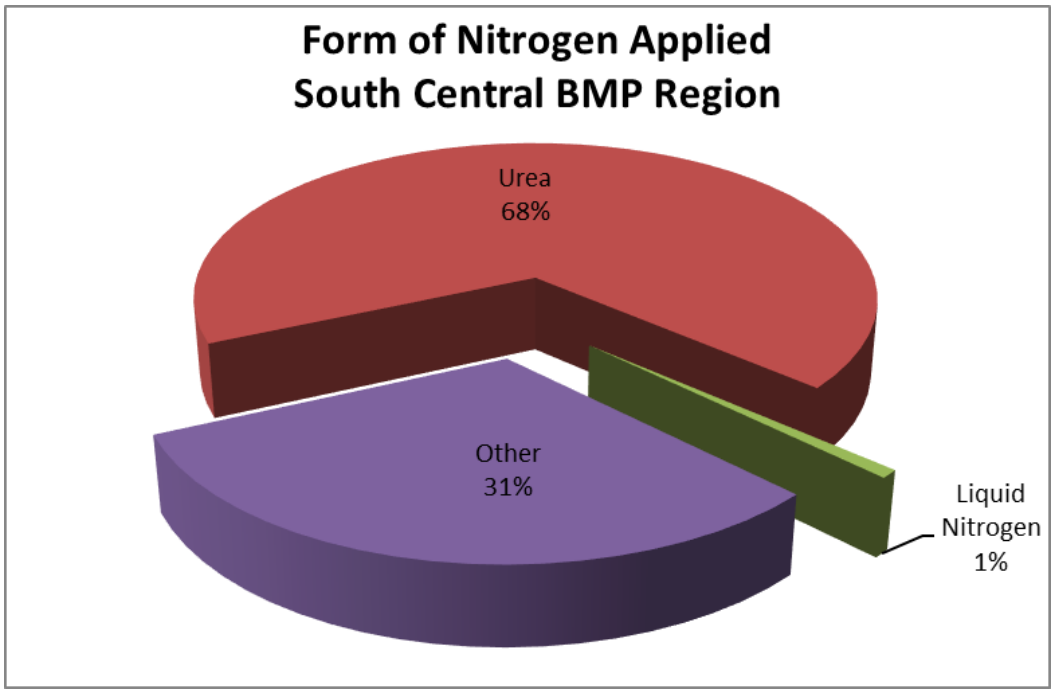

Figure 32. The form of the nitrogen applied to hay acres in the SC BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 33 details the form of nitrogen that was applied to hay acres in the SW BMP region based (HFQ-FERT TABLE).

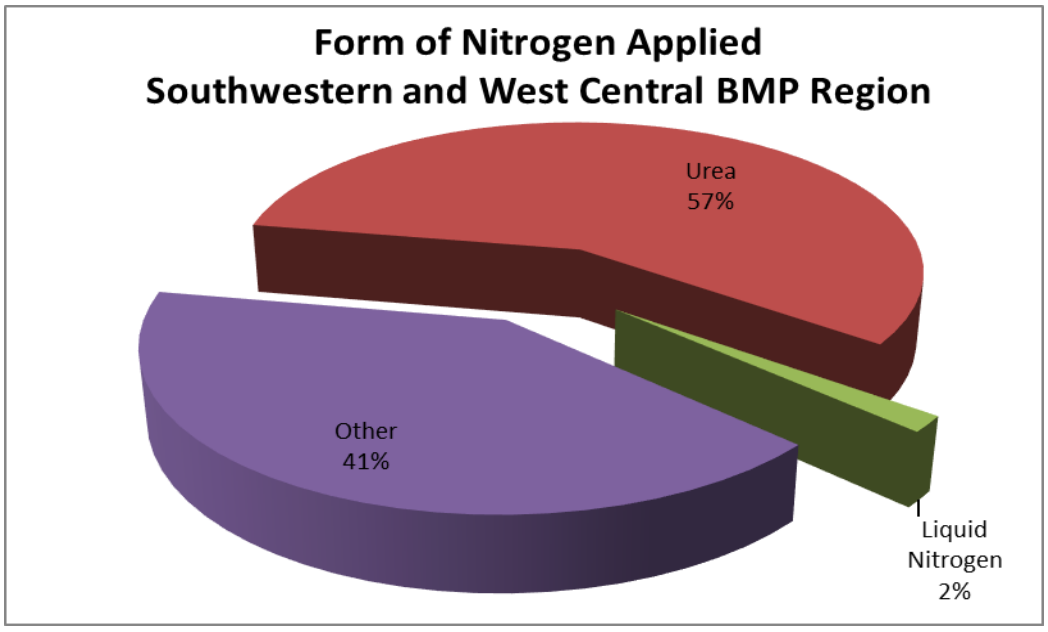

Figure 33. The form of the nitrogen applied to hay acres in the SW BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 34 details the form of nitrogen that was applied to hay acres in the NW BMP region based (HFQ-FERT TABLE).

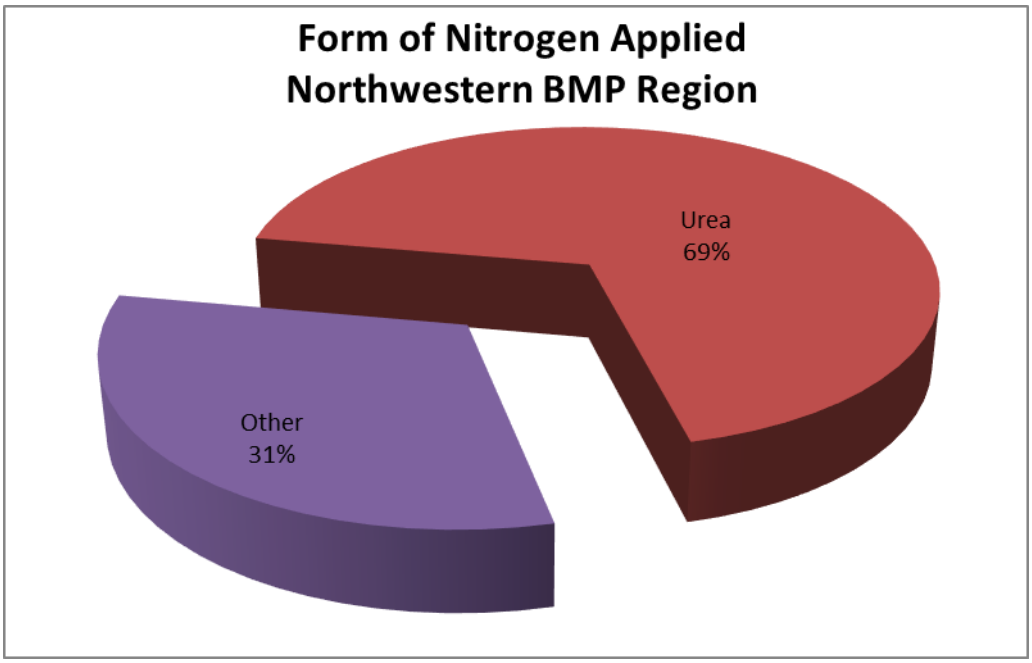

Figure 34. The form of the nitrogen applied to hay acres in the NW BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 35 details the form of nitrogen that was applied to hay acres in the IRR BMP region based (HFQ-FERT TABLE).

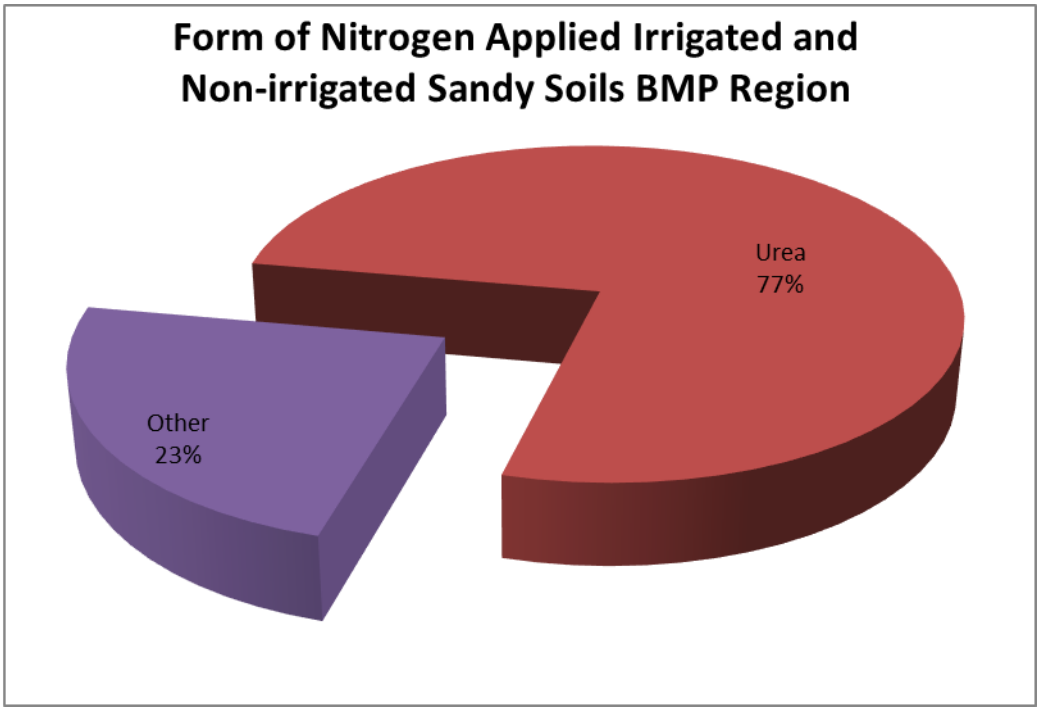

Figure 35. The form of the nitrogen applied to hay acres in the IRR BMP region for the 2018 survey for all fields applied with nitrogen fertilizer (Based on total pounds applied to the largest field)

Figure 36 details the application timing of urea on hay acres in Minnesota for the largest field by pounds of nitrogen applied (HFQ-FERT TABLE).

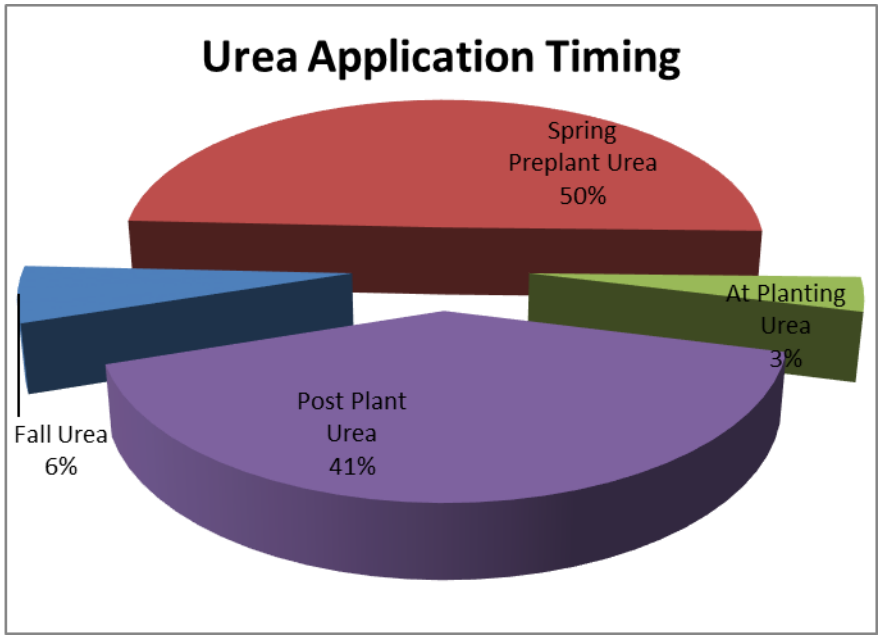

Figure 36. The application timing of urea to hay acres in Minnesota by pounds of nitrogen applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 37 details the application timing of liquid nitrogen on hay acres in Minnesota for the largest field by pounds of nitrogen applied (HFQ-FERT TABLE).

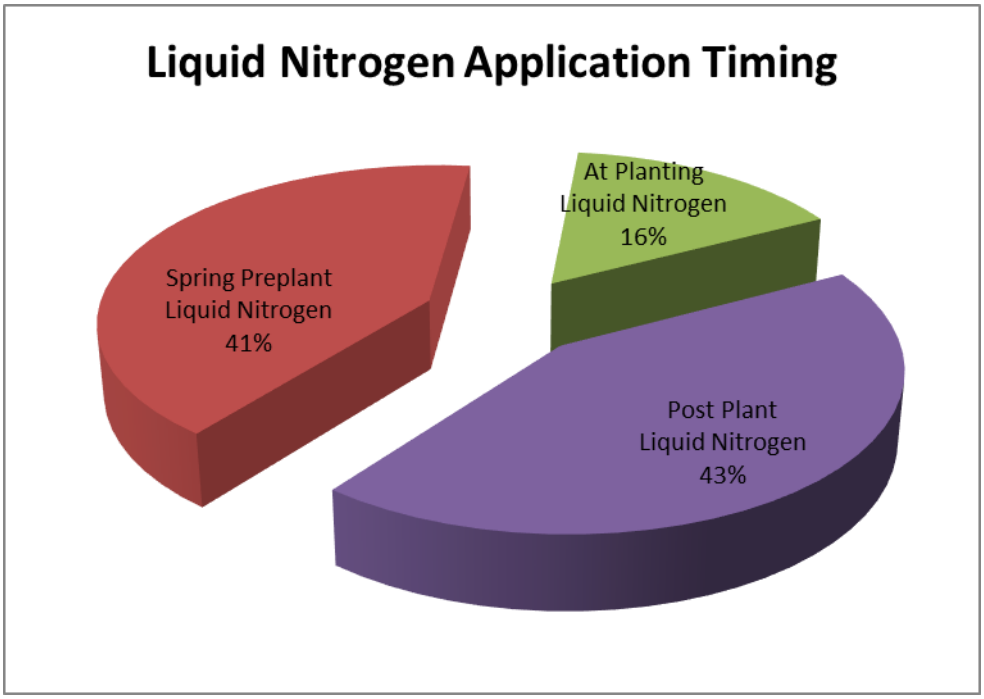

Figure 37. The application timing of liquid nitrogen to hay acres in Minnesota by pounds of nitrogen applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 38 details the application timing of other nitrogen sources on hay acres in Minnesota for the largest field by pounds of nitrogen applied (HFQ-FERT TABLE).

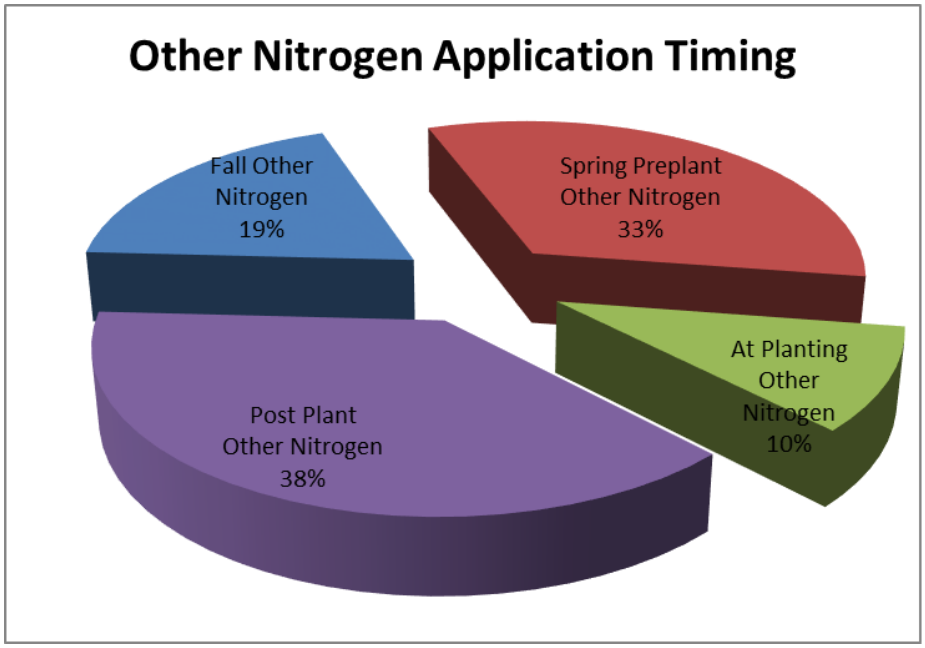

Figure 38. The application timing of other nitrogen sources to hay acres in Minnesota by pounds of nitrogen applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 39 details the application timing of phosphorus on hay acres in Minnesota for the largest field by pounds of phosphorus applied (HFQ-FERT TABLE).

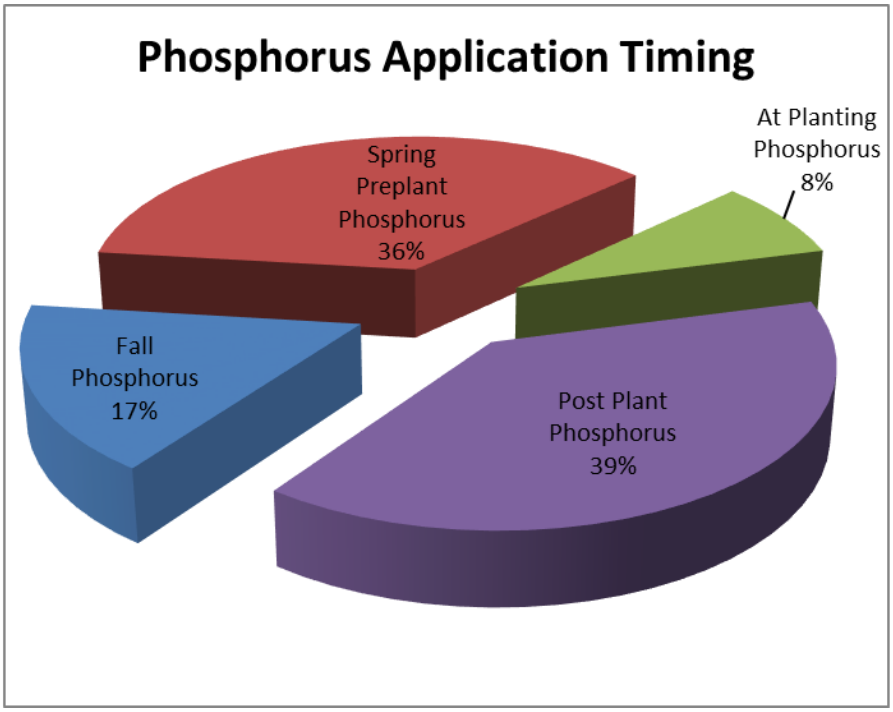

Figure 39. The application timing of phosphorus to hay acres in Minnesota by pounds of phosphorus applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 40 details the application timing of potassium on hay acres in Minnesota for the largest field by pounds of potassium applied (HFQ-FERT TABLE).

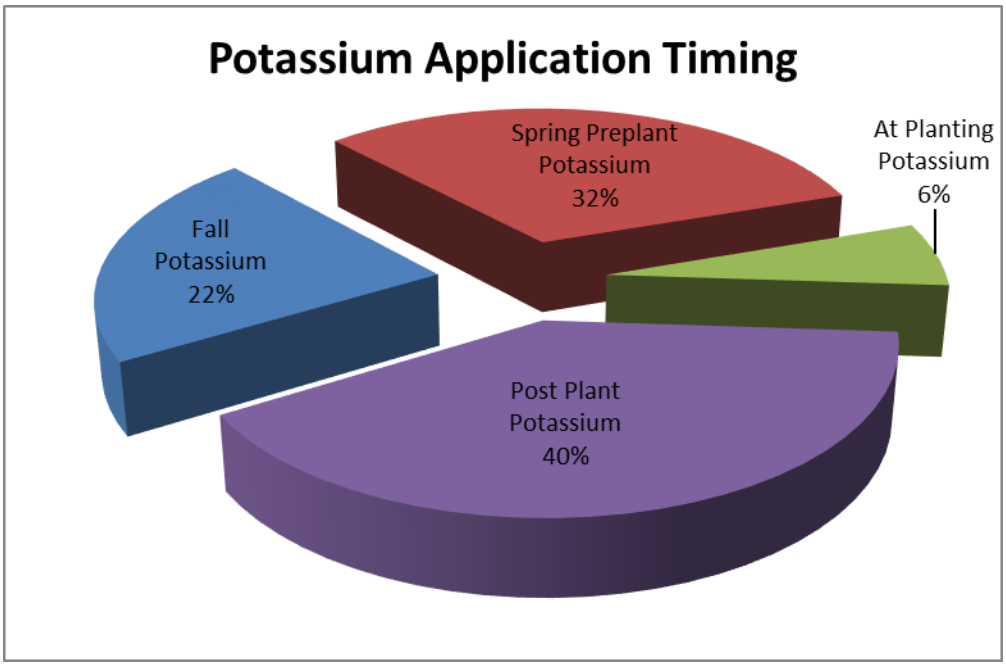

Figure 40. The application timing of potassium to hay acres in Minnesota by pounds of potassium applied in the 2018 survey (Based on total pounds applied to the largest field)

Figure 41 details the application timing of sulfur on hay acres in Minnesota for the largest field by pounds of sulfur applied (HFQ-FERT TABLE).

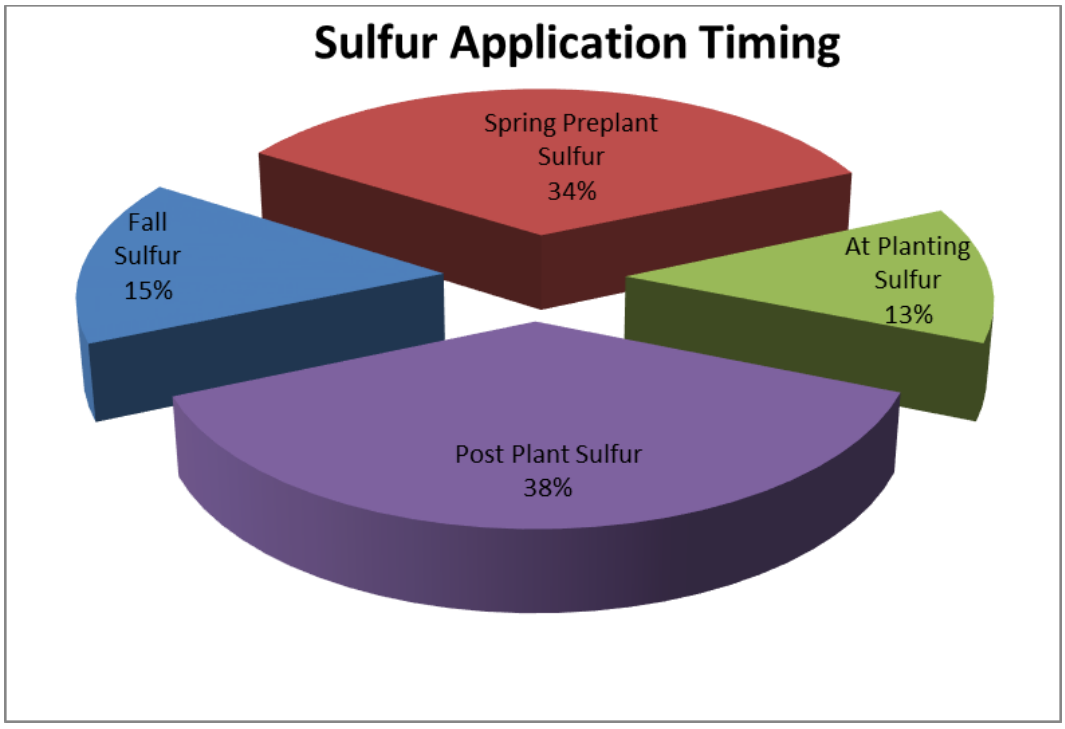

Figure 41. The application timing of sulfur to hay acres in Minnesota by pounds of sulfur applied in the 2018 survey (Based on total pounds applied to the largest field)

Farmers were asked “Did you use a nitrogen inhibitor or stabilizer on this field?”

Table 109 details the percent of respondents that used a nitrogen inhibitor or stabilizer in 2017 or 2018 for the 2018 hay crop on the farmer’s largest field (HFQ-6 and HFQ-9).

Table 109. Nitrogen inhibitor or stabilizer use for the 2018 hay crop

BMP Region	Nitrogen Inhibitor or Stabilizer Use	Percent of Respondents
Northwestern	Yes	**
Northwestern	No	96
Northwestern	Don’t Know	**
Irrigated and Non-irrigated Sandy Soils	Yes	9
Irrigated and Non-irrigated Sandy Soils	No	87
Irrigated and Non-irrigated Sandy Soils	Don’t Know	4
Southwestern and West Central	Yes	**
Southwestern and West Central	No	97
Southwestern and West Central	Don’t Know	**
South Central	Yes	**
South Central	No	93
South Central	Don’t Know	**
Southeastern	Yes	**
Southeastern	No	84
Southeastern	Don’t Know	**
Statewide	**Yes**	**6**
Statewide	**No**	**90**
Statewide	**Don’t Know**	**4**

** Less than five responses

The following tables and figures in the remaining hay section represent the 3,527 statistically weighted respondents that reported on their largest hay field including fertilizer rate, timing, and previous crop planted. Fertilizer rates are based on the rate for each nutrient applied (nitrogen rate for fields fertilized with nitrogen, phosphorus rate for fields fertilized with phosphorus, potassium rate for fields fertilized with potassium and sulfur rate for fields fertilized with sulfur). Nutrient rates are only published if there are more than five responses.

Statewide: Hay Following Soybeans

Statewide, three percent of the fields reported were hay following soybeans. Figure 42 details the BMP regions where farmers reported on fields with hay following soybeans. There were 122 fields represented in Minnesota.[37]

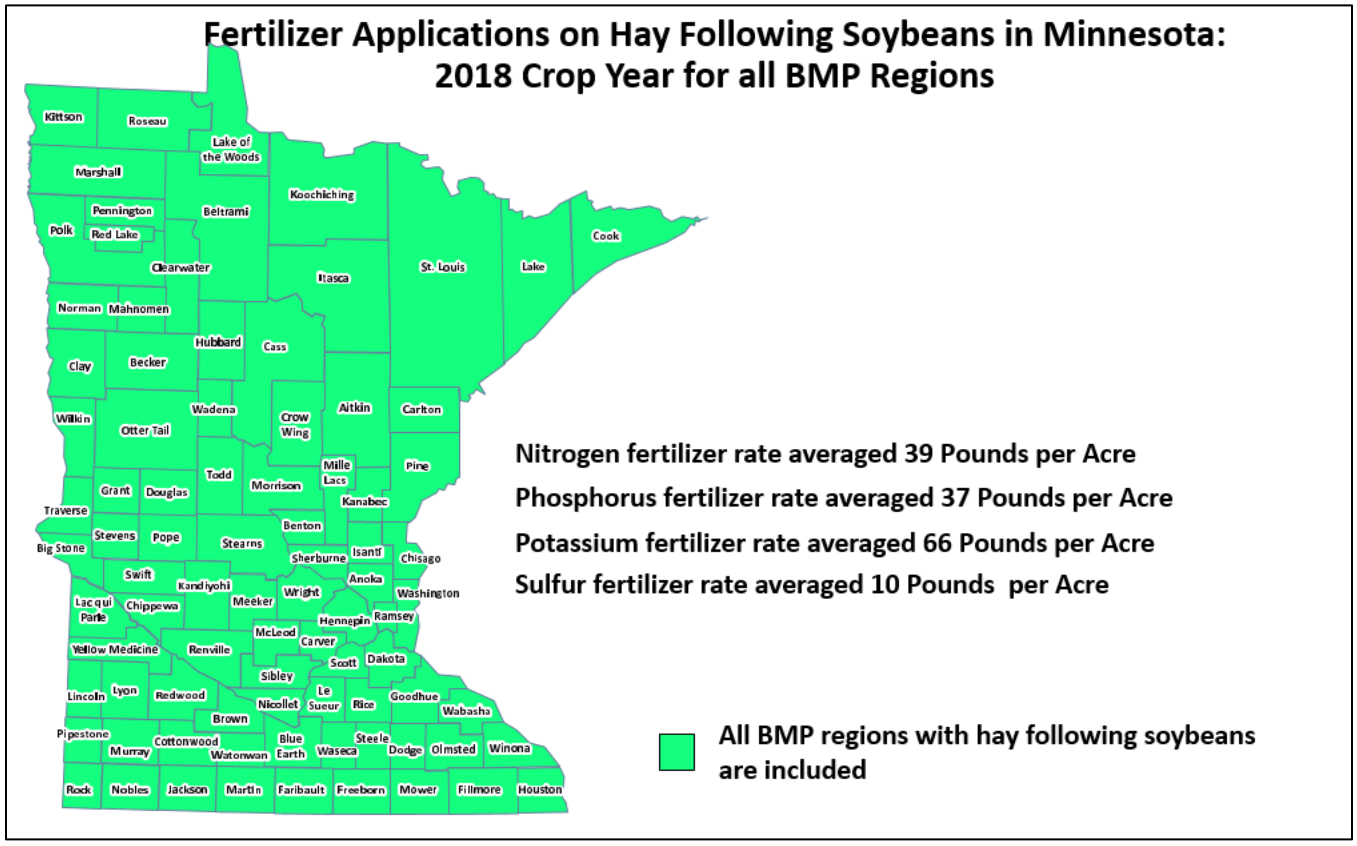

Figure 42. The average fertilizer rate for hay following soybeans in Minnesota

[37] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 95% applied nitrogen, 74% applied phosphorus, 72% applied potassium, and 68% applied sulfur on fields with hay following soybeans.

Figure 43 provides the distribution of average nitrogen fertilizer rate in Minnesota for hay following soybeans. Nitrogen rates are only from commercial fertilizer.

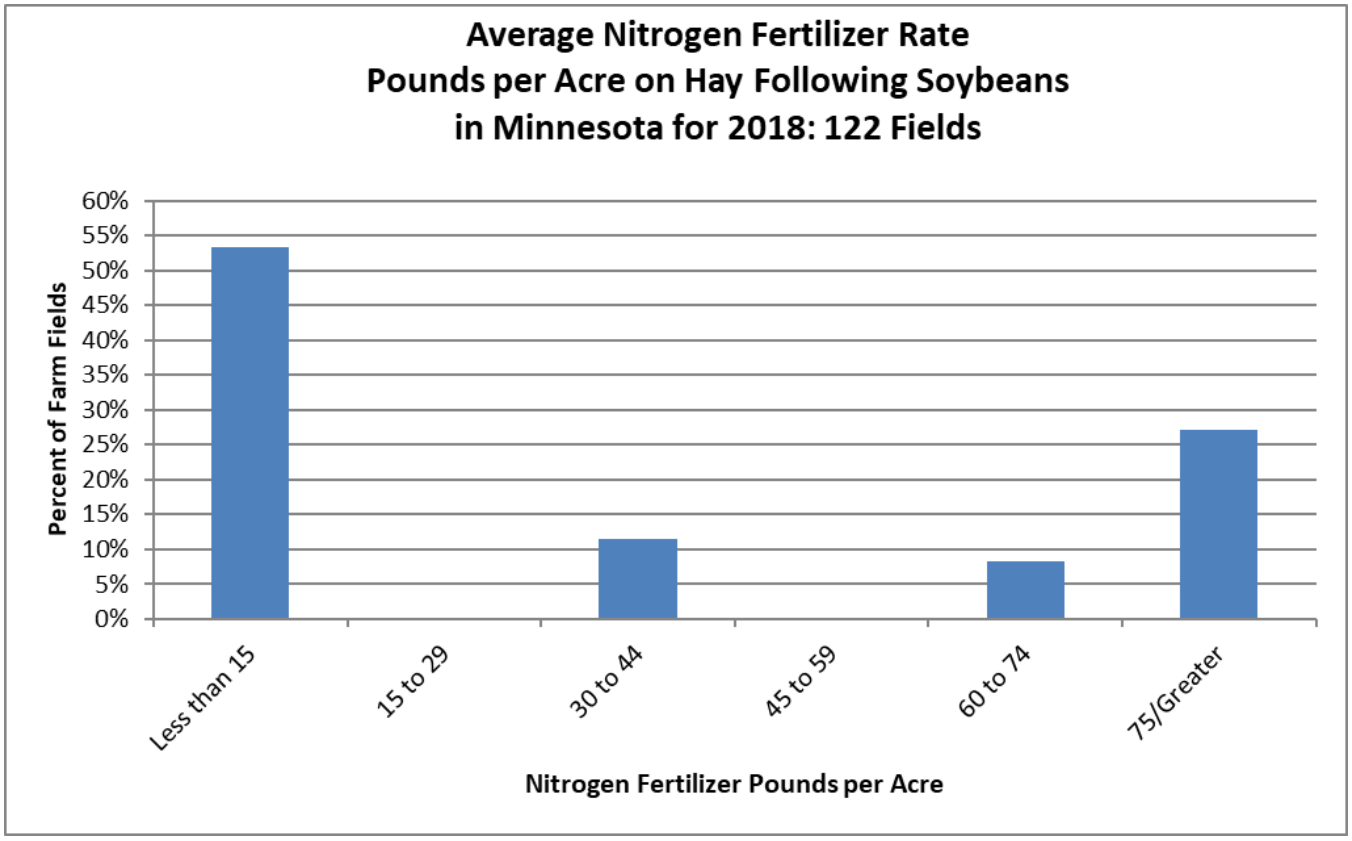

Figure 43. Average nitrogen fertilizer rate on hay following soybeans in Minnesota for 2018: 122 fields

In Minnesota, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields on hay following soybeans in Table 110.

Table 110. Average fertilizer rate in Minnesota for hay following soybeans

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	95	39	37
Phosphorus	74	37	27
Potassium	72	66	48
Sulfur	68	10	7

Southeastern BMP Region: Hay Following Soybeans

The SE BMP region had less than five responses for hay following soybeans.

South Central BMP Region: Hay Following Soybeans

The SC BMP region had less than five responses for hay following soybeans.

Southwestern and West Central BMP Region: Hay Following Soybeans

The SW BMP region had less than five responses for hay following soybeans

Northwest BMP Region: Hay Following Soybeans

The NW BMP region had less than five responses for hay following soybeans.

Irrigated and Non-irrigated Sandy Soils BMP Region: Hay Following Soybeans

The IRR BMP region had less than five responses for hay following soybeans.

Statewide: Hay Following Corn

Statewide, nine percent of the fields reported were hay following corn. Figure 44 details the BMP regions where farmers reported on fields with hay following corn. There were 317 fields represented in Minnesota.[38]

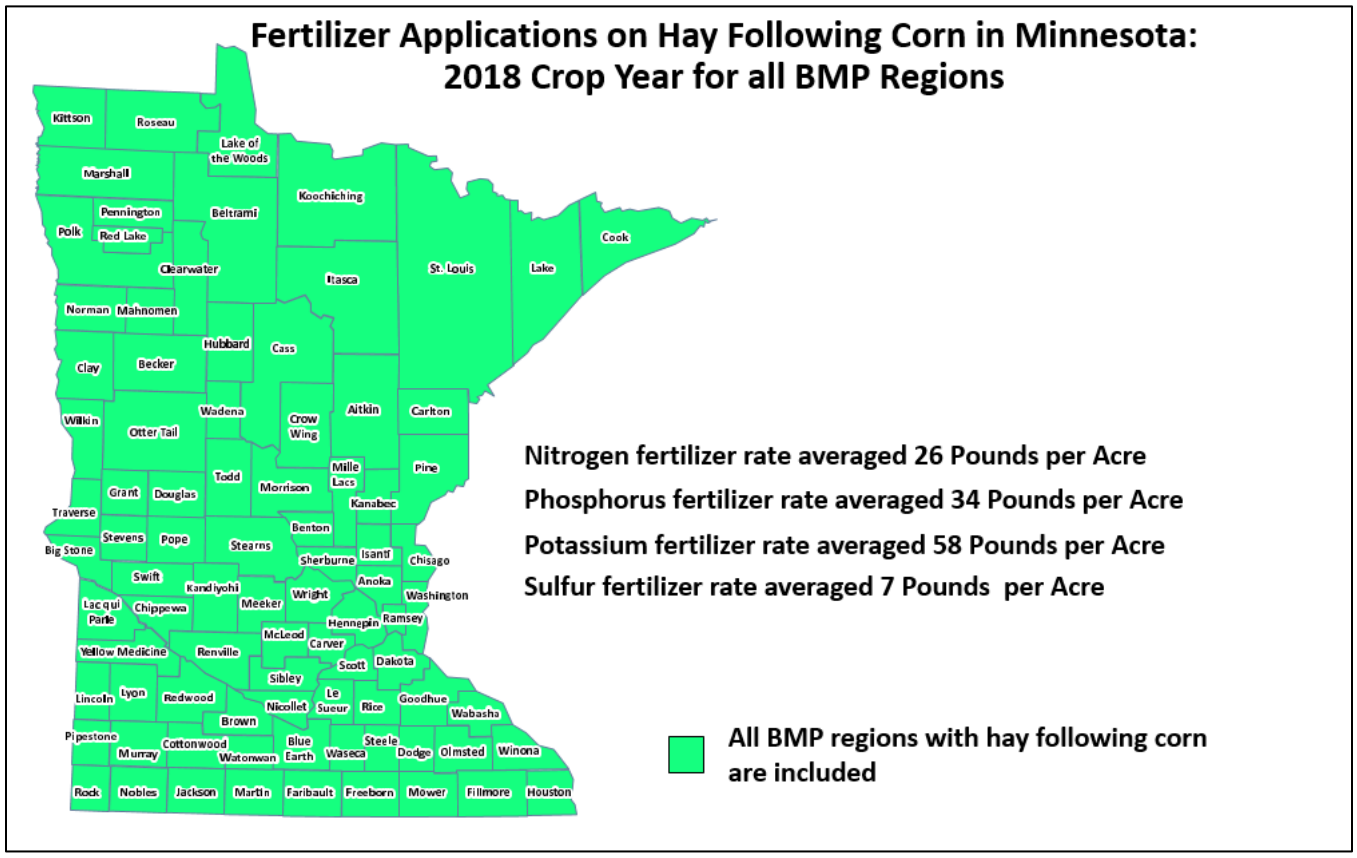

Figure 44. The average fertilizer rate for hay following corn in Minnesota

[38] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 75% applied nitrogen, 71% applied phosphorus, 87% applied potassium, and 40% applied sulfur on fields with hay following corn.

Figure 45 provides the distribution of average nitrogen fertilizer rate in Minnesota for hay following corn. Nitrogen rates are only from commercial fertilizer.

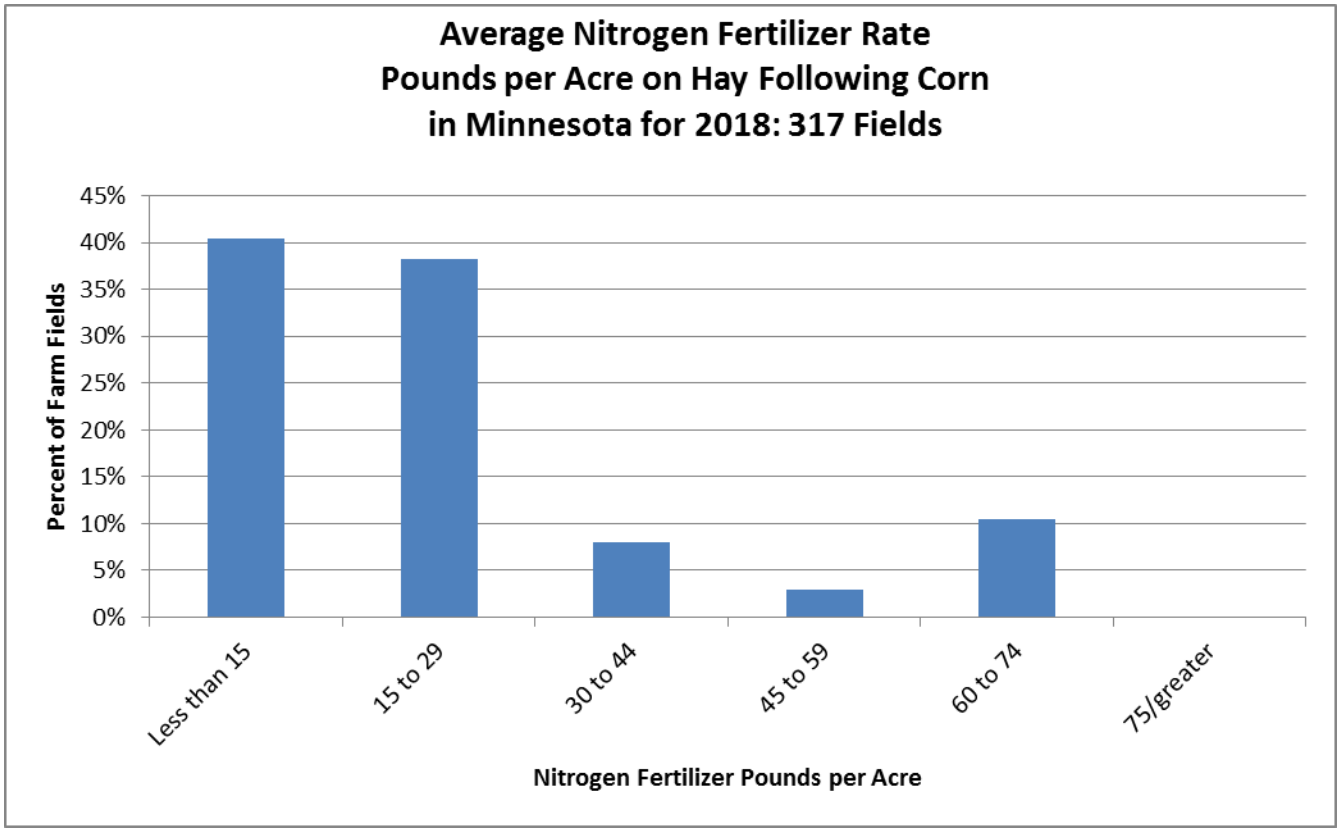

Figure 45. Average nitrogen fertilizer rate on hay following corn in Minnesota for 2018: 317 fields

In Minnesota, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields on hay following corn are shown in Table 111.

Table 111. Average fertilizer rate in Minnesota for hay following corn

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	75	26	19
Phosphorus	71	34	24
Potassium	87	58	50
Sulfur	40	7	3

Southeastern BMP Region: Hay Following Corn

The SE BMP region had less than five responses for hay following corn.

South Central BMP Region: Hay Following Corn

The SC BMP region had less than five responses for hay following corn.

Southwestern and West Central BMP Region: Hay Following Corn

The SW BMP region had less than five responses for hay following corn.

Northwestern BMP Region: Hay Following Corn

The NW BMP region had less than five responses for hay following corn.

Irrigated and Non-irrigated Sandy Soils BMP Region: Hay Following Corn

The IRR BMP region had less than five responses for hay following corn.

Statewide: Hay Following Corn Following Alfalfa

Statewide, less than five responses were reported for hay following corn following alfalfa: therefore, no BMP region had five or more responses for reporting.

Statewide: Hay Following Alfalfa

Statewide, forty nine percent of the fields reported were hay following alfalfa. Figure 46 details the BMP regions where farmers reported on fields with hay following alfalfa. There were 1,720 fields represented in Minnesota.[39]

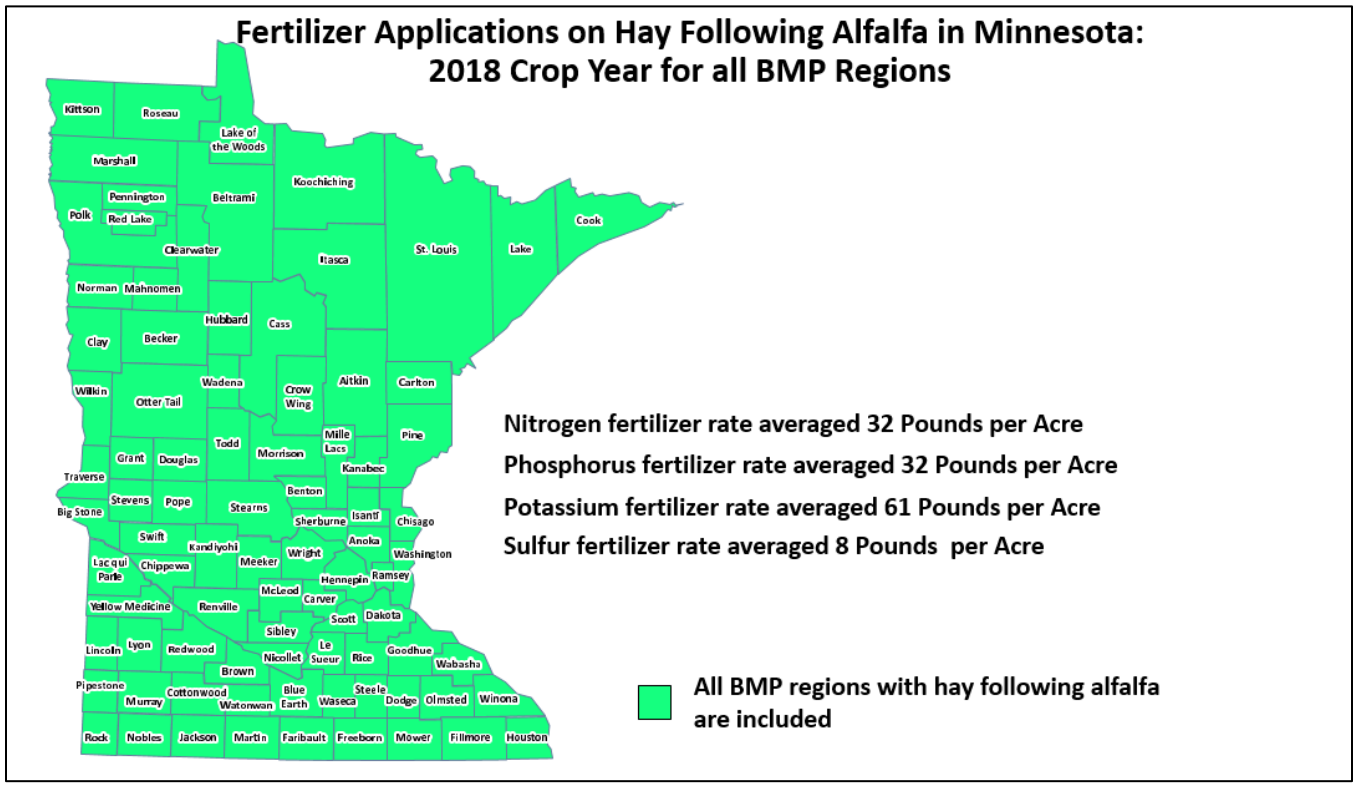

Figure 46. The average fertilizer rate for hay following alfalfa in Minnesota

[39] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 85% applied nitrogen, 57% applied phosphorus, 83% applied potassium, and 41% applied sulfur on fields with hay following alfalfa.

Figure 47 provides the distribution of average nitrogen fertilizer rate in Minnesota for hay following alfalfa. Nitrogen rates are only from commercial fertilizer.

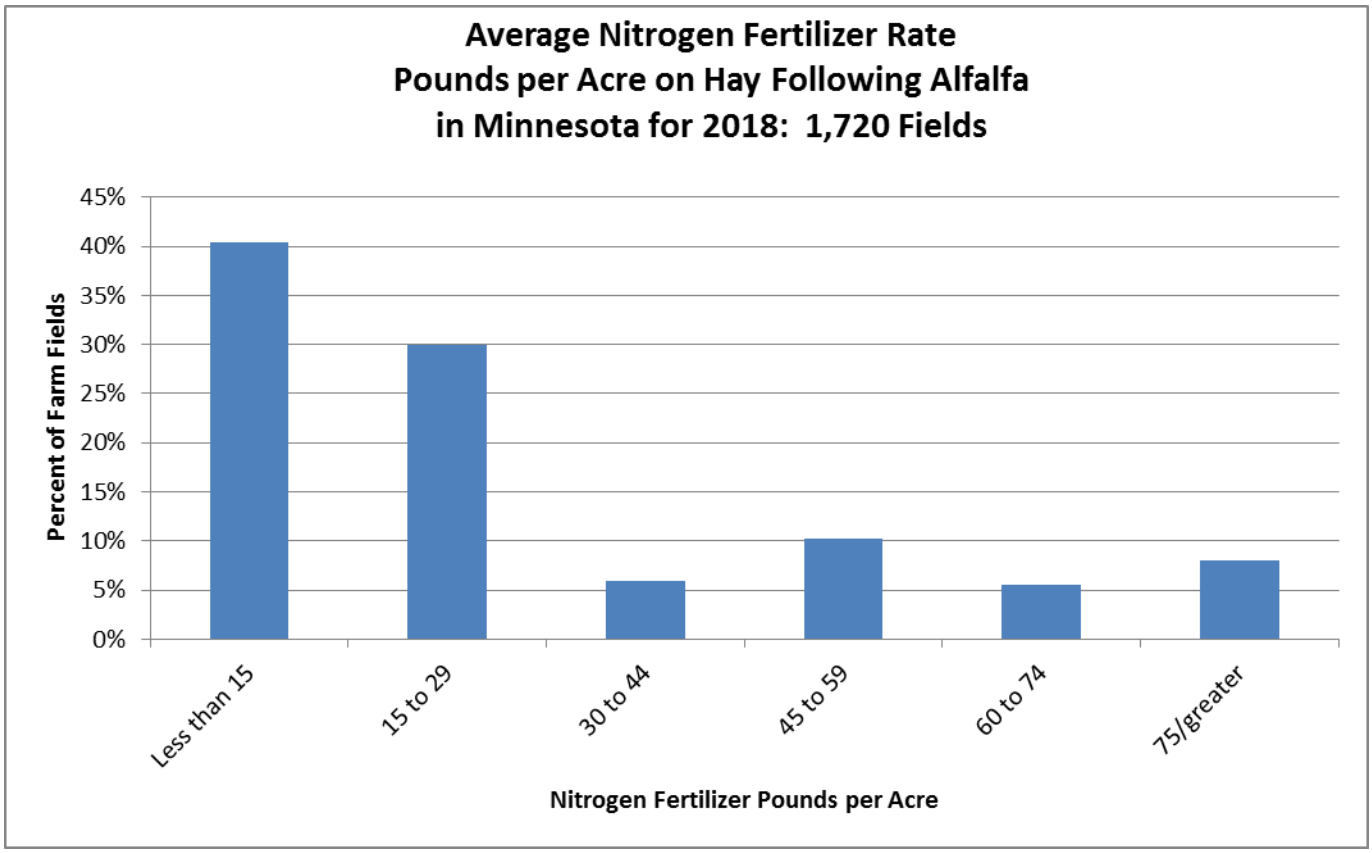

Figure 47. Average nitrogen fertilizer rate on hay following alfalfa in Minnesota for 2018: 1,720 fields

In Minnesota, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following alfalfa are shown in Table 112.

Table 112. Average fertilizer rate in Minnesota for hay following alfalfa

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	85	32	27
Phosphorus	57	32	18
Potassium	83	61	51
Sulfur	41	8	3

Southeastern BMP Region: Hay Following Alfalfa

There were 223 fields that were represented in the SE BMP region for hay following alfalfa analysis. Figure 48 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following alfalfa in the SE BMP region.[40]

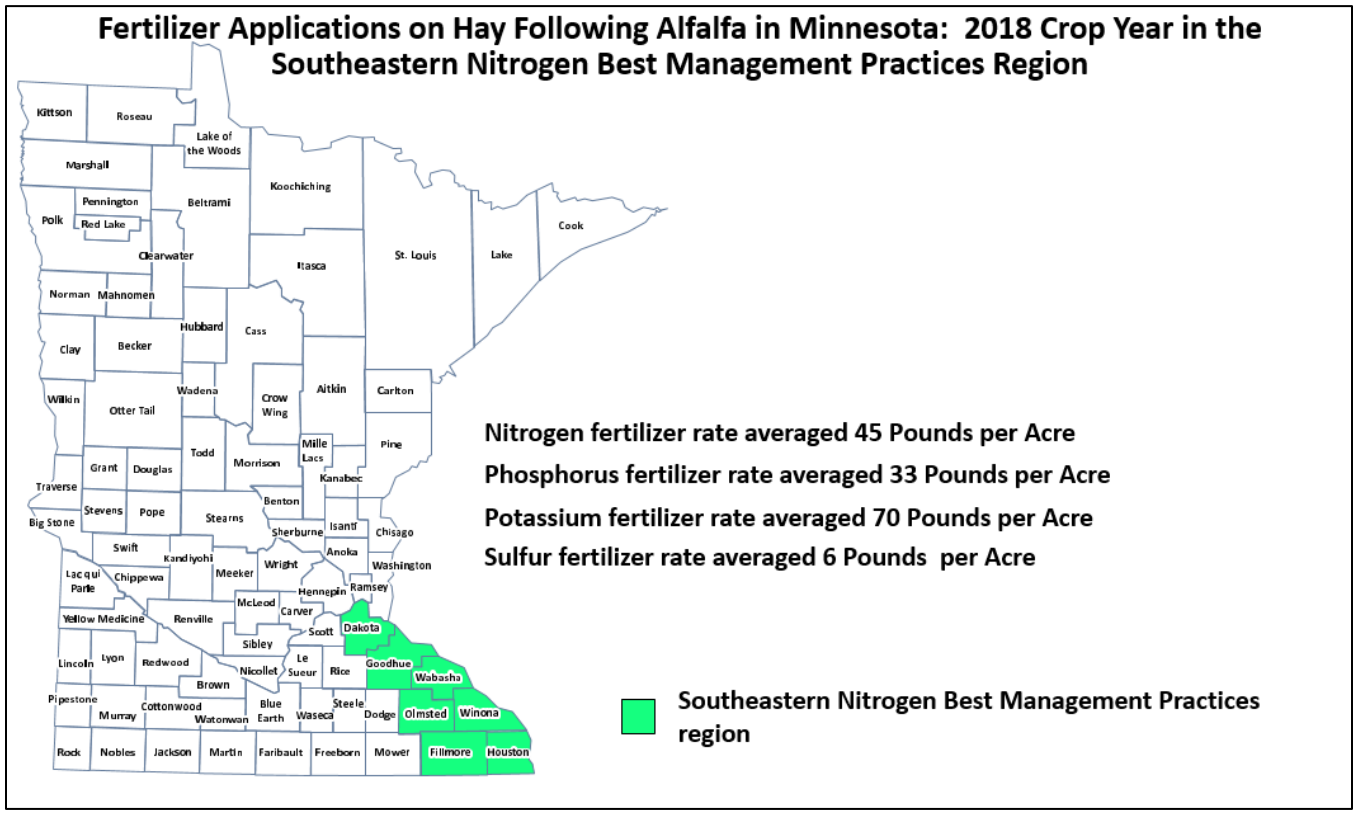

Figure 48. The average fertilizer rate for hay following alfalfa in the SE BMP region

[40] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 83% applied nitrogen, 61% applied phosphorus, 75% applied potassium, and 48% applied sulfur on fields with hay following alfalfa.

Figure 49 provides the distribution of average nitrogen fertilizer rate in the SE BMP region for hay following alfalfa. Nitrogen rates are only from commercial fertilizer.

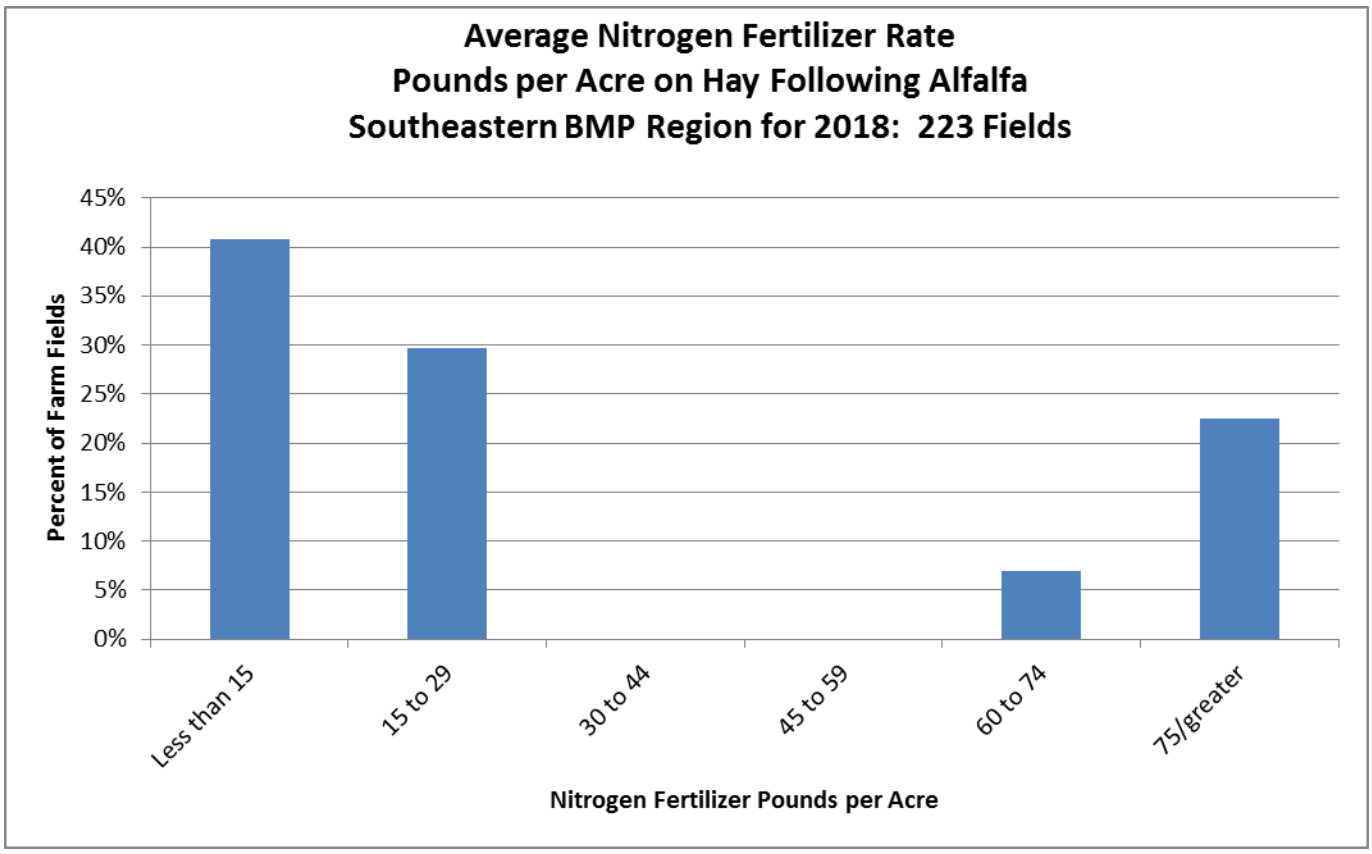

Figure 49. Average nitrogen fertilizer rate on hay following alfalfa in the SE BMP region for 2018: 223 fields

In the SE BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following alfalfa are shown in Table 113.

Table 113. Average fertilizer rate in the SE BMP region for hay following alfalfa

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	83	45	37
Phosphorus	61	33	20
Potassium	75	70	52
Sulfur	48	6	3

South Central BMP Region: Hay Following Alfalfa

There were 258 fields that were represented in the SC BMP region for hay following alfalfa analysis. Figure 50 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following alfalfa in the SC BMP region.[41]

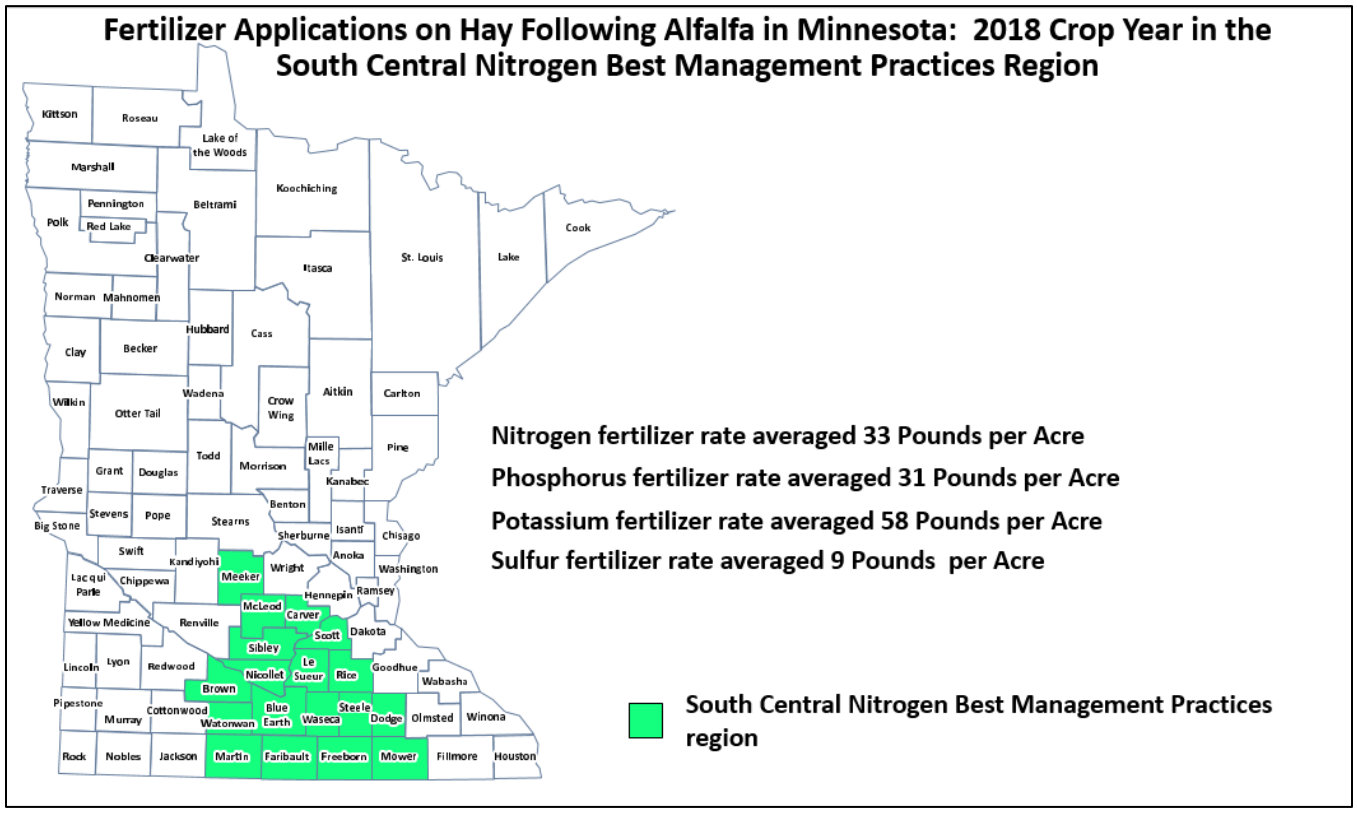

Figure 50. The average fertilizer rate for hay following alfalfa in the SC BMP region

[41] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 74% applied nitrogen, 56% applied phosphorus, 84% applied potassium, and 30% applied sulfur on fields with hay following alfalfa.

Figure 51 provides the distribution of average nitrogen fertilizer rate in the SC BMP region for hay following alfalfa. Nitrogen rates are only from commercial fertilizer.

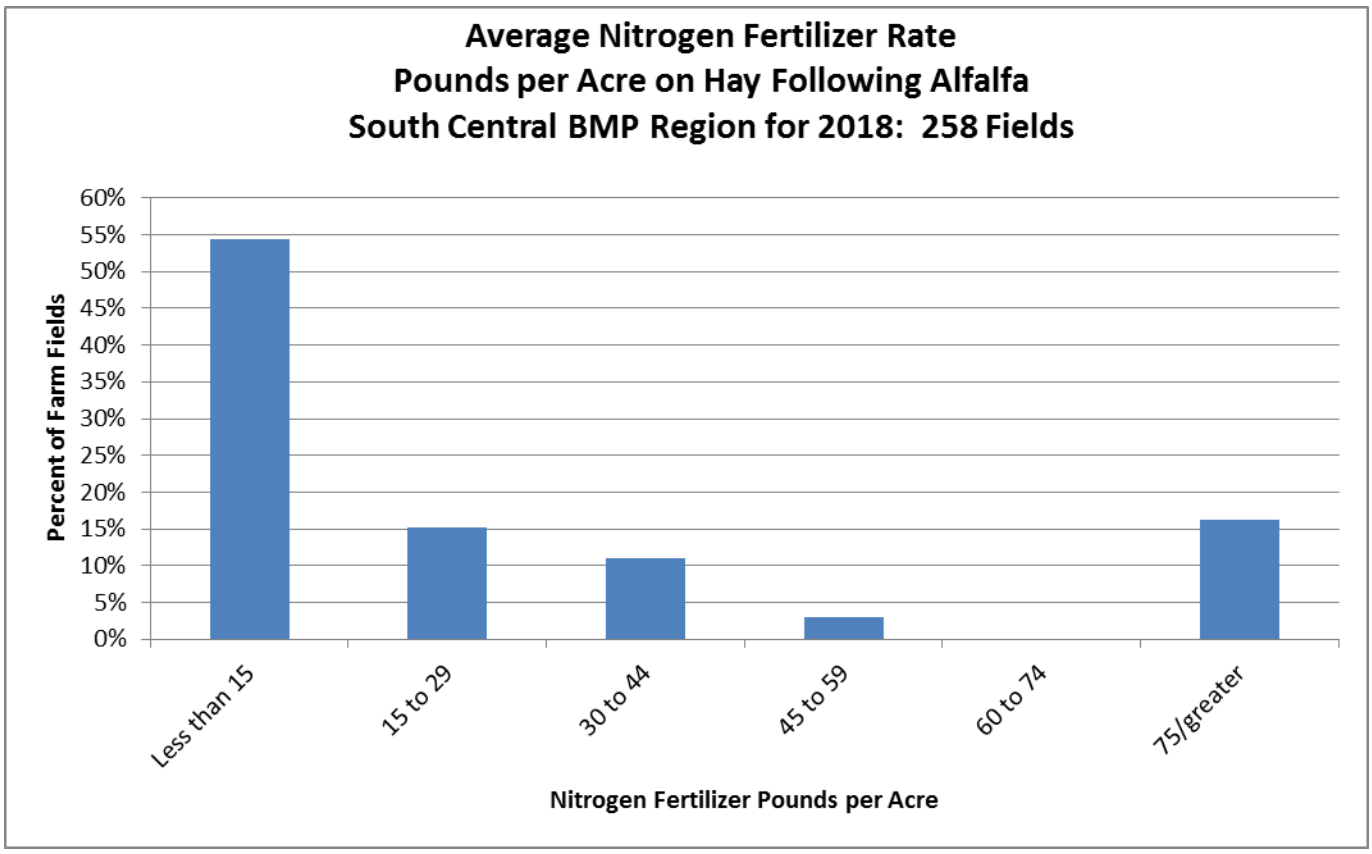

Figure 51. Average nitrogen fertilizer rate on hay following alfalfa in the SC BMP region for 2018: 258 fields

In the SC BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following alfalfa are shown in Table 114.

Table 114. Average fertilizer rate in the SC BMP region for hay following alfalfa

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	74	33	25
Phosphorus	56	31	17
Potassium	84	58	48
Sulfur	30	9	3

Southwestern and West Central BMP Region: Hay Following Alfalfa

There were 314 fields that were represented in the SW BMP region for hay following alfalfa analysis. Figure 52 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following alfalfa in the SW BMP region.[42]

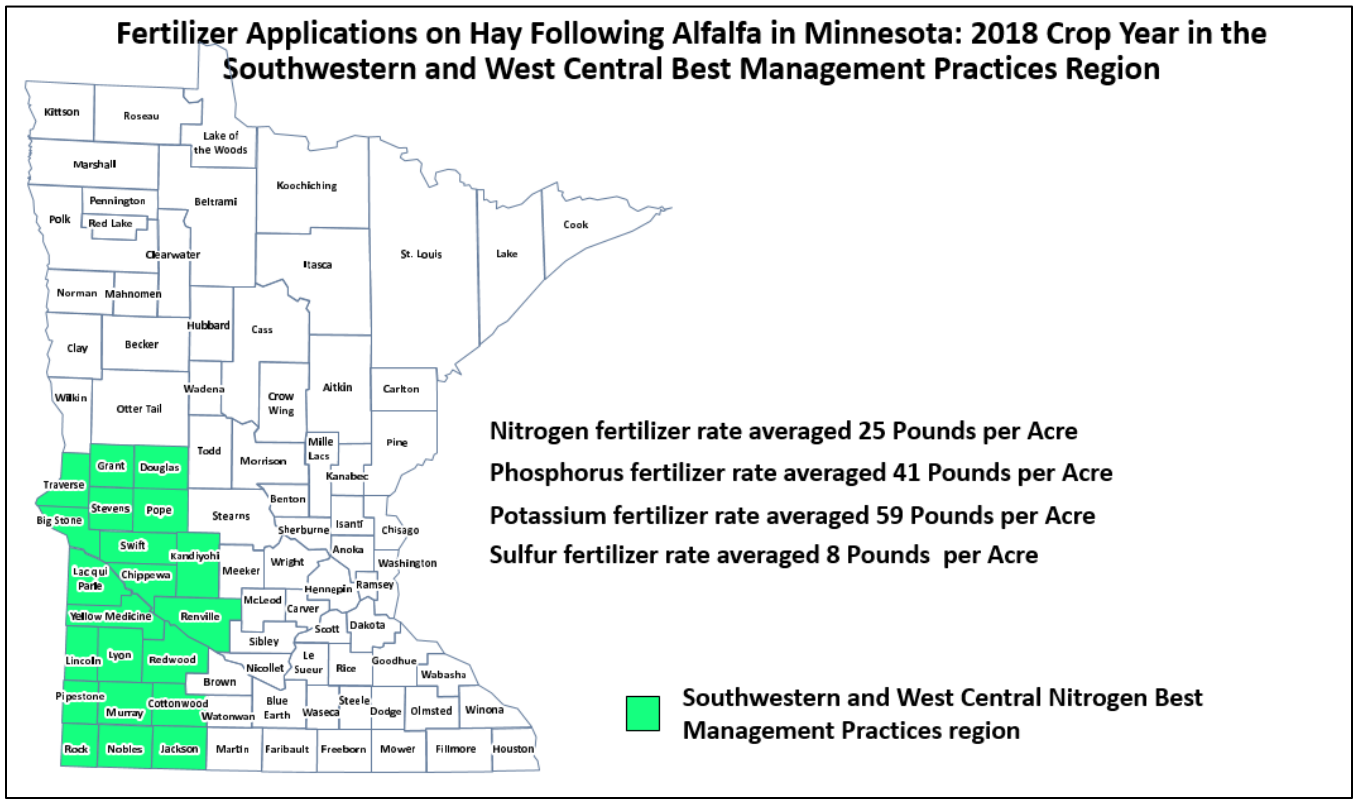

Figure 52. The average fertilizer rate for hay following alfalfa in the SW BMP region

[42] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 92% applied nitrogen, 69% applied phosphorus, 80% applied potassium, and 46% applied sulfur on fields with hay following alfalfa.

Figure 53 provides the distribution of average nitrogen fertilizer rate in the SW BMP region for hay following alfalfa. Nitrogen rates are only from commercial fertilizer.

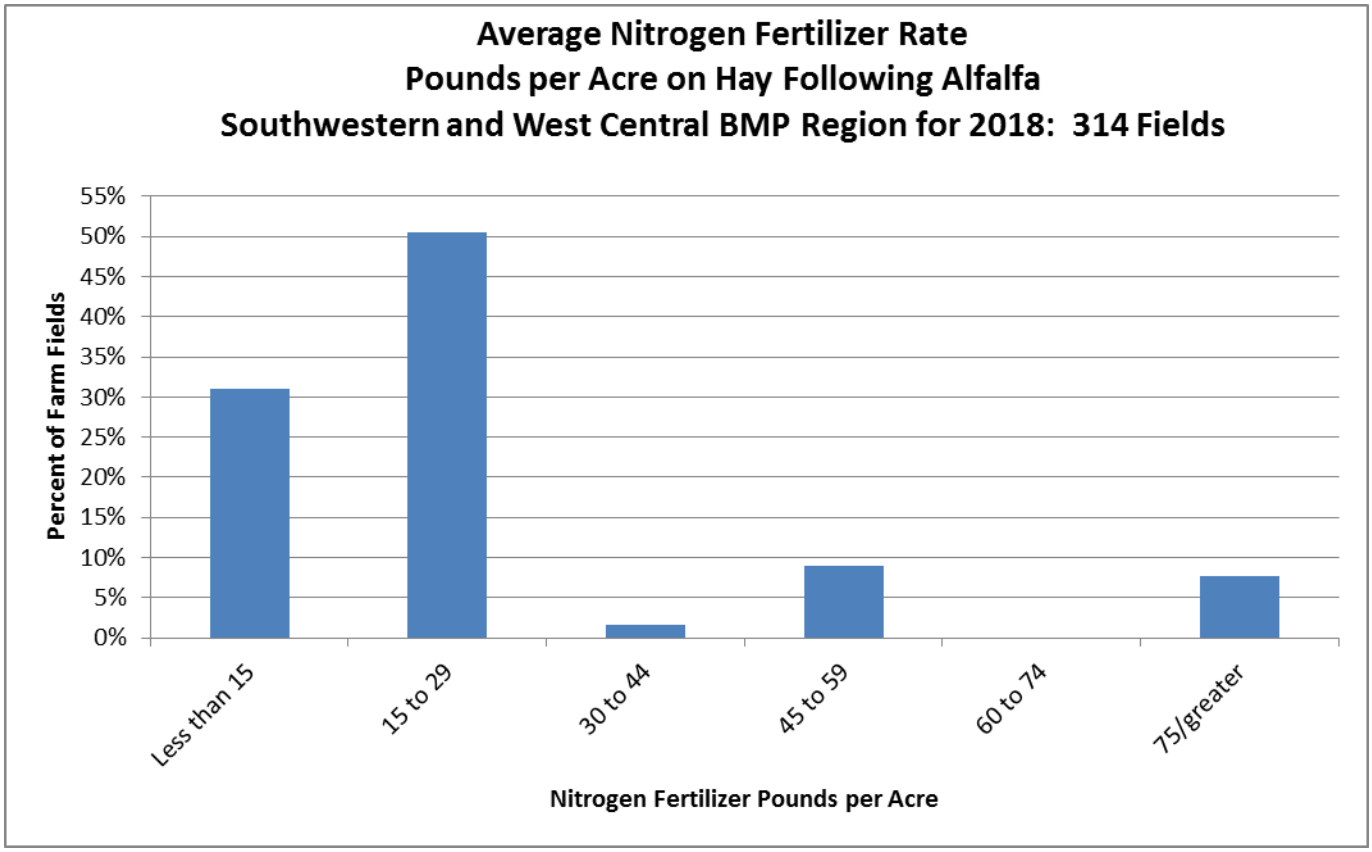

Figure 53. Average nitrogen fertilizer rate on hay following alfalfa in the SW BMP region for 2018: 314 fields

In the SW BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following alfalfa are shown in Table 115.

Table 115. Average fertilizer rate in the SW BMP region for hay following alfalfa

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	92	25	24
Phosphorus	69	41	28
Potassium	80	59	48
Sulfur	46	8	4

Northwestern BMP Region: Hay Following Alfalfa

There were 177 fields that were represented in the NW BMP region for hay following alfalfa analysis. Figure 54 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following alfalfa in the NW BMP region.[43]

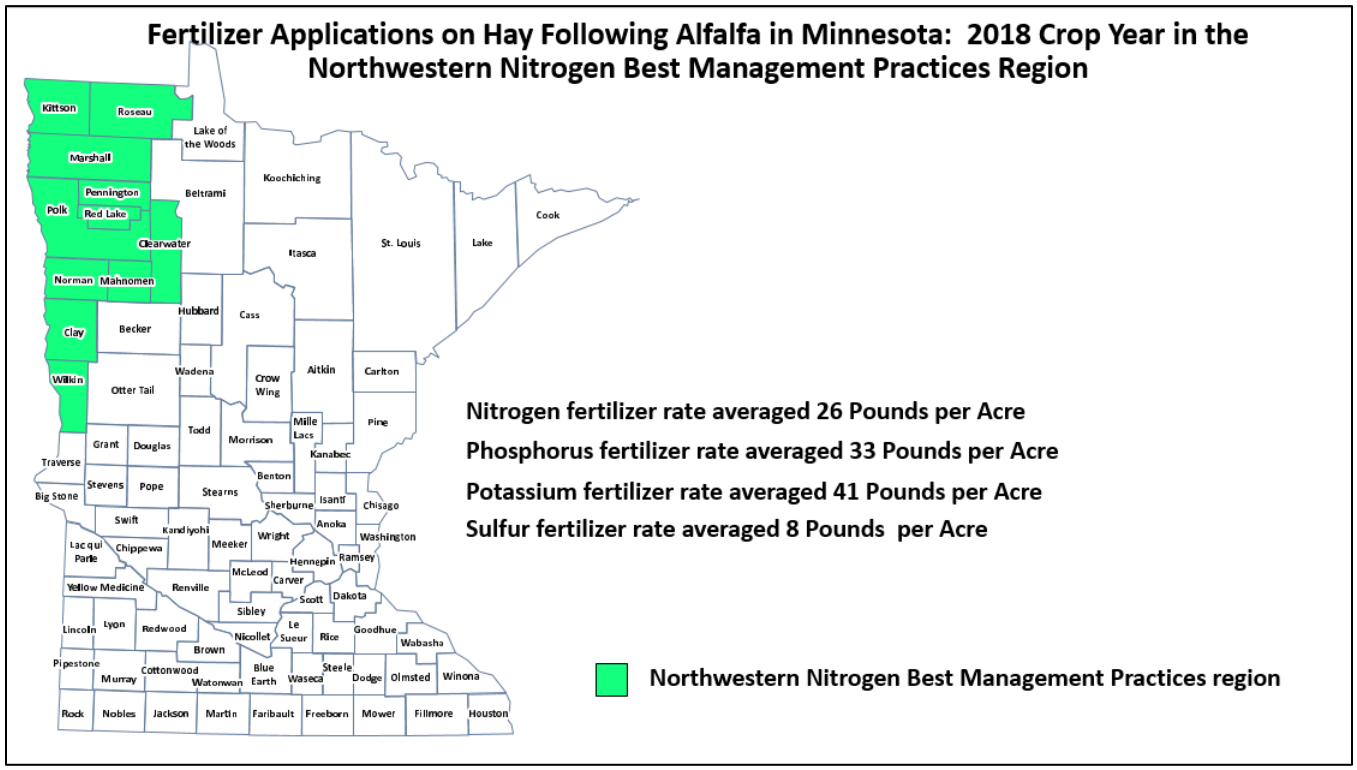

Figure 54. The average fertilizer rate for hay following alfalfa in the NW BMP region

[43] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 84% applied phosphorus, 83% applied potassium, and 45% applied sulfur on fields with hay following alfalfa.

Figure 55 provides the distribution of average nitrogen fertilizer rate in the NW BMP region for hay following alfalfa. Nitrogen rates are only from commercial fertilizer.

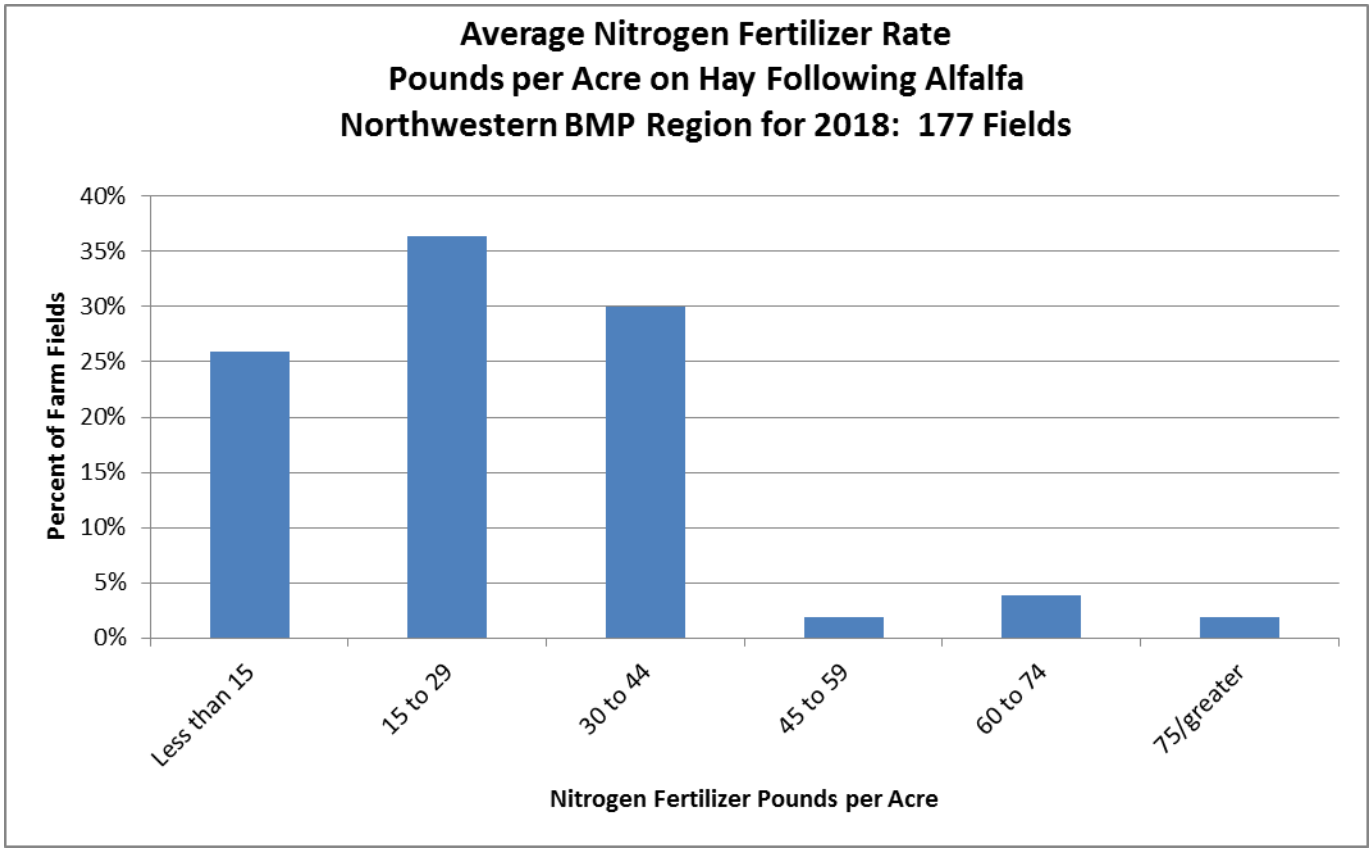

Figure 55. Average nitrogen fertilizer rate on hay following alfalfa in the NW BMP region for 2018: 177 fields

In the NW BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following alfalfa are shown in Table 116.

Table 116. Average fertilizer rate in the NW BMP region for hay following alfalfa

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	100	26	26
Phosphorus	84	33	28
Potassium	83	41	34
Sulfur	45	8	4

Irrigated and Non-irrigated Sandy Soils BMP Region: Hay Following Alfalfa

There were 748 fields that were represented in the IRR BMP region for hay following alfalfa analysis. Figure 56 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following alfalfa in the IRR BMP region.[44]

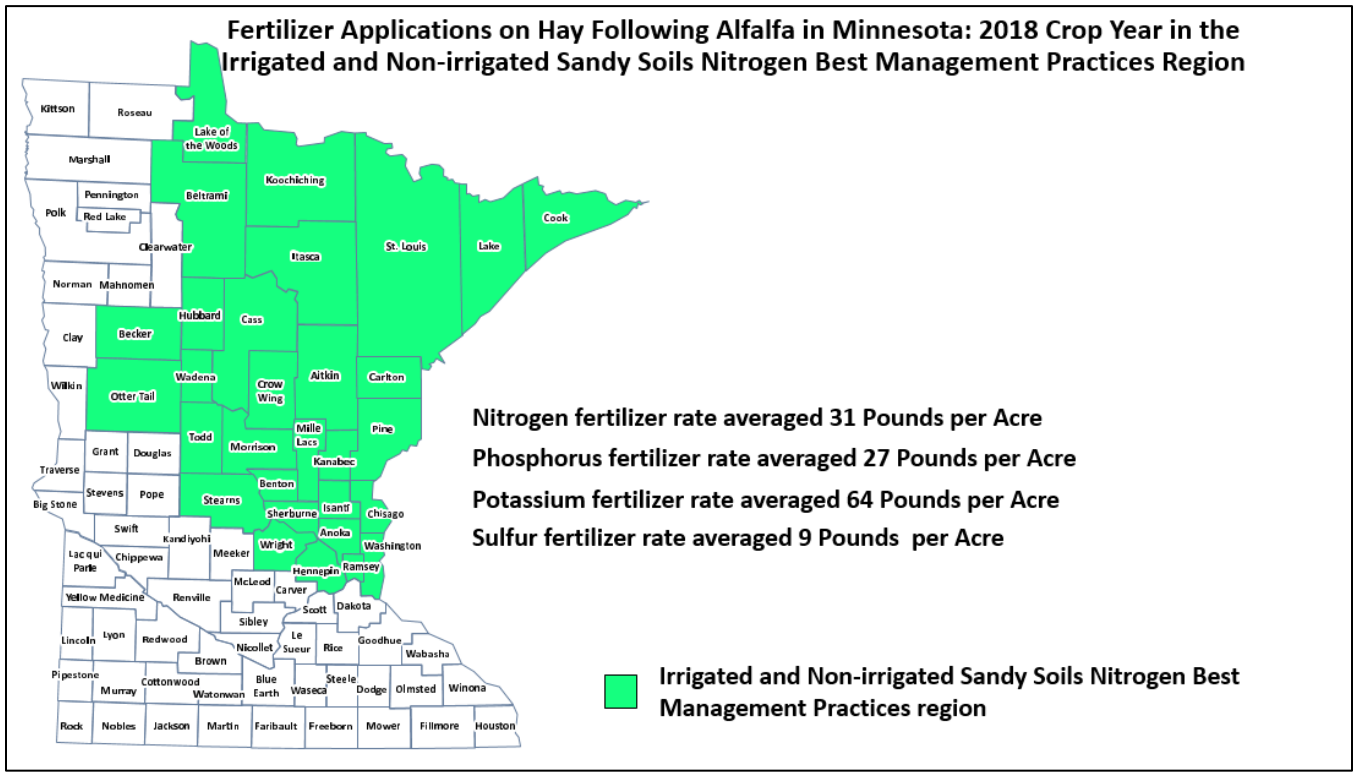

Figure 56. The average fertilizer rate for hay following alfalfa in the IRR BMP region

[44] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 83% applied nitrogen, 45% applied phosphorus, 87% applied potassium, and 41% applied sulfur on fields with hay following alfalfa.

Figure 57 provides the distribution of average nitrogen fertilizer rate in the IRR BMP region for hay following alfalfa. Nitrogen rates are only from commercial fertilizer.

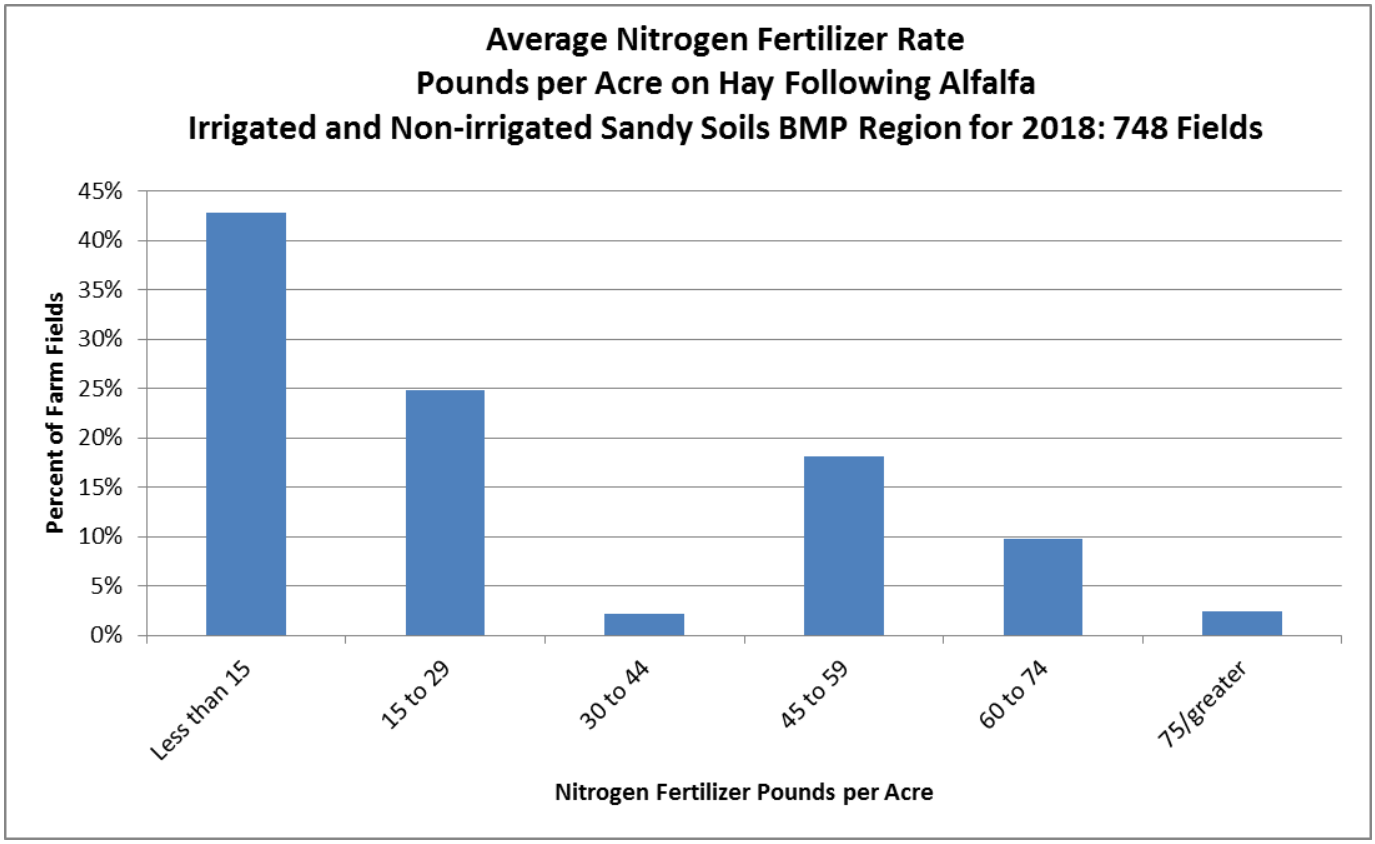

Figure 57. Average nitrogen fertilizer rate on hay following alfalfa in the IRR BMP region for 2018: 748 fields

In the IRR BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following alfalfa are shown in Table 117.

Table 117. Average fertilizer rate in the IRR BMP region for hay following alfalfa

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	83	31	26
Phosphorus	45	27	12
Potassium	87	64	56
Sulfur	41	9	4

Statewide: Hay Following Small Grains

Statewide, six percent of the fields reported were hay following small grains. Figure 58 details the BMP regions where farmers reported on fields with hay following small grains. There were 206 fields represented in Minnesota.[45]

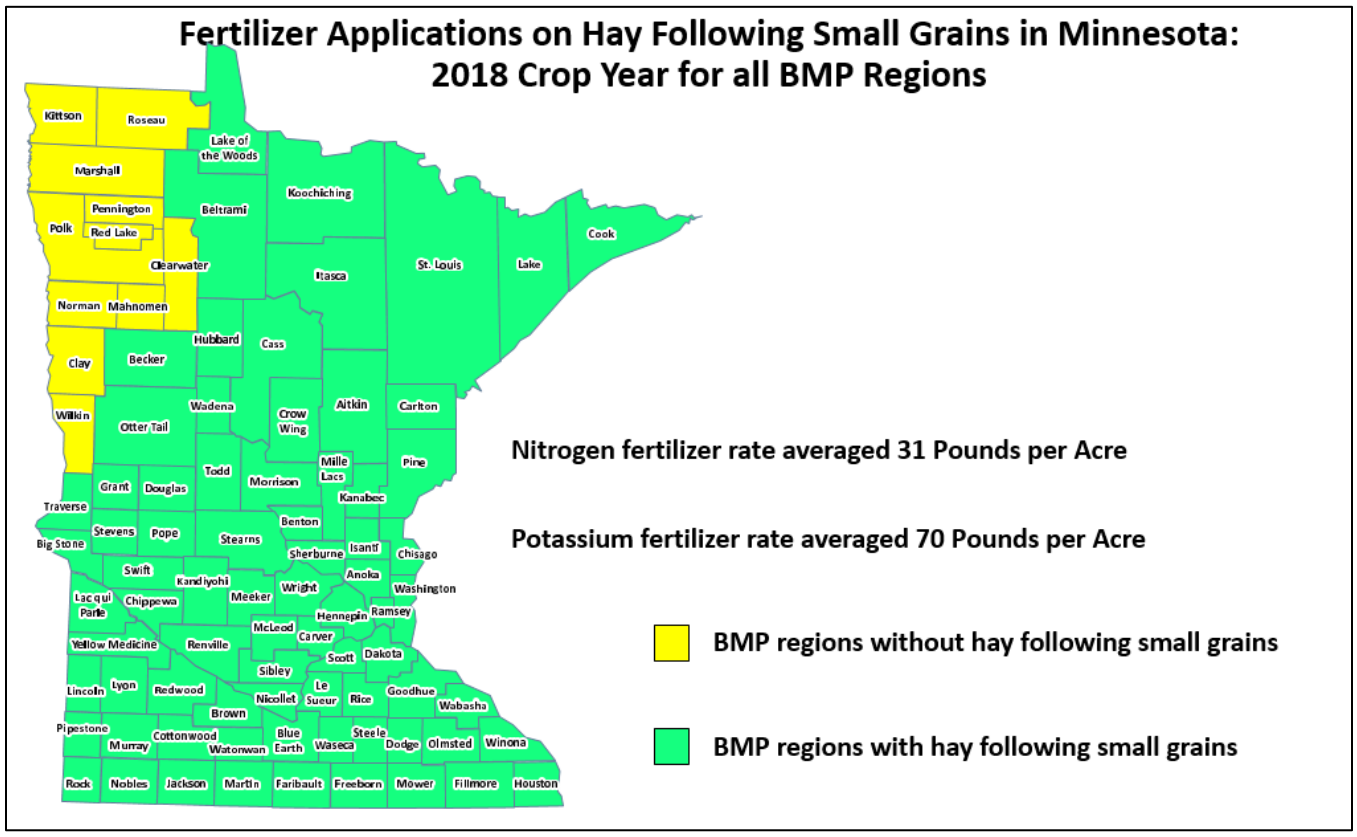

Figure 58. The average fertilizer rate for hay following small grains in Minnesota

[45] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 40% applied nitrogen and 100% applied potassium on fields with hay following small grains. Fewer than five respondents reported applying phosphorus and sulfur.

Figure 59 provides the distribution of average nitrogen fertilizer rate in Minnesota for hay following small grains. Nitrogen rates are only from commercial fertilizer.

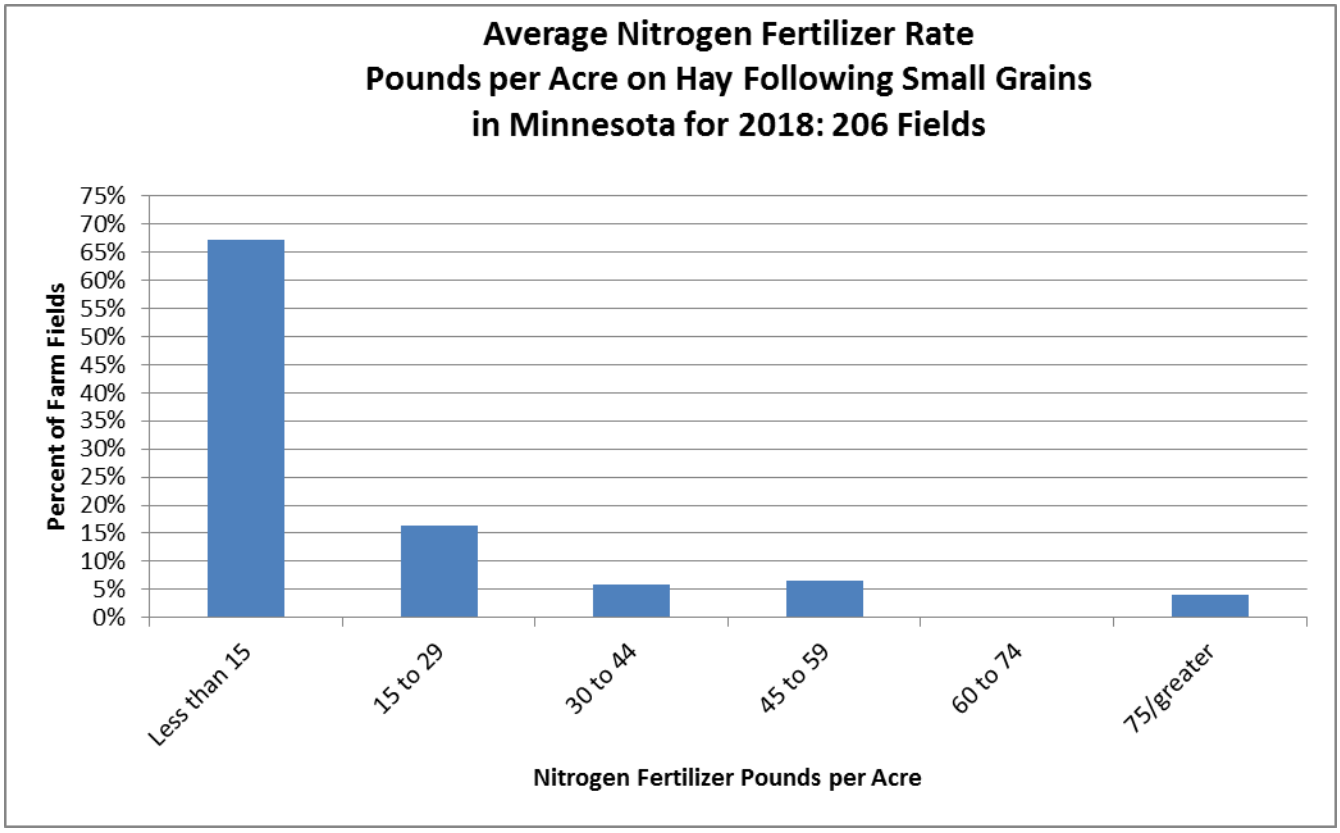

Figure 59. Average nitrogen fertilizer rate on hay following small grains in Minnesota for 2018: 206 fields

In Minnesota, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following small grains are shown in Table 118.

Table 118. Average fertilizer rate in Minnesota for hay following small grains

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	40	31	13
Phosphorus	**	**	**
Potassium	100	70	70
Sulfur	**	**	**

Southeastern BMP Region: Hay Following Small Grains

The SE BMP had less than five responses for hay following small grains.

South Central BMP Region: Hay Following Small Grains

The SC BMP had less than five responses for hay following small grains.

Southwestern and West Central BMP Region: Hay Following Small Grains

The SW BMP had less than five responses for hay following small grains.

Northwestern BMP Region: Hay Following Small Grains

The NW BMP had no responses for hay following small grains.

Irrigated and Non-irrigated Sandy Soils BMP Region: Hay Following Small Grains

The IRR BMP had less than five responses for hay following small grains.

Statewide: Hay Following Other Crops

Statewide, thirty percent of the fields represented were hay following other crops. Figure 60 details the BMP regions where farmers reported on fields with hay following other crops. There were 1,055 fields represented in Minnesota.[46]

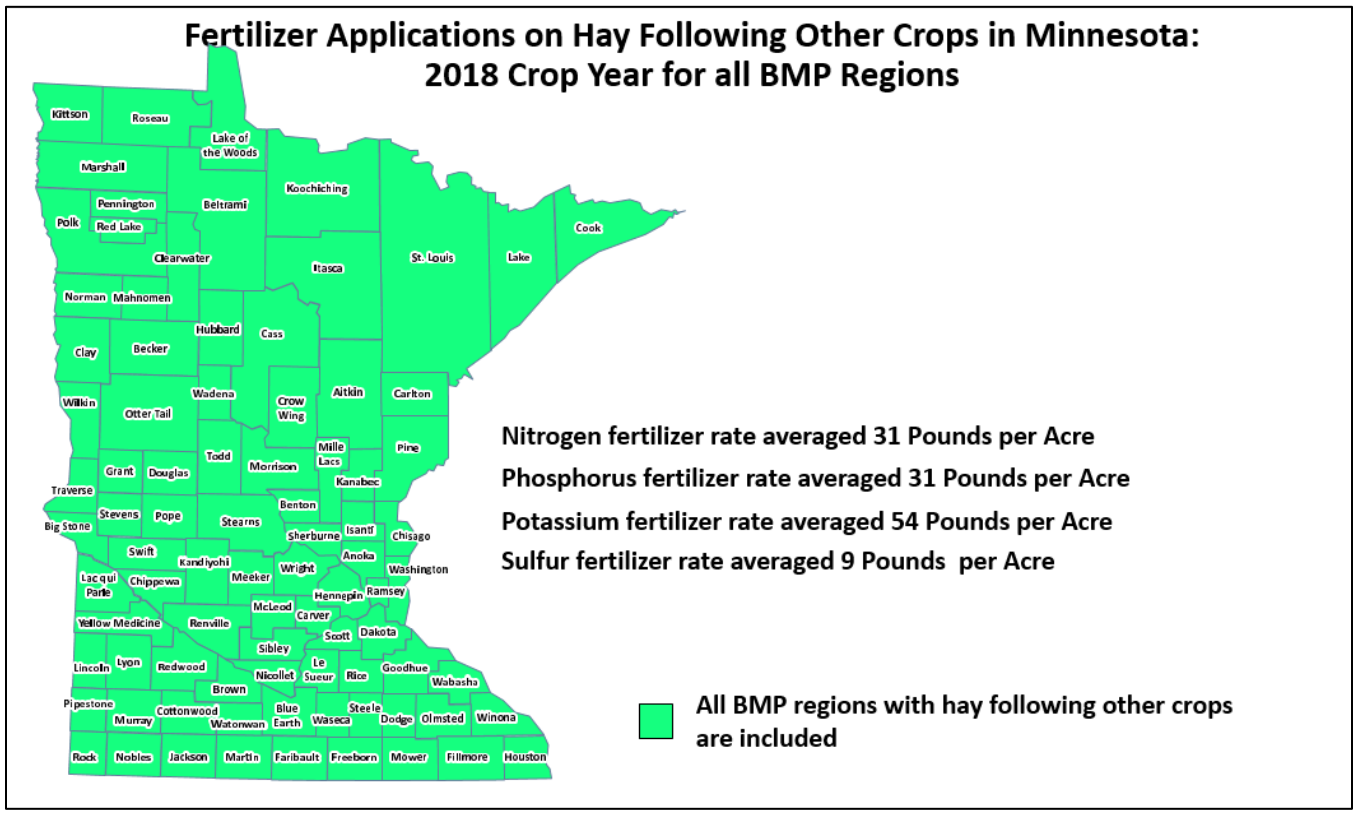

Figure 60. The average fertilizer rate for hay following other crops in Minnesota

[46] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 84% applied nitrogen, 49% applied phosphorus, 84% applied potassium, and 33% applied sulfur on fields with hay following other crops.

Figure 61 provides the distribution of average nitrogen fertilizer rate in Minnesota for hay following other crops. Nitrogen rates are only from commercial fertilizer.

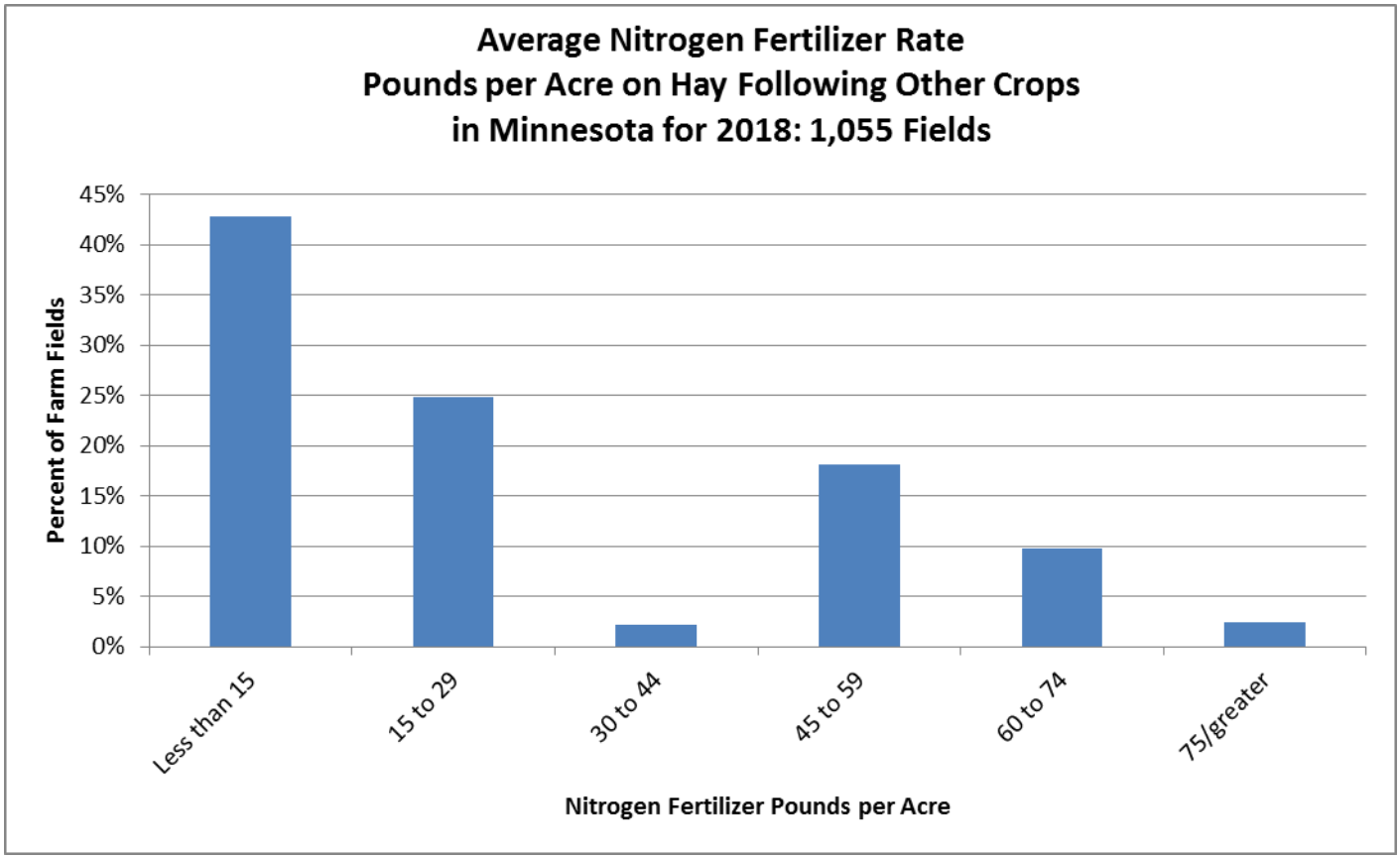

Figure 61. Average nitrogen fertilizer rate on hay following other crops in Minnesota for 2018: 1,055 fields.

In Minnesota, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following other crops are shown in Table 119.

Table 119. Average fertilizer rate in Minnesota for hay following other crops

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	84	31	26
Phosphorus	49	31	15
Potassium	84	54	45
Sulfur	33	9	3

Southeastern BMP Region: Hay Following Other Crops

There were 240 fields that were represented in the SE BMP region for hay following other crop analysis. Figure 62 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following other crops in the SE BMP region.[47]

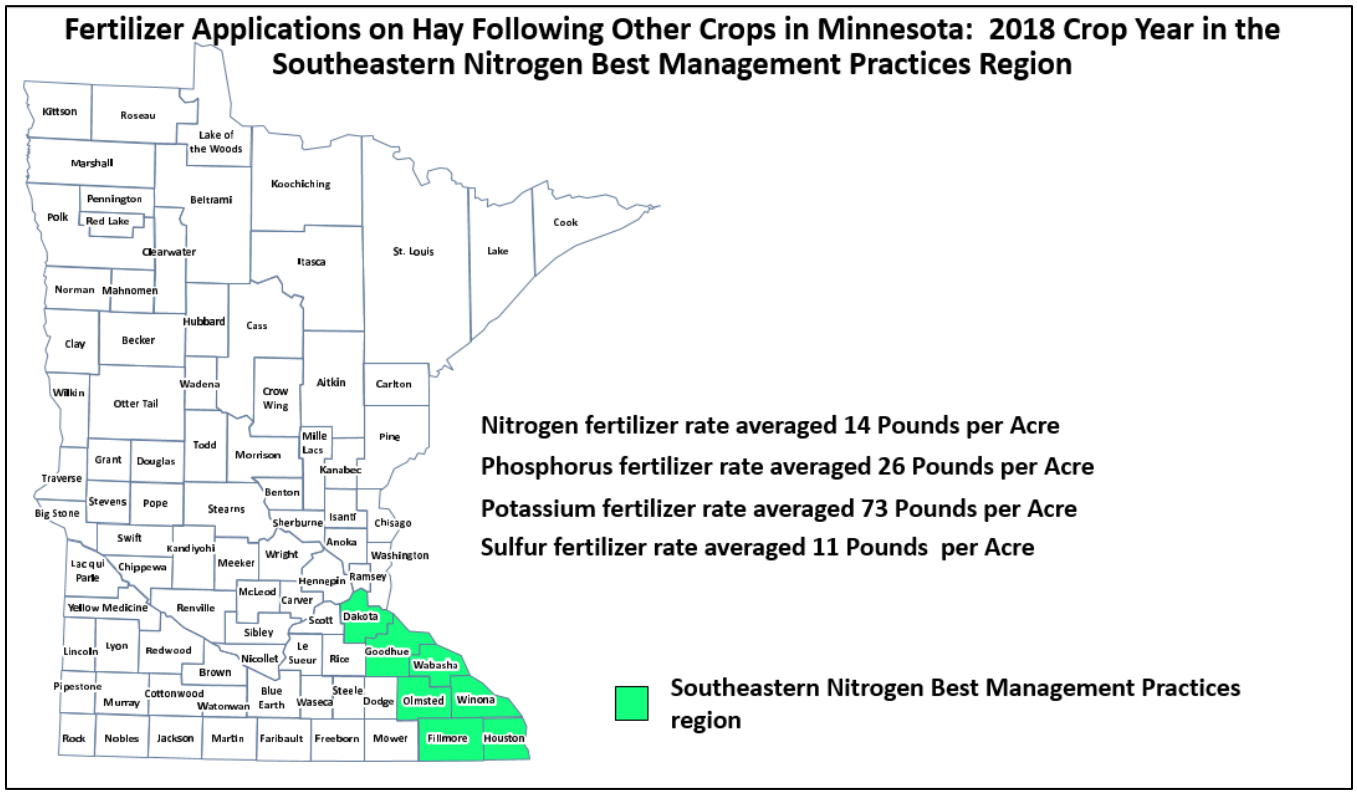

Figure 62. The average fertilizer rate for hay following other crops in the SE BMP region

[47] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 81% applied nitrogen, 46% applied phosphorus, 84% applied potassium, and 36% applied sulfur on fields with hay following other crops.

Figure 63 provides the distribution of average nitrogen fertilizer rate in the SE BMP region for hay following other crops. Nitrogen rates are only from commercial fertilizer.

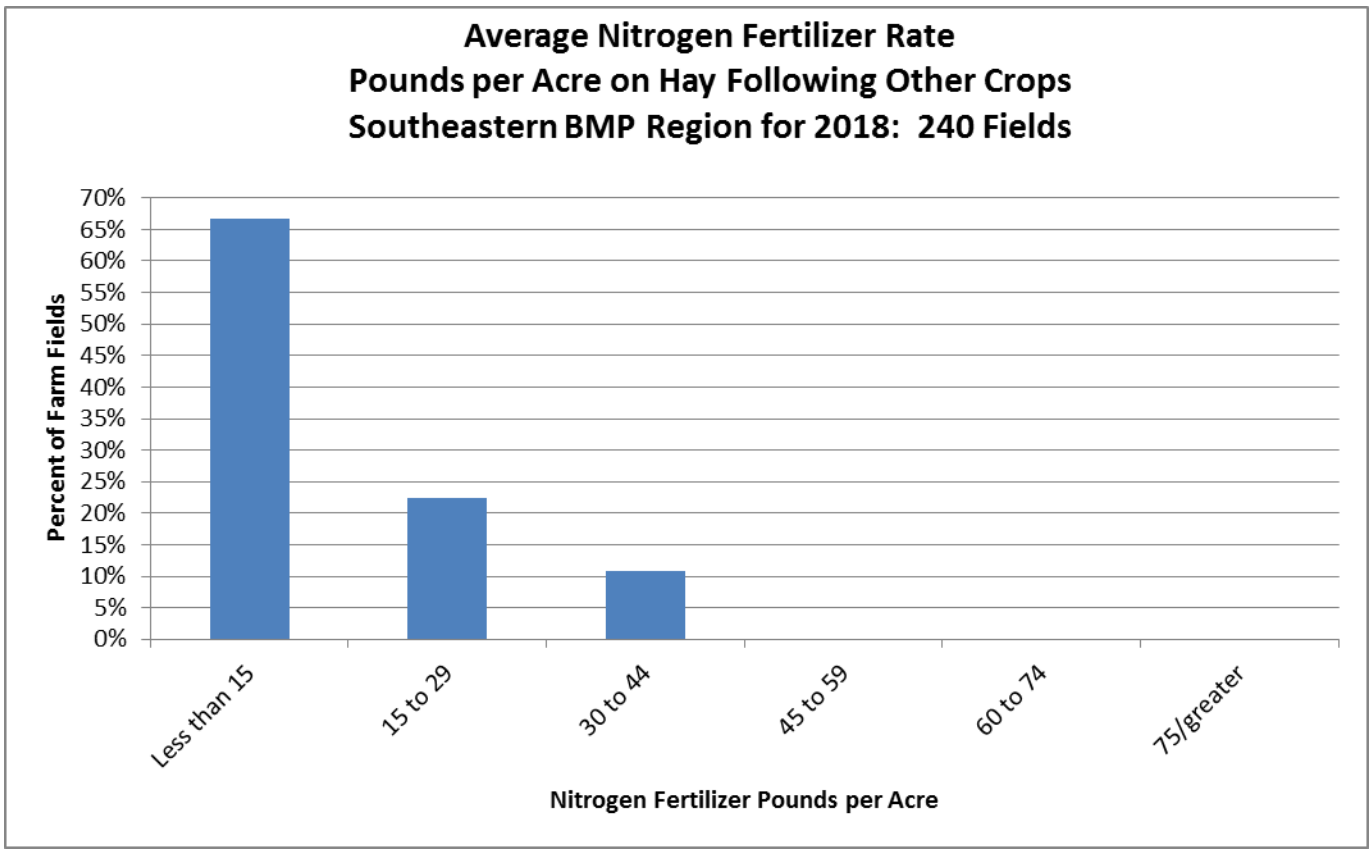

Figure 63. Average nitrogen fertilizer rate on hay following other crops in the SE BMP region for 2018: 240 fields.

In the SE BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following other crops are shown in Table 120.

Table 120. Average fertilizer rate in the SE BMP region for hay following other crops

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	81	14	11
Phosphorus	46	26	12
Potassium	84	73	61
Sulfur	36	11	4

South Central BMP Region: Hay Following Other Crops

There were 78 fields that were represented in the SC BMP region for hay following other crop analysis. Figure 64 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following other crops in the SC BMP region.[48]

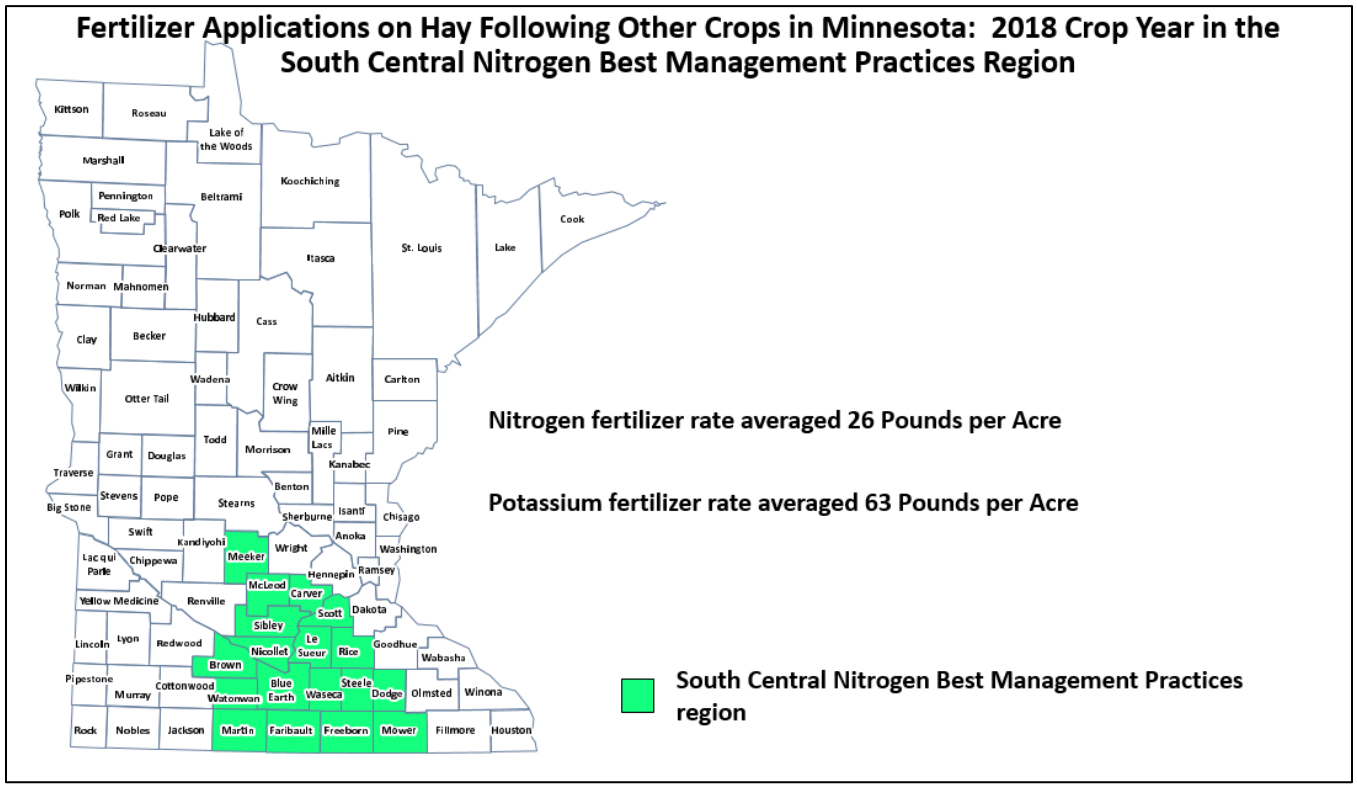

Figure 64. The average fertilizer rate for hay following other crops in the SC BMP region

[48] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 94% applied nitrogen and 62% applied potassium on fields with hay following other crops. Less than five respondents reported applying phosphorus and sulfur.

Figure 65 provides the distribution of average nitrogen fertilizer rate in the SC BMP region for hay following other crops. Nitrogen rates are only from commercial fertilizer.

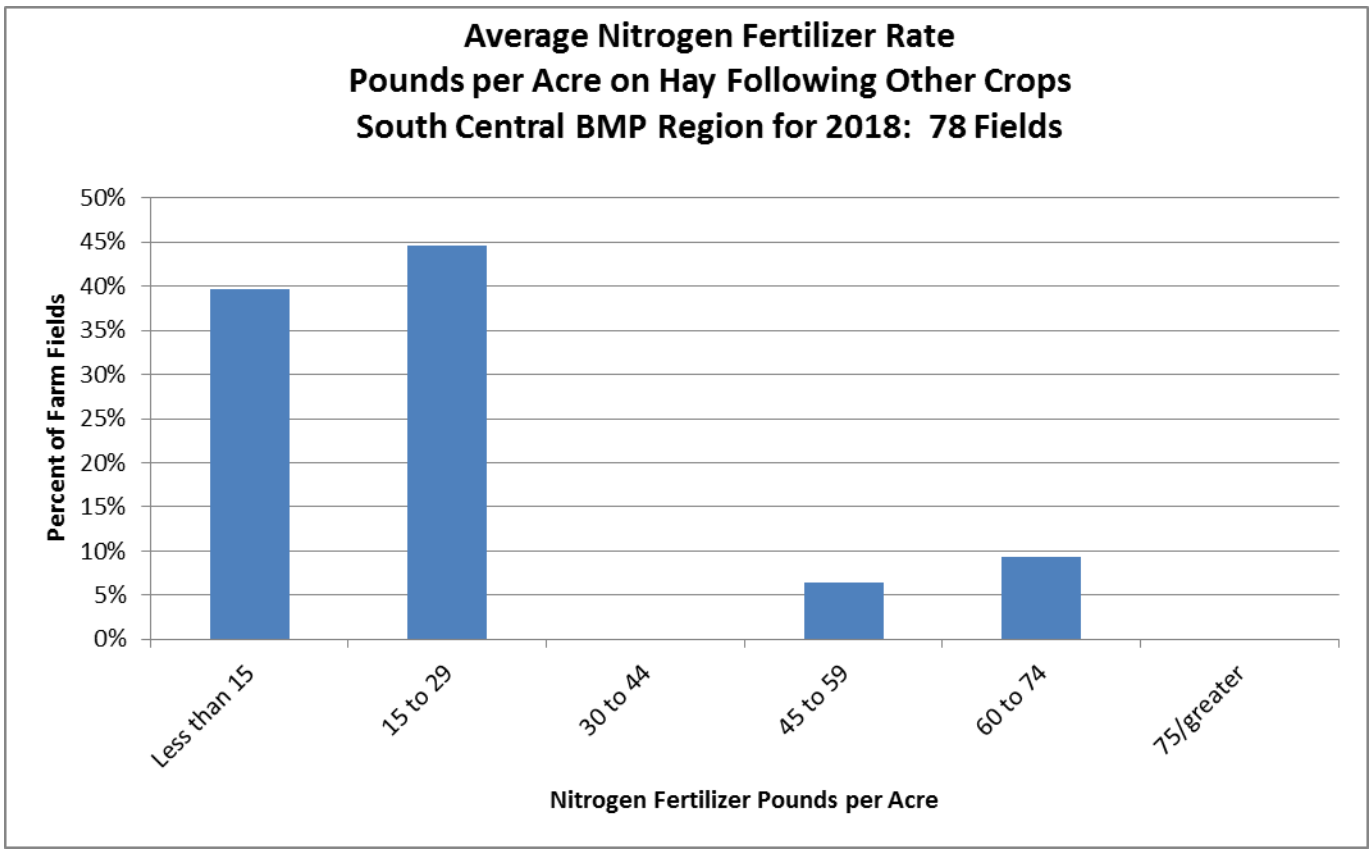

Figure 65. Average nitrogen fertilizer rate on hay following other crops in the SC BMP region for 2018: 78 fields

In the SC BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following other crops are shown in Table 121.

Table 121. Average fertilizer rate in the SC BMP region for hay following other crops

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	94	26	24
Phosphorus	**	**	**
Potassium	62	63	39
Sulfur	**	**	**

** Less than five respondents

Southwestern and West Central BMP Region: Hay Following Other Crops

There were 88 fields that were represented in the SW BMP region for hay following other crop analysis. Figure 66 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following other crops in the SW BMP region.[49]

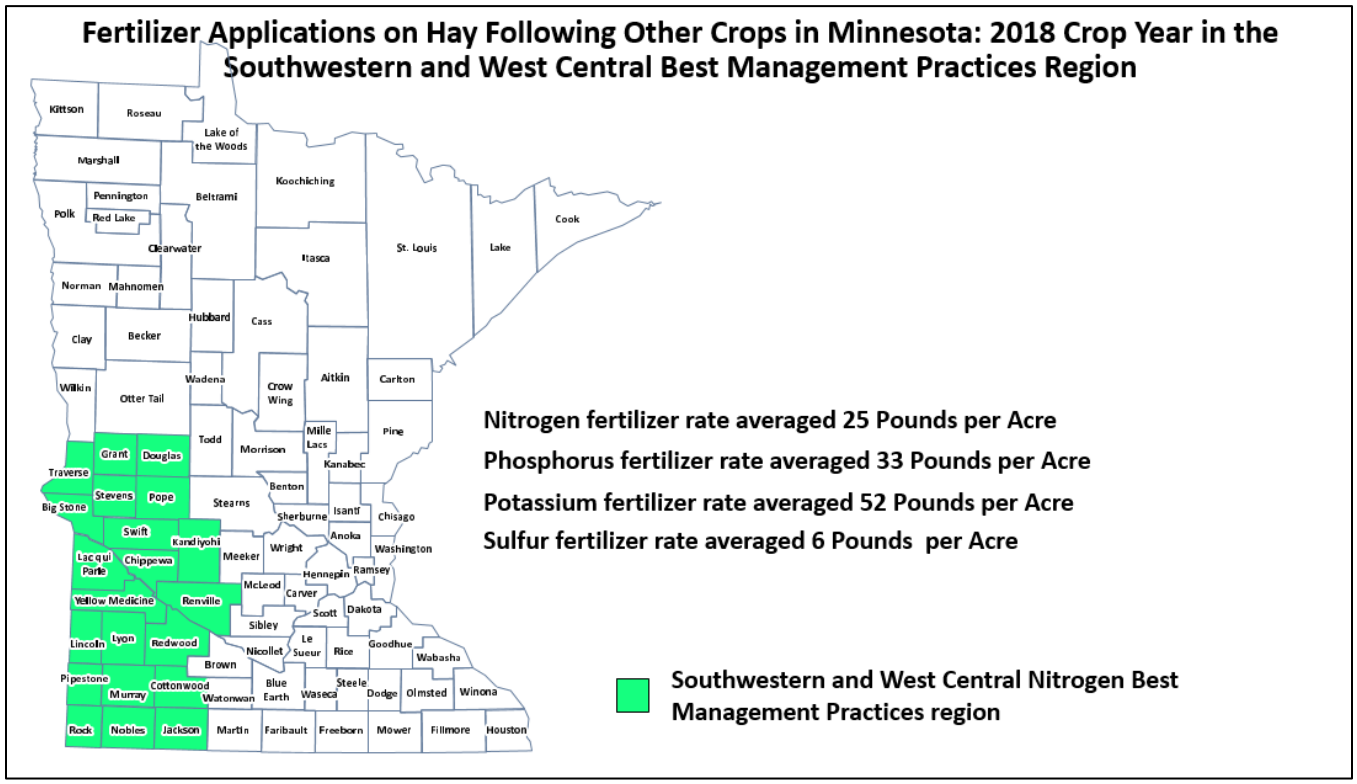

Figure 66. The average fertilizer rate for hay following other crops in the SW BMP region

[49] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 94% applied phosphorus, 100% applied potassium, and 48% applied sulfur on fields with hay following other crops.

Figure 67 provides the distribution of average nitrogen fertilizer rate in the SW BMP region for hay following other crops. Nitrogen rates are only from commercial fertilizer.

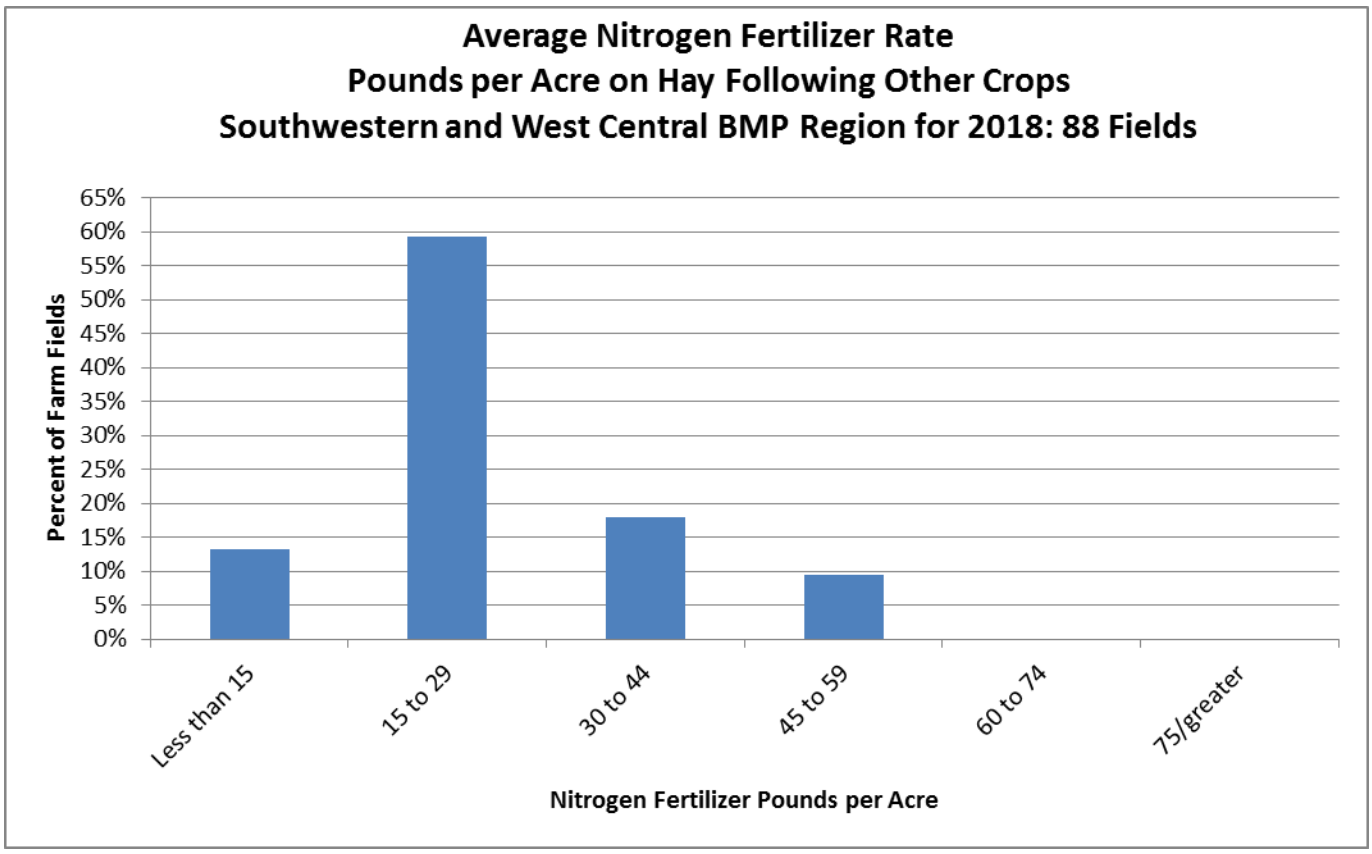

Figure 67. Average nitrogen fertilizer rate on hay following other crops in the SW BMP region for 2018: 88 fields

In the SW BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following other crops are shown in Table 122.

Table 122. Average fertilizer rate in the SW BMP region for hay following other crops

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	100	25	25
Phosphorus	94	33	31
Potassium	100	52	52
Sulfur	48	6	3

Northwestern BMP Region: Hay Following Other Crops

There were 106 fields that were included in the NW BMP region for hay following other crops analysis. Figure 68 details the location, average rate of nitrogen, phosphorus, potassium, sulfur fertilizer for hay following other crops in the NW BMP region.[50]

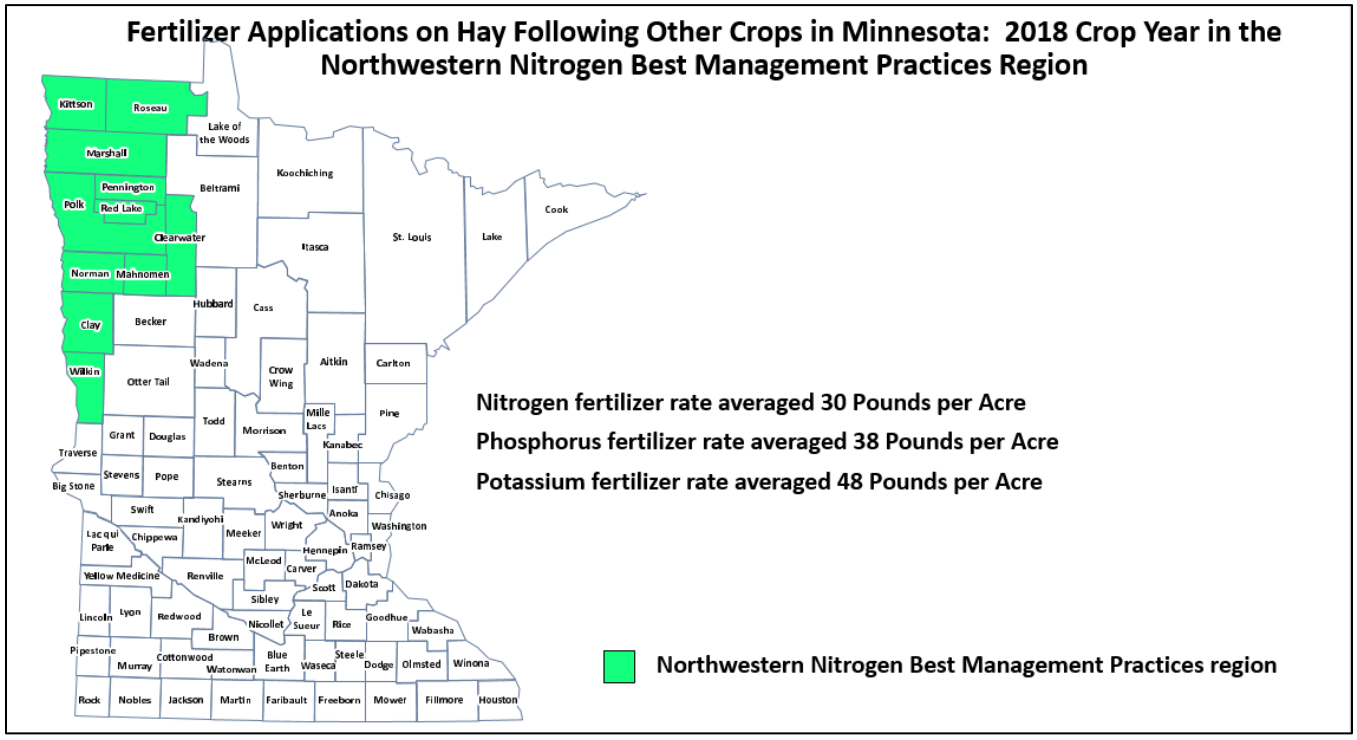

Figure 68. The average fertilizer rate for hay following other crops in the NW BMP region

[50] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 100% applied nitrogen, 81% applied phosphorus, and 100% applied potassium on fields with hay following other crops. Less than five respondents reported applying sulfur.

Figure 69 provides the distribution of average nitrogen fertilizer rate in the NW BMP region for hay following other crops. Nitrogen rates are only from commercial fertilizer.

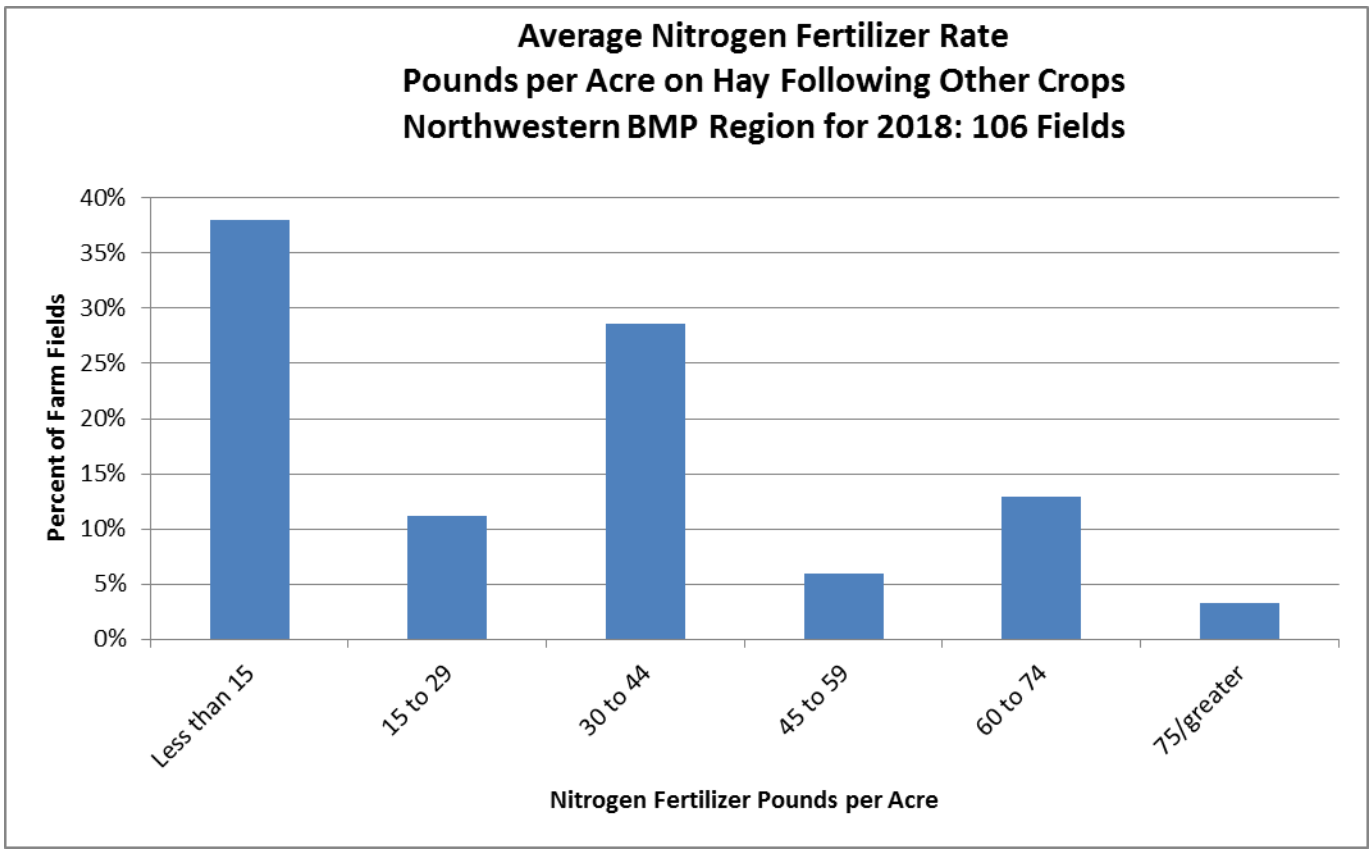

Figure 69. Average nitrogen fertilizer rate on hay following other crops in the NW BMP region for 2018: 106 fields

In the NW BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following other crops are shown in Table 123.

Table 123. Average fertilizer rate in the NW BMP region for hay following other crops

Nutrients Applied	Percent of Fertilized Soybean Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Soybean Fields Pounds per Acre
Nitrogen	100	30	30
Phosphorus	81	38	31
Potassium	100	48	48
Sulfur	**	**	**

** Less than five responses

Irrigated and Non-irrigated Sandy Soils BMP Region: Hay Following Other Crops

There were 543 fields that were represented in the IRR BMP region for hay following other crops analysis. Figure 70 details the location, average rate of nitrogen, phosphorus, potassium, and sulfur fertilizer for hay following other crops in the IRR BMP region.[51]

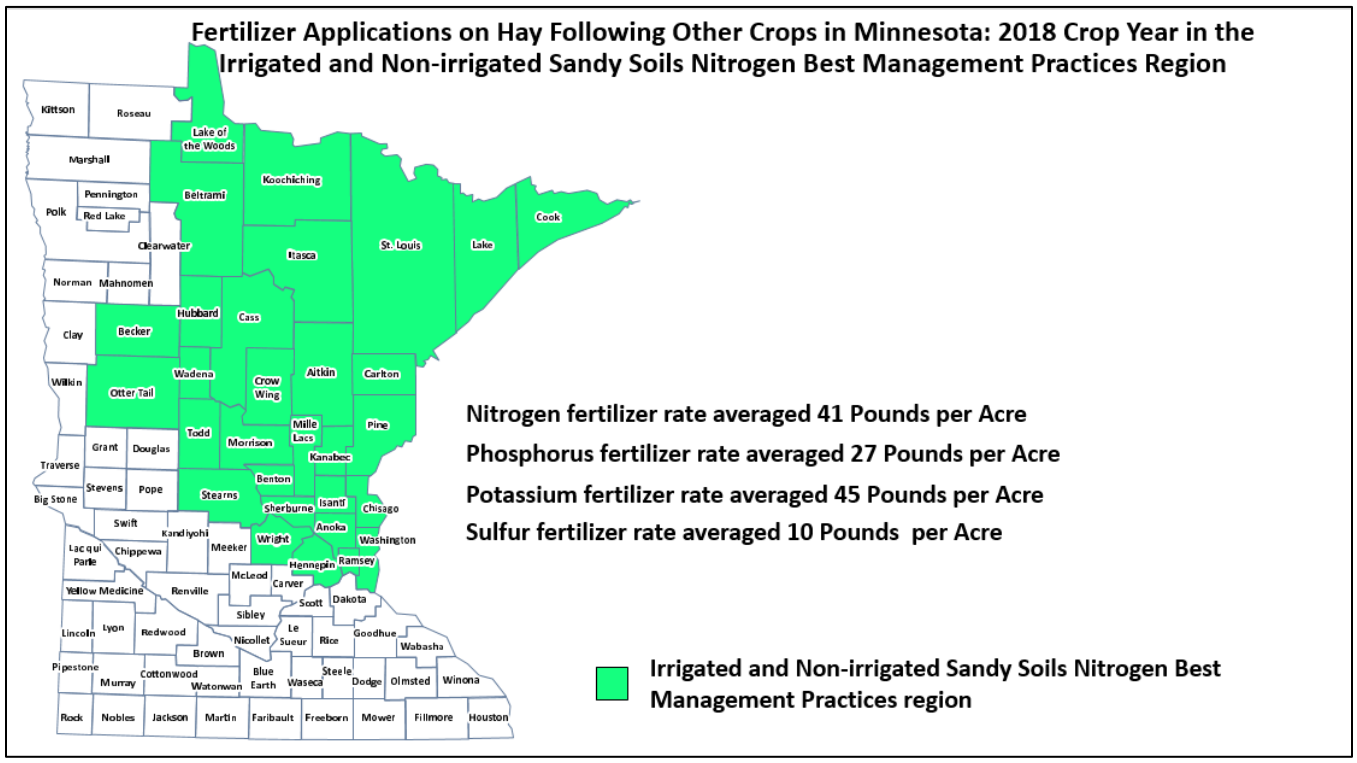

Figure 70. The average fertilizer rate for hay following other crops in the IRR BMP region

[51] The published averages are for respondents that applied commercial fertilizer on hay fields without manure to the 2018 hay crop. Of the respondents that applied commercial fertilizer, 79% applied nitrogen, 35% applied phosphorus, 81% applied potassium, and 28% applied sulfur on fields with hay following other crops.

Figure 71 provides the distribution of average nitrogen fertilizer rate in the IRR BMP region for hay following other crops. Nitrogen rates are only from commercial fertilizer.

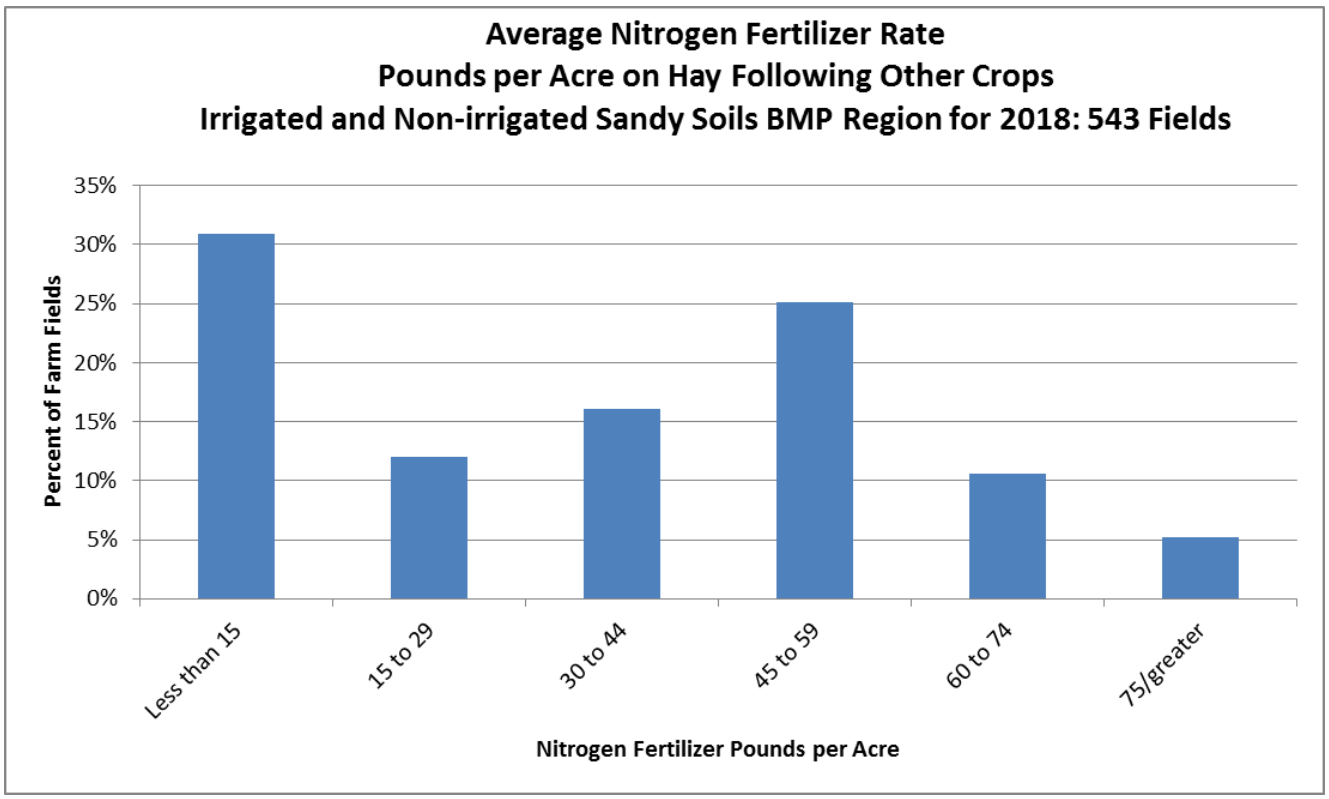

Figure 71. Average nitrogen fertilizer rate on hay following other crops in the IRR BMP region for 2018: 543 fields

In the IRR BMP region, the percent of fertilized hay fields that had commercial fertilizer applied with nitrogen, phosphorus, potassium, or sulfur; pounds per acre of actual nutrients; and the average nutrient rate across all fertilized fields of hay following other crops are shown in Table 124.

Table 124. Average fertilizer rate in the IRR BMP region for hay following other crops

Nutrients Applied	Percent of Fertilized Hay Fields	Average Nutrient Rate on Fields Treated with Same Nutrient Pounds per Acre	Average Commercial Nutrient Rate Across All Fertilized Hay Fields Pounds per Acre
Nitrogen	79	41	32
Phosphorus	35	27	9
Potassium	81	45	37
Sulfur	28	10	3

Manure Applications and Management on Wheat and Hay

2018 Manure Use Practices Summary and Highlights

Manure is a valuable source of nitrogen (and other nutrients) for Minnesota farmers. The primary purpose of this portion of the survey was to obtain an understanding of basic manure management practices associated with wheat and hay production.

This report summarized statistically weighted survey results for a number of important practices associated with manure use on Minnesota's 2018 wheat and hay acres. There were 610 represented wheat producers with 53,182 acres and 4,356 represented hay producers with 358,681 acres, totaling 4,966 producers and 411,863 acres were analyzed in this report.[52]

[52] Thirty-eight wheat producers with 2,892 acres and 400 hay producers with 36,340 acres participated in the manure portion of the survey that reported at least one field received manure.

Data Reporting and Limitations

The primary purpose of this survey was to obtain an understanding of manure management practices used by Minnesota wheat and hay farmers.

Due to the simplified method used to collect what is typically considered complex data, it is imperative that the reader understand the limitations of the data sets. Farmers that grew wheat or hay were randomly selected from county lists of producers accessed by NASS to participate in the survey. Because NASS surveys are designed to represent a non-homogenous population, data are “weighted” to account for sample size, county size, crop acreage, nonresponse, etc. By giving statistical weight to each operation based standard protocol for NASS, data can better represent all Minnesota farmers with these two crops.

The NASS developed a sampling population of 7,600 farms by randomly drawing from its entire database of all wheat and hay producers in Minnesota. There were 438 respondents that were statistically weighted to represent 4,966 farmers that applied manure sometime between the fall of 2017 and the spring of 2018 for the 2018 growing season. All wheat and hay growers were asked basic questions regarding manure use and management.

Statewide Manure Applications and Management on Wheat

Information on manure management was gathered on the operator's largest wheat field for the 2018 growing season. Information about management on all wheat crops acres was not collected in this section of the survey. Manure applications on crops other than wheat were not collected in this section of the survey. Typically, in Minnesota, a small proportion of manure is applied for the wheat crop. Manure is generally applied after the previous crop is harvested and before a wheat crop is planted, usually in the fall or spring. Manure information was collected at the same time as pesticide and commercial nitrogen fertilizer information during the survey, thus limiting the amount of information that could be gathered due to time constraints for the respondent. If manure was not used, then the survey was concluded.

Participants who grew wheat were asked if they had a wheat field that was applied with manure. If yes, they were then asked the acreage of the largest field with manure coverage, the average yield of the wheat field during the past three wheat crops, and if the whole field was applied with manure. Table 127 summarizes the percent of manured wheat fields by previous crop and average wheat yield (WMQ-1 and WMQ-5). Table 128 details the average size of the wheat field, average yield, and percent of fields with complete manure coverage (WMQ-3, WMQ-4, WMQ-5, and WMQ-6).

Table 125 details the BMP regions where the total number represented wheat acres were planted for the 2018 wheat crop by farmers who applied manure to their fields (WMQ-1 and WMQ-4). All fields that had wheat planted in 2018 without manure are excluded from the following analysis.

Table 125. Summary of respondents and corresponding wheat acres applied with manure by BMP region for the 2018 crop year

BMP Region	Number of Respondents	Number of Wheat Acres Applied with at Least Some Manure[53]
Southwestern and West Central	255	10,944
Combined BMP Regions[54]	355	42,238
Statewide	**610**	**53,182**

[53] The survey questions asked about the farmer's manure applications on their largest field. Manure applications may have been applied multiple fields, but the survey did not ask about the total amount of manured acres.

[54] Due to the low number of wheat farmers with manured acres in the NW, IRR, SC, and SE BMP regions, these regions are combined for all manured wheat survey results and published as Combined BMP Regions.

Table 126 details the number of represented operations that had at least one field with manure applied for the 2018 wheat crop (WMQ-1).

Table 126. Percent of respondents that reported a wheat field applied with manure

BMP Region	Wheat Field Applied with Manure	Percent of Respondents
Southwestern and West Central	Yes	22
Southwestern and West Central	No	78
Combined BMP Regions	Yes	10
Combined BMP Regions	No	90
Statewide	**Yes**	**13**
Statewide	**No**	**87**

Table 127 details the previous crop planted before the 2018 wheat crop by region and the corresponding wheat yield over the last three wheat crops (WMQ-1, WMQ-2, WMQ-3, and WMQ-5).

Table 127. Percent of wheat acres by previous crop and the corresponding yields in manured fields

BMP Region	Previous Crop	Percent of Manured Fields	Average Wheat Yield Bushels per Acre
Southwestern and West Central	Soybeans	53	40
Southwestern and West Central	Corn	36	35
Southwestern and West Central	Small Grains	**	**
Combined BMP Regions	Soybeans	41	62
Combined BMP Regions	Corn	40	40
Combined BMP Regions	Other	**	**
Statewide	**Soybeans**	**46**	**51**
Statewide	**Corn**	**38**	**39**
Statewide	**Small Grains**	**	**
Statewide	**Other**	**	**

** Less than five responses

Table 128 details average field size where manure is applied, average yield over the last three wheat crops, and manure coverage of the manured fields. Fields without manure were excluded from this analysis (WMQ-4, WMQ-5, and WMQ-6).

Table 128. Acres of the average wheat field by BMP region, average yield over the last three wheat crops for wheat fields with 100 percent manure coverage and percent of wheat fields with complete manure coverage

BMP Region	Average Size of Wheat Field in Acres	Average Wheat Yield Bushels per Acre	Percent of Fields with Complete Manure Coverage
Southwestern and West Central	35	41	94
Combined BMP Regions	45	46	77
Statewide	**40**	**43**	**84**

Table 129 details all wheat fields with manure or with manure and commercial nitrogen fertilizer and average yield for the last three wheat crops regardless of the percent of manure coverage on the wheat field for the 2018 wheat crop. (WMQ-4, WMQ-5, and WMQ-6).

Table 129. Average wheat yield over the last three wheat crops on wheat fields applied with manure or manure and commercial nitrogen fertilizer

BMP Region	Average Wheat Yield Bushels per Acre
Southwestern and West Central	39
Combined BMP Regions	50
Statewide	**46**

Table 130 details the main source of manure applied on the wheat field for the 2018 wheat crop (WMQ-7).

Table 130. The main source of manure applied to the wheat field by livestock type

BMP Region	Main Source of Manure	Percent of Respondents
Southwestern and West Central	Dairy	**
Southwestern and West Central	Beef	66
Southwestern and West Central	Hog	**
Southwestern and West Central	Poultry	**
Southwestern and West Central	Other	**
Combined BMP Regions	Dairy	41
Combined BMP Regions	Beef	32
Combined BMP Regions	Hog	**
Combined BMP Regions	Other	**
Statewide	**Dairy**	**31**
Statewide	**Beef**	**46**
Statewide	**Hog**	****
Statewide	**Poultry**	****
Statewide	**Other**	****

** Less than five responses

Table 131 details the percent of respondents that applied liquid or solid manure to their wheat fields. (WMQ-8).

Table 131. Percent of respondents that applied liquid or solid manure to the surveyed wheat acres

BMP Region	Solid or Liquid	Percent of Respondents
Southwestern and West Central	Solid	91
Southwestern and West Central	Liquid	9
Combined BMP Regions	Solid	63
Combined BMP Regions	Liquid	37
Statewide	**Solid**	**76**
Statewide	**Liquid**	**24**

Less than five responses reported the method of application of liquid manure (WMQ-8A).

Table 132 details the percent of respondents and the method of application of solid manure (WMQ-8B).

Table 132. Method of application of solid manure and corresponding percent of respondents

BMP Region	Method of Application for Solid Manure	Percent of Respondents
Southwestern and West Central	Broadcast Incorporation within One Day	**
Southwestern and West Central	Broadcast Incorporation within Two to Four Days	55
Southwestern and West Central	Broadcast Incorporation within Over Four Days	**
Southwestern and West Central	Broadcast No Incorporation	**
Combined BMP Regions	Broadcast Incorporation within One Day	**
Combined BMP Regions	Broadcast Incorporation within Two to Four Days	**
Combined BMP Regions	Broadcast Incorporation within Over Four Days	48
Combined BMP Regions	Broadcast No Incorporation	**
Statewide	**Broadcast Incorporation within One Day**	**14**
Statewide	**Broadcast Incorporation within Two to Four Days**	**41**
Statewide	**Broadcast Incorporation within Over Four Days**	**34**
Statewide	**Broadcast No Incorporation**	**

Table 133 details the percent of respondents on how often manure was applied to the wheat field (WMQ-9). Farmers can apply manure on a field all at one time (approximate date) or over a period of time, such as daily or weekly.

Table 133. Timing of manure application by approximate date or over time

BMP Region	Manure Application Frequency: Approximate Date or Over Time	Percent of Respondents
Southwestern and West Central	Approximate Date	56
Southwestern and West Central	Over a Period of Time	44
Combined BMP Regions	Approximate Date	66
Combined BMP Regions	Over a Period of Time	34
Statewide	**Approximate Date**	**62**
Statewide	**Over a Period of Time**	**38**

Table 134 details the percent of respondents that applied manure on a specific date as to when the manure was applied in regard to the general season (WMQ-9A).

Table 134. Seasonal timing for wheat fields applied with manure on a specific date

BMP Region	Approximate Date of the Manure Application	Percent of Respondents
Southwestern and West Central	Fall 2017	53
Southwestern and West Central	Spring 2018	47
Combined BMP Regions	Summer 2017	6
Combined BMP Regions	Fall 2017	82
Combined BMP Regions	Spring 2018	12
Statewide	**Summer 2017**	**4**
Statewide	**Fall 2017**	**71**
Statewide	**Spring 2018**	**25**

Table 135 details the percent of respondents on how often the manure was applied over a period of time (WMQ-9B).

Table 135. The frequency of manure applications for represented wheat fields over a period of time

BMP Region	Manure Application Frequency	Percent of Respondents
Southwestern and West Central	Daily	23
Southwestern and West Central	Weekly	18
Southwestern and West Central	Monthly	32
Southwestern and West Central	Other	27
Combined BMP Regions	Daily	53
Combined BMP Regions	Weekly	38
Combined BMP Regions	Monthly	9
Statewide	**Daily**	**38**
Statewide	**Weekly**	**29**
Statewide	**Monthly**	**20**
Statewide	**Other**	**13**

Table 136 details the percent of respondents as to the last time manure was applied on the wheat field, before the current manure application for the 2018 wheat crop (WMQ-10).

Table 136. The date of last manure application before the manure application for the 2018 wheat crop

BMP Region	Last Application of Manure on the largest Wheat Field	Percent of Respondents
Southwestern and West Central	2013 and Before	6
Southwestern and West Central	2014	14
Southwestern and West Central	2015	12
Southwestern and West Central	2016	59
Southwestern and West Central	2017	9
Combined BMP Regions	2013 and Before	2
Combined BMP Regions	2014	35
Combined BMP Regions	2015	9
Combined BMP Regions	2016	33
Combined BMP Regions	2017	21
Statewide	**2013 and Before**	**4**
Statewide	**2014**	**26**
Statewide	**2015**	**10**
Statewide	**2016**	**44**
Statewide	**2017**	**16**

Table 137 details the average miles traveled from the manure source to the wheat field applied with manure (WMQ-11).

Table 137. Distance to the wheat field for manure applications by composition of manure

BMP Region	Liquid or Solid Manure	Average Miles to the Wheat Field
Southwestern and West Central	Solid	1.89
Southwestern and West Central	Liquid	1.65
Southwestern and West Central	All	1.87
Combined BMP Regions	Solid	0.64
Combined BMP Regions	Liquid	1.94
Combined BMP Regions	All	1.28
Statewide	**Solid**	**1.34**
Statewide	**Liquid**	**1.90**
Statewide	**All**	**1.52**

Table 138 details the average miles traveled to the wheat field from the manure source by animal type (WMQ-7 and WMQ-11).

Table 138. Distance to the wheat field for manure applications by animal type

BMP Region	Animal Type	Average Miles to the Wheat Field
Southwestern and West Central	Dairy	**
Southwestern and West Central	Beef	0.82
Southwestern and West Central	Hog	**
Southwestern and West Central	Poultry	**
Southwestern and West Central	Other	**
Combined BMP Regions	Dairy	0.36
Combined BMP Regions	Beef	0.73
Combined BMP Regions	Hog	**
Combined BMP Regions	Other	**
Statewide	**Dairy**	**0.39**
Statewide	**Beef**	**0.78**
Statewide	**Hog**	****
Statewide	**Poultry**	****
Statewide	**Other**	****

** Less than five responses

Table 139 details the percent of respondents who knew the amount of nitrogen in the manure applied for the 2018 wheat crop.

Table 139. The farmers' knowledge of nitrogen content of manure being applied for the 2018 wheat crop

BMP Region	Knowledge of the Actual Amount of Nitrogen Applied	Percent of Respondents
Southwestern and West Central	Yes	15
Southwestern and West Central	No	85
Combined BMP Regions	Yes	26
Combined BMP Regions	No	74
Statewide	**Yes**	**21**
Statewide	**No**	**79**

Table 140 details the average amount of nitrogen applied per acre by type of livestock manure when the farmer knew the amount of nitrogen in the manure applied (WMQ-7, WMQ-12, and WMQ-13).

Table 140. Average amount of nitrogen applied per acre from manure by livestock type when the farmer knew the amount of nitrogen in the manure source

BMP Region	Animal Type	Average Nitrogen Rate Applied From Manure in Pounds per Acre
Southwestern and West Central	All	**
Southwestern and West Central	Dairy	**
Southwestern and West Central	Beef	**
Southwestern and West Central	Hog	**
Combined BMP Regions	All	111
Combined BMP Regions	Dairy	**
Combined BMP Regions	Hog	**
Statewide	**All**	**98**
Statewide	**Dairy**	****
Statewide	**Beef**	****
Statewide	**Hog**	****

** Less than five responses

Average Nitrogen Rate from Manure Applications

Figure 72 details the distribution of average nitrogen rates in Minnesota from farmers that applied manure[55] regardless of whether additional commercial nitrogen fertilizer was applied to the largest wheat field. The rates do not include nitrogen from additional commercial nitrogen fertilizer applied to the 2018 wheat crop (WMQ-7, WMQ-12, and WMQ-13).

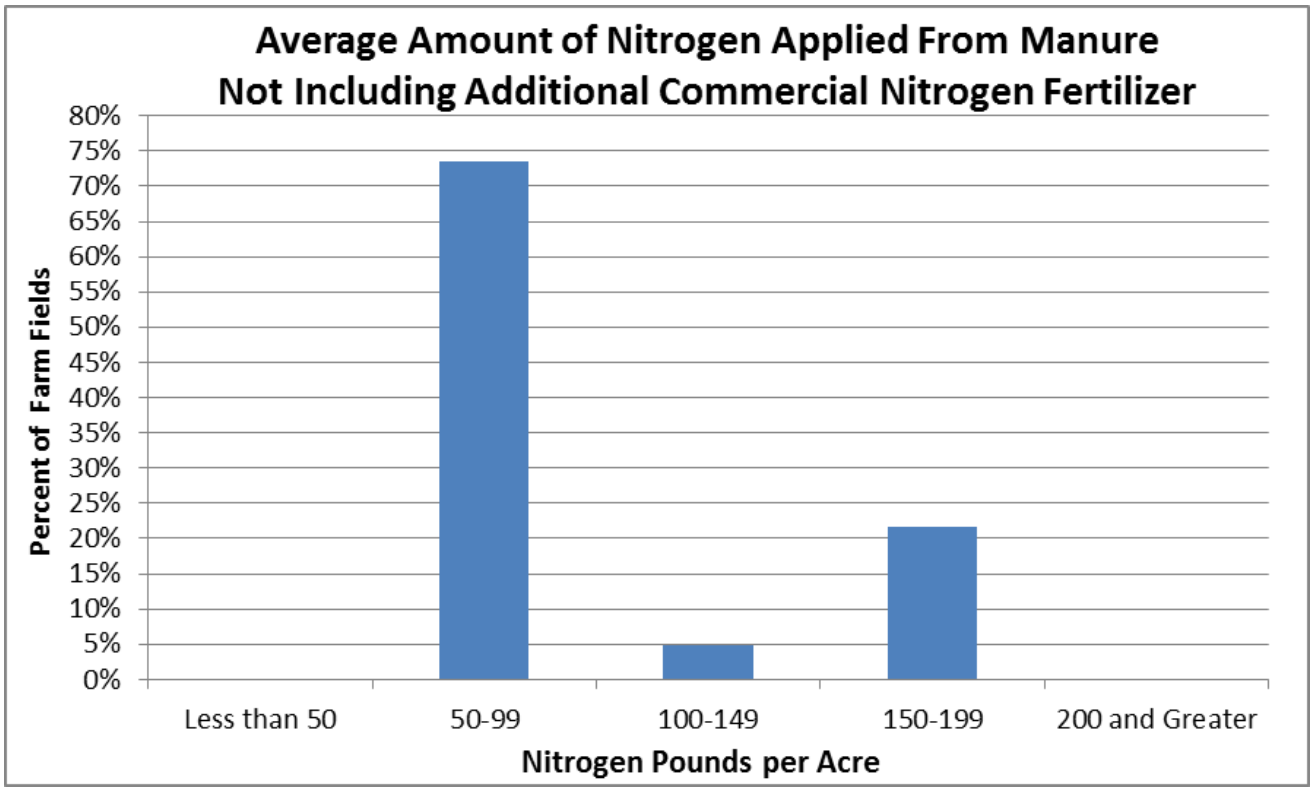

Figure 72. Average nitrogen rates applied to fields from manure and does not include additional commercial nitrogen fertilizer in Minnesota for 2018: 121 fields

Less than five responses were reported for the average manure nitrogen rate regardless if additional commercial nitrogen fertilizer was applied to the 2018 wheat crop from:

- Dairy manure.
- Beef manure.
- Hog manure.
- Poultry manure.
- Other sources of manure.

[55] Manure is from all manure sources

Average Nitrogen Rate from Manure and Commercial Nitrogen Fertilizer Applications

- Statewide, less than five responses reported the average nitrogen rate from manure[56] and commercial nitrogen fertilizer sources applied to the 2018 wheat crop. Therefore, there is no additional nitrogen rate from individual sources of manure and commercial nitrogen fertilizer applications.

[56] Manure is from all manure sources

Nitrogen Applications from All Manure Sources for All Crops following Wheat

Less than five responses reported manure nitrogen rates from manure or manure with commercial nitrogen fertilizer from wheat following soybeans:

- when the farmer knew the amount of nitrogen in manure applied.

Figure 73 details the distribution of average nitrogen rates in Minnesota from farmers that applied manure and commercial nitrogen fertilizer to wheat following soybeans when the farmer did not know the nitrogen of the manure application. (WMQ-2, WMQ-7, WMQ-12, WMQ-13). Therefore, manure nitrogen was not included in the analysis when the quantity of nitrogen from manure applied to the field is not known. The average wheat yield was 51 bushels per acre. The average commercial nitrogen fertilizer rate was 96 pounds per acre.

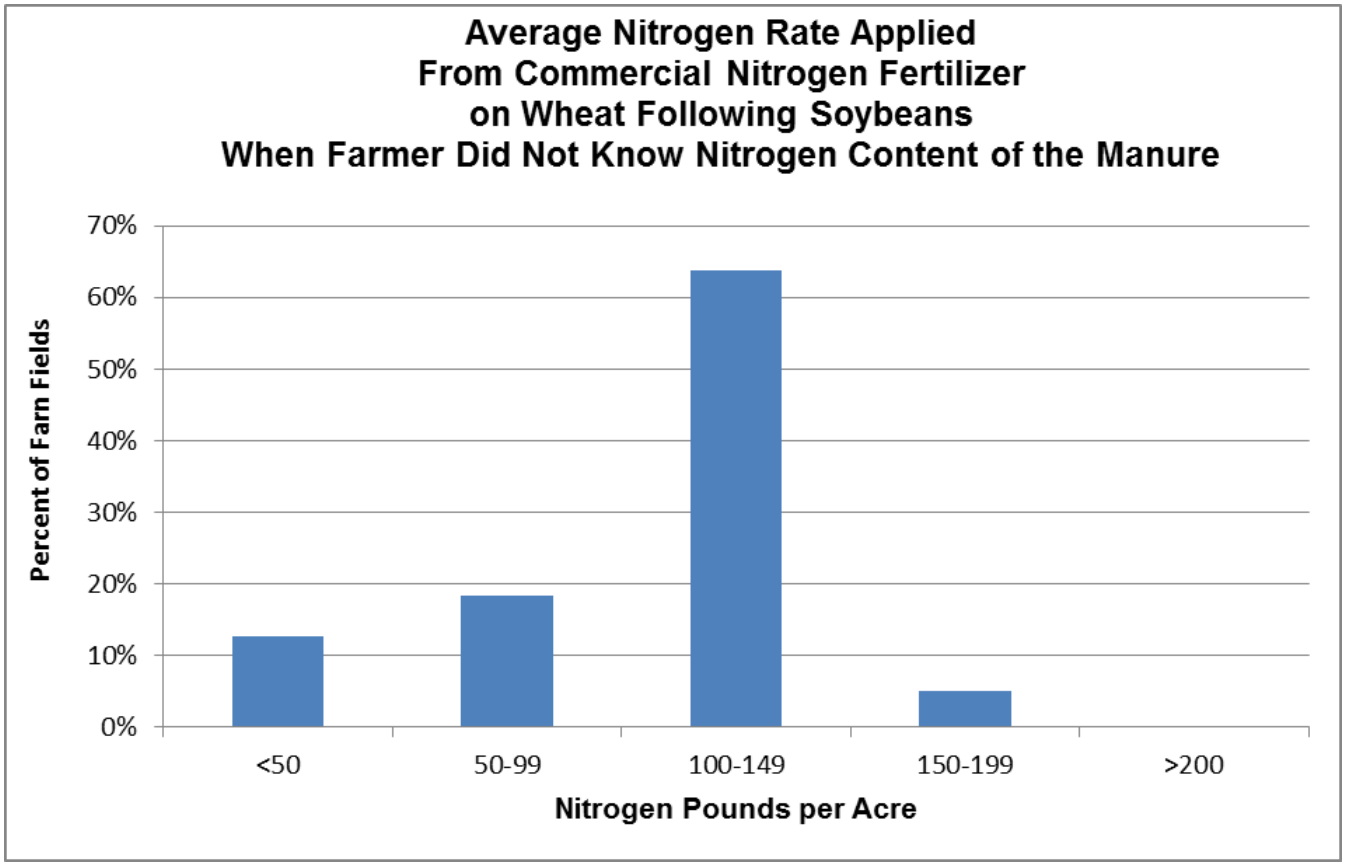

Figure 73. Average nitrogen rates applied to wheat following soybeans from commercial nitrogen fertilizer in Minnesota for 2018 when the manure nitrogen content is unknown: 105 fields

Less than five responses reported manure nitrogen rates from manure or manure with commercial nitrogen fertilizer from wheat following corn:

- when the farmer knew the amount of nitrogen in manure applied.
- when the farmer did not know the amount of nitrogen in manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported manure nitrogen rates from manure or manure with commercial nitrogen fertilizer from wheat following corn following alfalfa:

- when the farmer knew the amount of nitrogen in manure applied.
- when the farmer did not know the amount of nitrogen in manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported manure nitrogen rates from manure or manure with commercial nitrogen fertilizer from wheat following small grains:

- when the farmer knew the amount of nitrogen in manure applied.
- when the farmer did not know the amount of nitrogen in manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported manure nitrogen rates from manure or manure with commercial nitrogen fertilizer from wheat following other crops:

- when the farmer knew the amount of nitrogen in manure applied.
- when the farmer did not know the amount of nitrogen in manure applied and applied additional commercial nitrogen fertilizer.

Statewide Manure Use and Practices

Table 141 details the percent of respondents on manure applications using variable rate technology (WMQ-14).

Table 141. Manure applications using variable rate technology

BMP Region	Manure Applications Using Variable Rate	Percent of Respondents
Southwestern and West Central	Yes	2
Southwestern and West Central	No	98
Combined BMP Regions	Yes	21
Combined BMP Regions	No	79
Statewide	**Yes**	**13**
Statewide	**No**	**87**

Table 142 details the percent of respondents who knew the manure application rate (WMQ-15).

Table 142. Farmer's knowledge of manure application rates

BMP Region	Farmer Knowledge of Manure Application Rate	Percent of Respondents
Southwestern and West Central	Yes	59
Southwestern and West Central	No	41
Combined BMP Regions	Yes	53
Combined BMP Regions	No	47
Statewide	**Yes**	**55**
Statewide	**No**	**45**

Table 143 details the application rate for liquid manure, if known by the farmer (WMQ-16 and WMQ-16A).

Table 143. Rates for liquid manure applications by region

BMP Region	Average Gallons per Acre
Southwestern and West Central	**
Combined BMP Regions	2,997.58
Statewide	**2,882.37**

** Less than five responses

Table 144 details the application rate for solid manure, if known by the farmer (WMQ-16 and WMQ-16A).

Table 144. Rates for solid manure application by region

BMP Region	Average Tons per Acre
Southwestern and West Central	7.03
Combined BMP Regions	**
Statewide	**6.32**

** Less than five responses

Table 145 details the percent of respondents who applied commercial fertilizer on manured wheat fields (WMQ-17).

Table 145. Commercial fertilizer applications on manured fields by region

BMP Region	Application of Commercial Fertilizer to Manured Wheat Field	Percent of Respondents
Southwestern and West Central	Yes	59
Southwestern and West Central	No	41
Combined BMP Regions	Yes	53
Combined BMP Regions	No	47
Statewide	**Yes**	**55**
Statewide	**No**	**45**

Table 146 details the average amount of nitrogen applied per acre to the manured wheat field from commercial nitrogen fertilizer by livestock type (WMQ-18).

Table 146. Average amount of nitrogen from commercial fertilizer applied to manured wheat fields by livestock type

BMP Region	Animal Type	Average Nitrogen Rate From Commercial Fertilizer Pounds per Acre
Southwestern and West Central	All	78
Southwestern and West Central	Dairy	**
Southwestern and West Central	Beef	**
Combined BMP Regions	All	74
Combined BMP Regions	Beef	62
Combined BMP Regions	Hog	**
Combined BMP Regions	Other	**
Statewide	**All**	**65**
Statewide	**Dairy**	****
Statewide	**Beef**	**53**
Statewide	**Hog**	****
Statewide	**Other**	****

** Less than five responses

Table 147 details the average amount of nitrogen applied per acre to the manured wheat field from manure and commercial nitrogen fertilizer by livestock type (WMQ-18).

Table 147. Average amount of nitrogen from manure and commercial fertilizer applied to manured wheat fields by livestock type

BMP Region	Animal Type	Average Nitrogen Rate From Manure and Commercial Fertilizer Pounds per Acre
Southwestern and West Central	All	86
Southwestern and West Central	Dairy	**
Southwestern and West Central	Beef	**
Combined BMP Regions	All	111
Combined BMP Regions	Beef	78
Combined BMP Regions	Hog	**
Combined BMP Regions	Other	**
Statewide	**All**	**104**
Statewide	**Dairy**	****
Statewide	**Beef**	**82**
Statewide	**Hog**	****
Statewide	**Other**	****

** Less than five responses

Table 148 details if the manure applied was from the farmer's livestock (WMQ-19).

Table 148. Origin of the manure in regards to livestock ownership source

BMP Region	Manure From the Farmer's Livestock	Percent of Respondents
Southwestern and West Central	Yes	89
Southwestern and West Central	No	11
Combined BMP Regions	Yes	84
Combined BMP Regions	No	16
Statewide	**Yes**	**86**
Statewide	**No**	**14**

Table 149 when the manure was last tested for nutrients (WMQ-20).

Table 149. Date of last test for manure nutrient content

BMP Region	Last Manure Test	Percent of Respondents
Southwestern and West Central	This Year	18
Southwestern and West Central	Last Three Years	18
Southwestern and West Central	Over Three Years Ago	20
Southwestern and West Central	Don't Test	44
Combined BMP Regions	This Year	14
Combined BMP Regions	Last Three Years	22
Combined BMP Regions	Over Three Years Ago	11
Combined BMP Regions	Don't Test	53
Statewide	**This Year**	**16**
Statewide	**Last Three Years**	**20**
Statewide	**Over Three Years Ago**	**14**
Statewide	**Don't Test**	**50**

Soil Testing in the Last Five Years

Table 150 details the type of soil test the farmer used in the last five years (WMQ-21).

Table 150. Types of soils tests used in the last five years

BMP Region	Type of Soil Testing	Percent of Respondents
Southwestern and West Central	Traditional	22
Southwestern and West Central	Grid	18
Southwestern and West Central	Zone	2
Southwestern and West Central	None	58
Combined BMP Regions	Traditional	49
Combined BMP Regions	Grid	39
Combined BMP Regions	None	12
Statewide	**Traditional**	**38**
Statewide	**Grid**	**30**
Statewide	**Zone**	**1**
Statewide	**None**	**31**

Statewide Manure Applications and Management on Hay

Information on manure management was gathered on the operator's largest hay field for the 2018 growing season. Information about management on all hay acres was not collected in this section of the survey. Manure applications on crops other than hay were not collected in this section of the survey. Hay can be harvested multiple times in a year. Due to these restraints, yields for hay were not collected. Typically, in Minnesota, a small proportion of manure is applied for the hay crop. Alfalfa generally does not need additional nitrogen. However, grass hay does respond to nitrogen. Manure is generally applied in the fall or spring. Manure information was collected at the same time as pesticide and commercial nitrogen fertilizer information during the survey, thus limiting the amount of information that could be gathered due to time constraints for the respondent. If manure was not used, then the survey was concluded.

Participants who grew hay were asked if they had a hay field that was applied with manure. If yes, they were then asked the acreage of the largest field with manure coverage and if the whole field was applied with manure. Table 153 summarizes the percent of manured hay fields by previous crop (HMQ-1, HMQ-2, and HMQ-3). Table 154 details the average size of the hay field and percent of fields with complete manure coverage (HMQ-4 and HMQ-5).

Table 151 details the BMP regions where the total number represented hay acres were harvested for the 2018 hay crop by farmers who applied manure to their fields (HMQ- 1 and HMQ-4). All fields that had hay harvested in 2018 without manure are excluded from the following analysis.

Table 151. Summary of respondents and corresponding hay acres applied with manure by BMP region for the 2018 crop year[57]

BMP Region	Number of Respondents	Number of Hay Acres with at Least Some Manure Applied[58]
Northwestern	264	45,950
Irrigated and Non-irrigated Sandy Soils	2,213	215,602
Southwestern and West Central	627	31,820
South Central	713	29,768
Southeastern	540	35,541
Statewide	**4,356**	**358,681**

[57] The respondent was asked about the largest hay field applied with manure. The farmer may have had multiple fields with manure or one field with manure.

[58] The survey questions asked about the farmer's manure applications on their largest field. Manure applications may have been applied multiple fields, but the survey did not ask about the total amount of manured acres.

Table 152 details the number of represented operations that had at least one field with with manure applied for the 2018 hay crop season (HMQ-1).

Table 152. Percent of respondents that applied manure on one or more of their hay acres

BMP Region	Hay Field Applied with Manure	Percent of Respondents
Northwestern	Yes	19
Northwestern	No	81
Irrigated and Non-irrigated Sandy Soils	Yes	27
Irrigated and Non-irrigated Sandy Soils	No	73
Southwestern and West Central	Yes	24
Southwestern and West Central	No	76
South Central	Yes	26
South Central	No	74
Southeastern	Yes	24
Southeastern	No	76
Statewide	**Yes**	**25**
Statewide	**No**	**75**

Table 153 details the previous crop planted before the 2018 hay crop by region (HMQ-1, HMQ-2, and HMQ-3).

Table 153. Percent of hay acres by previous crop in manured fields

BMP Region	Previous Crop	Percent of Manured Fields
Northwestern	Soybeans	**
Northwestern	Corn	**
Northwestern	Alfalfa	55
Northwestern	Small Grains	**
Northwestern	Other	31
Irrigated and Non-irrigated Sandy Soils	Corn	10
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	29
Irrigated and Non-irrigated Sandy Soils	Small Grains	**
Irrigated and Non-irrigated Sandy Soils	Other	56
Southwestern and West Central	Soybeans	8
Southwestern and West Central	Corn	**
Southwestern and West Central	Corn/Alfalfa	**
Southwestern and West Central	Alfalfa	54
Southwestern and West Central	Small Grains	**
Southwestern and West Central	Other	34
South Central	Soybeans	**
South Central	Corn	8
South Central	Corn/Alfalfa	**
South Central	Alfalfa	40
South Central	Small Grains	**
South Central	Other	44
Southeastern	Corn	**
Southeastern	Corn/Alfalfa	**
Southeastern	Alfalfa	45
Southeastern	Small Grains	**
Southeastern	Other	35
Statewide	**Soybeans**	**2**
Statewide	**Corn**	**8**
Statewide	**Corn/Alfalfa**	**4**
Statewide	**Alfalfa**	**38**
Statewide	**Small Grains**	**1**
Statewide	**Other**	**47**

** Less than five responses

Table 154 details average hay field size where manure is applied and the manure coverage of the manured hay fields. Fields without manure were excluded from this analysis (HMQ-4 and HMQ-5).

Table 154. Acres of the average hay field by BMP region and percent of hay fields with 100 percent manure coverage

BMP Region	Average Size of Hay Field in Acres	Percent of Fields with Complete Manure Coverage
Northwestern	39	78
Irrigated and Non-irrigated Sandy Soils	23	72
Southwestern and West Central	21	74
South Central	16	69
Southeastern	19	79
Statewide	**22**	**73**

Table 155 details the main source of manure applied on the hay field for the 2018 hay crop (HMQ-6).

Table 155. The main source of manure applied to the hay field by livestock type

BMP Region	Main Source of Manure	Percent of Respondents
Northwestern	Beef	89
Northwestern	Poultry	**
Northwestern	Other	**
Irrigated and Non-irrigated Sandy Soils	Dairy	17
Irrigated and Non-irrigated Sandy Soils	Beef	63
Irrigated and Non-irrigated Sandy Soils	Hog	**
Irrigated and Non-irrigated Sandy Soils	Poultry	7
Irrigated and Non-irrigated Sandy Soils	Other	10
Irrigated and Non-irrigated Sandy Soils	Don’t Know	**
Southwestern and West Central	Dairy	14
Southwestern and West Central	Beef	55
Southwestern and West Central	Hog	**
Southwestern and West Central	Poultry	**
Southwestern and West Central	Other	15
South Central	Dairy	27
South Central	Beef	38
South Central	Poultry	**
South Central	Other	29
South Central	Don't Know	**
Southeastern	Dairy	32
Southeastern	Beef	51
Southeastern	Hog	**
Southeastern	Other	14
Statewide	**Dairy**	**19**
Statewide	**Beef**	**58**
Statewide	**Hog**	**2**
Statewide	**Poultry**	**5**
Statewide	**Other**	**14**
Statewide	**Don't Know**	**

Table 156 details the percent of respondents that applied liquid or solid manure to their hay fields (HMQ-7).

Table 156. Percent of respondents that applied liquid or solid manure to the surveyed hay acres

BMP Region	Main Source of Manure	Percent of Respondents
Northwestern	Solid	100
Northwestern	Liquid	0
Irrigated and Non-irrigated Sandy Soils	Solid	94
Irrigated and Non-irrigated Sandy Soils	Liquid	6
South Central	Solid	87
South Central	Liquid	13
Southwestern and West Central	Solid	90
Southwestern and West Central	Liquid	10
Southeastern	Solid	88
Southeastern	Liquid	12
Statewide	**Solid**	**92**
Statewide	**Liquid**	**8**

Table 157 details the percent of respondents and the method of application of liquid manure (HMQ-7A). There were no applications of liquid manure reported in the NW BMP region.

Table 157. Method of application of liquid manure and corresponding percent of respondents.

BMP Region	Method of Application for Liquid Manure	Percent of Respondents
Irrigated and Non-irrigated Sandy Soils	Broadcast Incorporation within One Day	32
Irrigated and Non-irrigated Sandy Soils	Broadcast Incorporation within One to Two Days	28
Irrigated and Non-irrigated Sandy Soils	Broadcast with No Incorporation	40
Southwestern and West Central	Sweep Injection	74
Southwestern and West Central	Broadcast with No Incorporation	26
South Central	Sweep Injection	37
South Central	Broadcast with No Incorporation	63
Southeastern	Knife Injection	21
Southeastern	Broadcast Incorporation within One Day	37
Southeastern	Broadcast with No Incorporation	42
Statewide	**Sweep Injection**	**24**
Statewide	**Knife Injection**	**4**
Statewide	**Broadcast Incorporation within One Day**	**19**
Statewide	**Broadcast Incorporation within One to Two Days**	**11**
Statewide	**Broadcast with No Incorporation**	**42**

Table 158 details the percent of respondents and the method of application of solid manure (HMQ-7B).

Table 158. Method of application of solid manure and corresponding percent of respondents

BMP Region	Method of Application for Solid Manure	Percent of Respondents
Northwestern	Broadcast Incorporation within One Day	19
Northwestern	Broadcast Incorporation within Two to Four Days	11
Northwestern	Broadcast Incorporation within Over Four Days	15
Northwestern	Broadcast No Incorporation	55
Irrigated and Non-irrigated Sandy Soils	Broadcast Incorporation within One Day	10
Irrigated and Non-irrigated Sandy Soils	Broadcast Incorporation within Two to Four Days	14
Irrigated and Non-irrigated Sandy Soils	Broadcast Incorporation within Over Four Days	14
Irrigated and Non-irrigated Sandy Soils	Broadcast No Incorporation	62
Southwestern and West Central	Broadcast Incorporation within One Day	9
Southwestern and West Central	Broadcast Incorporation within Two to Four Days	16
Southwestern and West Central	Broadcast Incorporation within Over Four Days	13
Southwestern and West Central	Broadcast No Incorporation	62
South Central	Broadcast Incorporation within One Day	8
South Central	Broadcast Incorporation within Two to Four Days	12
South Central	Broadcast Incorporation within Over Four Days	9
South Central	Broadcast No Incorporation	71
Southeastern	Broadcast Incorporation within One Day	9
Southeastern	Broadcast Incorporation within Two to Four Days	6
Southeastern	Broadcast Incorporation within Over Four Days	7
Southeastern	Broadcast No Incorporation	78
Statewide	**Broadcast Incorporation within One Day**	**10**
Statewide	**Broadcast Incorporation within Two to Four Days**	**13**
Statewide	**Broadcast Incorporation within Over Four Days**	**12**
Statewide	**Broadcast No Incorporation**	**65**

Table 159 details the percent of respondents on how often manure was applied to the hay field (HMQ-8). Farmers can apply manure on a field all at one time (approximate date) or over a period of time, such as daily or weekly.

Table 159. Timing of manure application by approximate date or over time

BMP Region	Manure Application Frequency: Approximate Date or Over Time	Percent of Respondents
Northwestern	Approximate Date	48
Northwestern	Over a Period of Time	52
Irrigated and Non-irrigated Sandy Soils	Approximate Date	35
Irrigated and Non-irrigated Sandy Soils	Over a Period of Time	65
Southwestern and West Central	Approximate Date	54
Southwestern and West Central	Over a Period of Time	46
South Central	Approximate Date	37
South Central	Over a Period of Time	63
Southeastern	Approximate Date	35
Southeastern	Over a Period of Time	65
Statewide	**Approximate Date**	**39**
Statewide	**Over a Period of Time**	**61**

Table 160 details the percent of respondents that applied manure on a specific date as to when the manure was applied in regards to the general season (HMQ-8A).

Table 160. Seasonal timing for hay fields applied with manure on a specific date

BMP Region	Approximate Date of the Manure Application	Percent of Respondents
Northwestern	Don't Know	3
Northwestern	Summer 2017	32
Northwestern	Fall 2017	43
Northwestern	Spring 2018	22
Irrigated and Non-irrigated Sandy Soils	Don't Know	1
Irrigated and Non-irrigated Sandy Soils	Summer 2017	26
Irrigated and Non-irrigated Sandy Soils	Fall 2017	20
Irrigated and Non-irrigated Sandy Soils	Spring 2018	53
Southwestern and West Central	Don't Know	8
Southwestern and West Central	Summer 2017	38
Southwestern and West Central	Fall 2017	37
Southwestern and West Central	Spring 2018	17
South Central	Summer 2017	15
South Central	Fall 2017	58
South Central	Spring 2018	27
Southeastern	Summer 2017	49
Southeastern	Fall 2017	36
Southeastern	Spring 2018	15
Statewide	**Don't Know**	**2**
Statewide	**Summer 2017**	**30**
Statewide	**Fall 2017**	**33**
Statewide	**Spring 2018**	**35**

Table 161 details the percent of respondents on how often the manure was applied over a period of time (HMQ-8B).

Table 161. The frequency of manure applications for represented hay fields over a period of time

BMP Region	Manure Application Frequency	Percent of Respondents
Northwestern	Daily	31
Northwestern	Weekly	17
Northwestern	Monthly	10
Northwestern	Other	42
Irrigated and Non-irrigated Sandy Soils	Daily	26
Irrigated and Non-irrigated Sandy Soils	Weekly	19
Irrigated and Non-irrigated Sandy Soils	Monthly	24
Irrigated and Non-irrigated Sandy Soils	Other	31
Southwestern and West Central	Daily	25
Southwestern and West Central	Weekly	15
Southwestern and West Central	Monthly	20
Southwestern and West Central	Other	40
South Central	Daily	25
South Central	Weekly	22
South Central	Monthly	22
South Central	Other	31
Southeastern	Daily	26
Southeastern	Weekly	13
Southeastern	Monthly	27
Southeastern	Other	34
Statewide	**Daily**	**26**
Statewide	**Weekly**	**18**
Statewide	**Monthly**	**23**
Statewide	**Other**	**33**

Table 162 details the percent of respondents last manure application on the hay field, before the current manure application for the 2018 hay crop (HMQ-9).

Table 162. The date of last manure application before the manure application for the 2018 hay crop

BMP Region	Last Application of Manure on the largest Hay Field	Percent of Respondents
Northwestern	2013 and Before	9
Northwestern	2014	2
Northwestern	2015	7
Northwestern	2016	33
Northwestern	2017	49
Irrigated and Non-irrigated Sandy Soils	2013 and Before	11
Irrigated and Non-irrigated Sandy Soils	2014	1
Irrigated and Non-irrigated Sandy Soils	2015	15
Irrigated and Non-irrigated Sandy Soils	2016	21
Irrigated and Non-irrigated Sandy Soils	2017	52
Southwestern and West Central	2013 and Before	3
Southwestern and West Central	2014	11
Southwestern and West Central	2015	13
Southwestern and West Central	2016	31
Southwestern and West Central	2017	42
South Central	2013 and Before	4
South Central	2015	7
South Central	2016	30
South Central	2017	59
Southeastern	2014	6
Southeastern	2015	12
Southeastern	2016	35
Southeastern	2017	47
Statewide	**2013 and Before**	**7**
Statewide	**2014**	**3**
Statewide	**2015**	**13**
Statewide	**2016**	**26**
Statewide	**2017**	**51**

Table 163 details the average miles traveled from the manure source to the hay field applied with manure (HMQ-10).

Table 163. Distance to the hay field for manure applications by composition of manure

BMP Region	Liquid or Solid Manure	Average Miles to the Hay Field
Northwestern	Solid	0.61
Northwestern	All	0.61
Irrigated and Non-irrigated Sandy Soils	Solid	0.92
Irrigated and Non-irrigated Sandy Soils	Liquid	1.39
Irrigated and Non-irrigated Sandy Soils	All	0.95
Southwestern and West Central	Solid	1.50
Southwestern and West Central	Liquid	0.97
Southwestern and West Central	All	1.43
South Central	Solid	0.74
South Central	Liquid	1.40
South Central	All	0.80
Southeastern	Solid	0.57
Southeastern	Liquid	0.36
Southeastern	All	0.54
Statewide	**Solid**	**1.10**
Statewide	**Liquid**	**0.90**
Statewide	**All**	**0.93**

Table 164 details the average miles traveled to the hay field from the manure source by animal type (HMQ-6 and HMQ-10).

Table 164. Distance to the hay field for manure applications by animal type

BMP Region	Animal Type	Average Miles to the Hay Field
Northwestern	Beef	0.64
Northwestern	Poultry	**
Northwestern	Other	**
Irrigated and Non-irrigated Sandy Soils	Dairy	1.41
Irrigated and Non-irrigated Sandy Soils	Beef	0.56
Irrigated and Non-irrigated Sandy Soils	Hog	**
Irrigated and Non-irrigated Sandy Soils	Poultry	2.84
Irrigated and Non-irrigated Sandy Soils	Other	1.14
Irrigated and Non-irrigated Sandy Soils	Don't Know	**
Southwestern and West Central	Dairy	0.64
Southwestern and West Central	Beef	0.76
Southwestern and West Central	Hog	**
Southwestern and West Central	Poultry	**
Southwestern and West Central	Other	0.97
South Central	Dairy	1.18
South Central	Beef	0.86
South Central	Poultry	**
South Central	Other	0.35
South Central	Don't Know	**
Southeastern	Dairy	0.52
Southeastern	Beef	0.46
Southeastern	Hog	**
Southeastern	Other	0.93
Statewide	**Dairy**	**1.08**
Statewide	**Beef**	**0.62**
Statewide	**Hog**	**1.53**
Statewide	**Poultry**	**3.90**
Statewide	**Other**	**0.81**
Statewide	**Don't Know**	**

** Less than five responses

Table 165 details the percent of respondents who knew the amount of nitrogen in the manure applied for the 2018 hay crop (HMQ-11).

Table 165. The farmers' knowledge of nitrogen content of manure being applied for the 2018 hay crop

BMP Region	Knowledge of the Actual Amount of Nitrogen Applied	Percent of Respondents
Northwestern	Yes	5
Northwestern	No	95
Irrigated and Non-irrigated Sandy Soils	Yes	25
Irrigated and Non-irrigated Sandy Soils	No	75
Southwestern and West Central	Yes	18
Southwestern and West Central	No	82
South Central	Yes	11
South Central	No	89
Southeastern	Yes	13
Southeastern	No	87
Statewide	**Yes**	**19**
Statewide	**No**	**81**

Table 166 details the average amount of nitrogen applied per acre by type of livestock manure when the farmer knew the amount of nitrogen in the manure applied (HMQ-6, HMQ-11 and HMQ-12).

Table 166. Average amount of nitrogen applied per acre from manure by livestock type when the farmer knew the amount of nitrogen in the manure source

BMP Region	Animal Type	Average Nitrogen Rate Applied From Manure in Pounds per Acre
Northwestern	All	**
Northwestern	Beef	**
Irrigated and Non-irrigated Sandy Soils	All	78
Irrigated and Non-irrigated Sandy Soils	Dairy	**
Irrigated and Non-irrigated Sandy Soils	Beef	**
Irrigated and Non-irrigated Sandy Soils	Hog	**
Irrigated and Non-irrigated Sandy Soils	Poultry	**
Irrigated and Non-irrigated Sandy Soils	Other	**
Southwestern and West Central	All	87
Southwestern and West Central	Dairy	**
Southwestern and West Central	Beef	**
Southwestern and West Central	Hog	**
Southwestern and West Central	Other	**
South Central	All	120
South Central	Dairy	124
South Central	Beef	**
South Central	Poultry	**
Southeastern	All	**
Southeastern	Dairy	**
Statewide	**All**	**90**
Statewide	**Dairy**	**113**
Statewide	**Beef**	**66**
Statewide	**Hog**	****
Statewide	**Poultry**	****
Statewide	**Other**	****

** Less than five responses

Average Nitrogen Rate from Manure Applications

Figure 74 details the distribution of average nitrogen rates in Minnesota from farmers that applied manure[59] regardless of whether additional commercial nitrogen fertilizer was applied to the largest hay field. The rates do not include nitrogen from additional commercial nitrogen fertilizer applied to the 2018 hay crop (HMQ-6, HMQ-11, and HMQ-12).

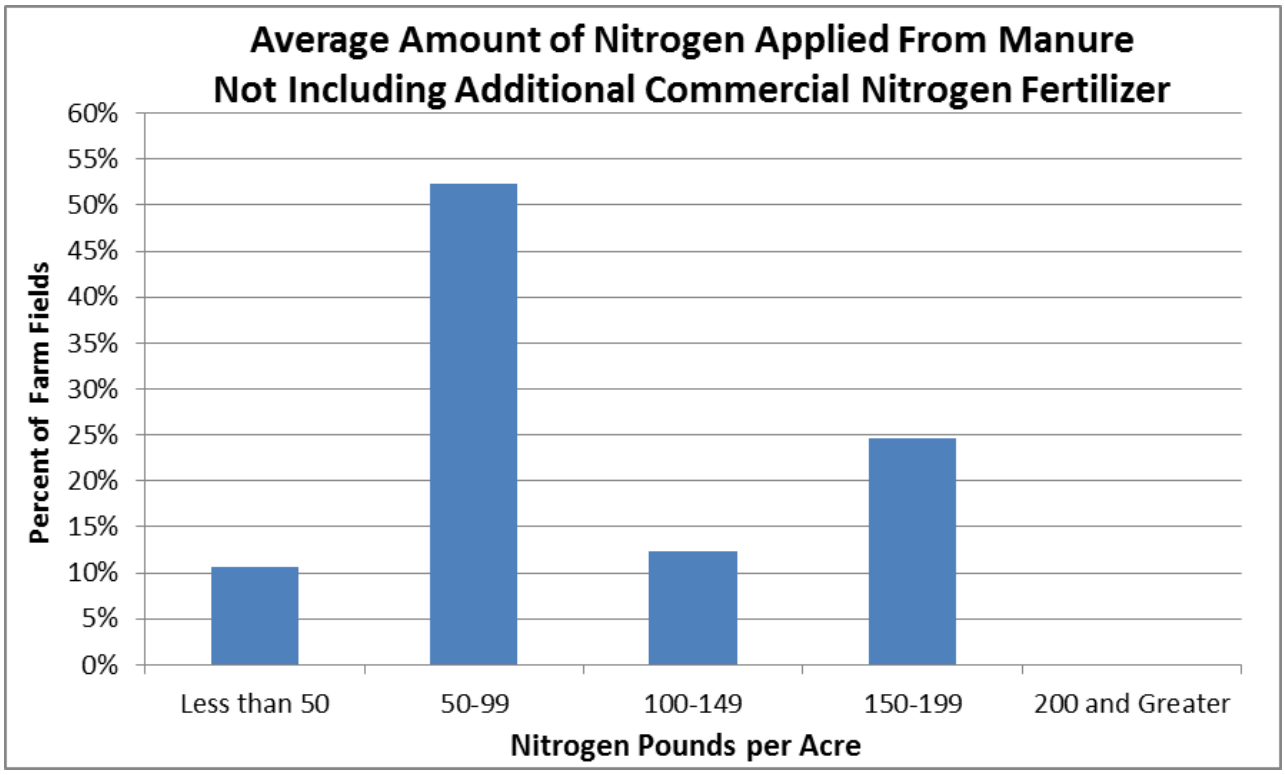

Figure 74. Average nitrogen rates applied to hay fields from manure and does not include additional commercial nitrogen fertilizer in Minnesota for 2018: 419 fields.

[59] Manure is from all manure sources

Figure 75 details the distribution of average nitrogen rates in Minnesota from farmers that applied dairy manure and does not include nitrogen from additional commercial nitrogen fertilizer applied to the 2018 hay crop (HMQ-6, HMQ-11, and HMQ-12).

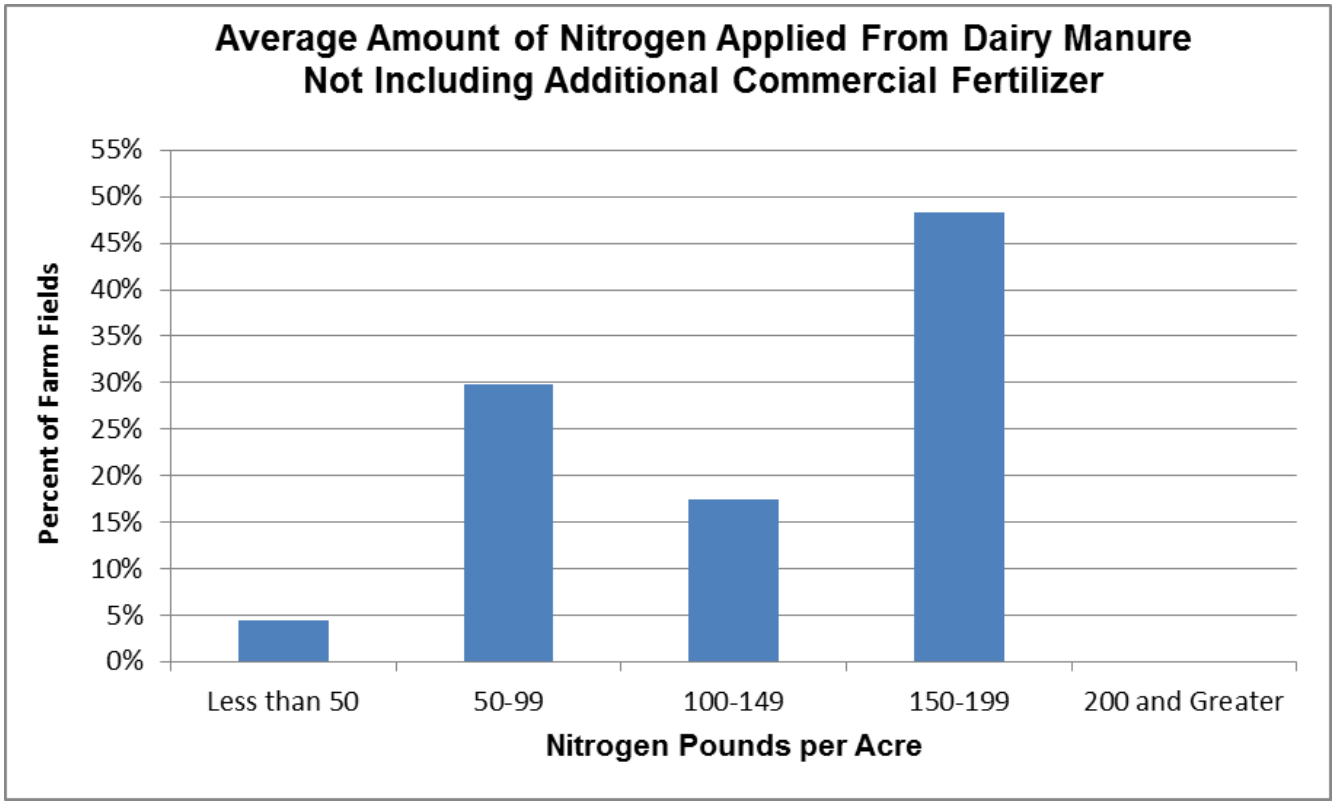

Figure 75. Average nitrogen rates applied to hay fields from dairy manure and does not include additional commercial nitrogen fertilizer in Minnesota for 2018: 197 fields.

Figure 76 details the distribution of average nitrogen rates in Minnesota from farmers that applied beef manure and does not include nitrogen from additional commercial nitrogen fertilizer applied to the 2018 hay crop (HMQ-6, HMQ-11, and HMQ-12).

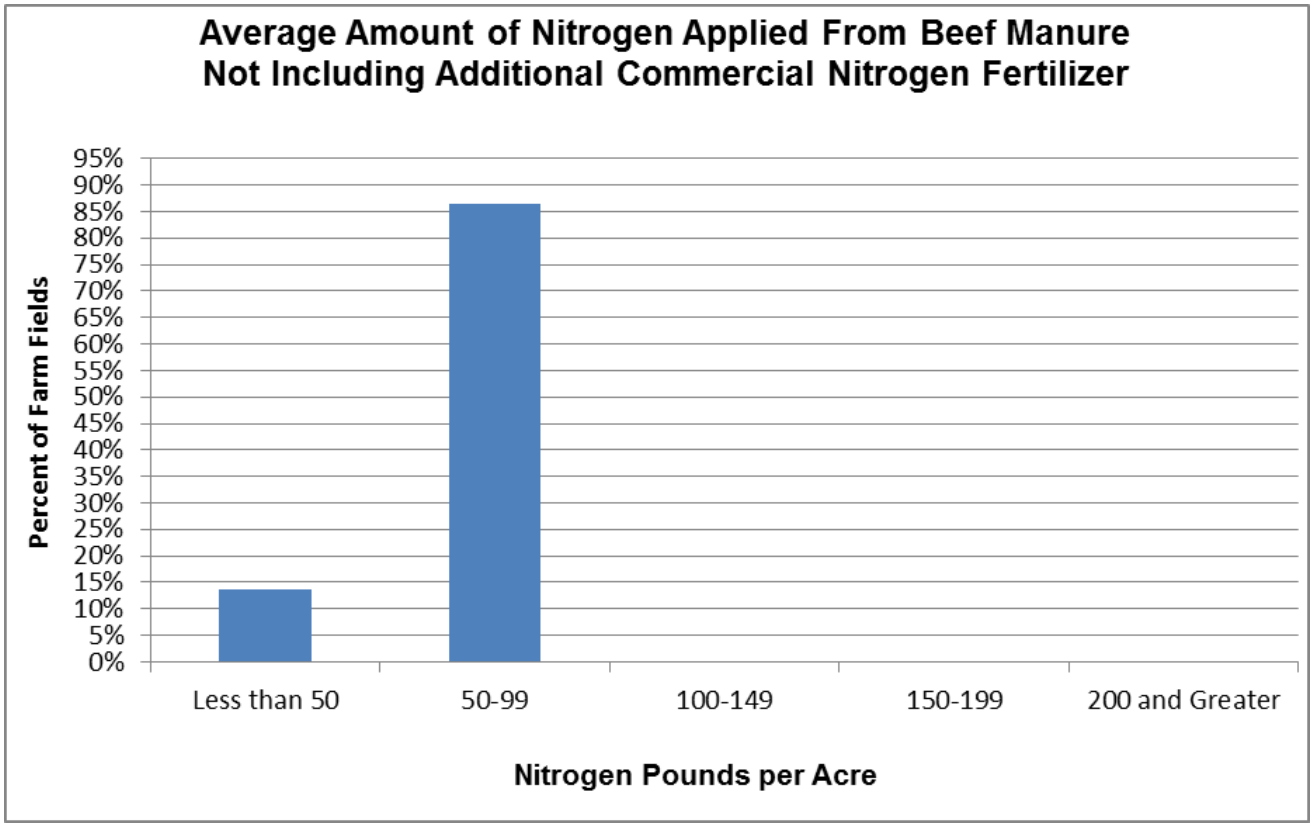

Figure 76. Average nitrogen rates applied to hay fields from beef manure and does not include additional commercial nitrogen fertilizer in Minnesota for 2018: 71 fields.

- Less than five responses reported the average nitrogen rate applied from hog manure.
- Less than five responses reported the average nitrogen rate applied from poultry manure.
- Less than five responses reported the average nitrogen rate applied from other manure.

Average Nitrogen Rate from Manure and Commercial Nitrogen Fertilizer Applications

Statewide, less than five responses reported the average nitrogen rate from manure and commercial nitrogen fertilizer sources to the 2018 hay crop.

- Less than five responses reported the average nitrogen rate from manure[60] and commercial nitrogen fertilizer sources applied to the 2018 hay crop. Therefore, there is no additional nitrogen rate from individual sources of manure[61] and commercial nitrogen fertilizer applications.

[60] Manure is from all manure sources
[61] The sources of manure include dairy, beef, hog, poultry, and other.

Nitrogen Rates on Manured Hay Fields

Table 167 details rates by BMP region on hay following various crops (HMQ-2, HMQ-3, HMQ-12, and HMQ-17). These are hay fields applied with manure or manure and commercial nitrogen fertilizer.

Table 167. Average amount of nitrogen applied from manure or manure and commercial nitrogen fertilizer by previous crop and BMP region.

BMP Region	Previous Crop	Average Nitrogen Rate from Manure Only or Manure and Commercial Nitrogen Fertilizer Pounds per Acre
Northwestern	Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Corn	**
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Other	**
Southwestern and West Central	Alfalfa	84
Southwestern and West Central	Small Grains	**
Southwestern and West Central	Other	**
South Central	Corn	**
South Central	Corn/Alfalfa	**
South Central	Alfalfa	**
South Central	Other	**
Southeastern	Corn	**
Southeastern	Small Grains	**
Southeastern	Other	**
Statewide	**Corn**	**
Statewide	**Corn/Alfalfa**	**
Statewide	**Alfalfa**	**72**
Statewide	**Small Grains**	**
Statewide	**Other**	**76**

** Less than five responses

Table 168 details rates by BMP region on hay following various crops (HMQ-2, HMQ-3, and HMQ-12). These are hay fields applied with manure only.

Table 168. Average amount of nitrogen applied from manure and no commercial nitrogen fertilizer by previous crop and BMP region.

BMP Region	Previous Crop	Average Nitrogen Rate from Manure Only Pounds per Acre
Northwestern	Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Corn	**
Irrigated and Non-irrigated Sandy Soils	Corn/Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Other	**
Southwestern and West Central	Alfalfa	77
Southwestern and West Central	Small Grains	**
Southwestern and West Central	Other	**
South Central	Corn	**
South Central	Corn/Alfalfa	**
South Central	Alfalfa	**
South Central	Other	**
Southeastern	Corn	**
Southeastern	Small Grains	**
Southeastern	Other	**
Statewide	**Corn**	**
Statewide	**Corn/Alfalfa**	**
Statewide	**Alfalfa**	**79**
Statewide	**Small Grains**	**
Statewide	**Other**	**59**

** Less than five responses

- Less than five responses reported nitrogen applied from manure and commercial nitrogen fertilizer on hay following various crops.

- Less than five responses reported nitrogen applied from dairy manure only or dairy manure and commercial nitrogen fertilizer on hay following various crops.

Table 169 details rates by BMP region on hay following various crops (HMQ-2, HMQ-3, HMQ-12, and HMQ-17). These are hay fields applied with beef manure or beef manure and commercial nitrogen fertilizer.

Table 169. Average amount of nitrogen applied from beef manure or beef manure and commercial nitrogen fertilizer by previous crop and BMP region.

BMP Region	Previous Crop	Average Nitrogen Rate from Beef Manure Only or Beef Manure and Commercial Nitrogen Fertilizer Pounds per Acre
Northwestern	Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Alfalfa	**
Irrigated and Non-irrigated Sandy Soils	Other	**
Southwestern and West Central	Alfalfa	**
Southwestern and West Central	Other	**
South Central	Other	**
Southeastern	Corn	**
Southeastern	Other	**
Statewide	**Alfalfa**	**68**
Statewide	**Other**	**

- Less than five responses reported nitrogen applied from hog manure only or hog manure and commercial nitrogen fertilizer on hay following various crops.

- Less than five responses reported nitrogen applied from poultry manure only or poultry manure and commercial nitrogen fertilizer on hay following various crops.

- Less than five responses reported nitrogen applied from other manure only or other manure and commercial nitrogen fertilizer on hay following various crops.

Nitrogen Applications from All Manure Sources for All Crops following Hay

No responses reported manure nitrogen rates from manure or manure with commercial nitrogen fertilizer from hay following soybeans:

- When the farmer knew the amount of nitrogen in the manure applied.
- When the farmer did not know the amount of nitrogen in the manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from manure or manure and commercial nitrogen fertilizer to hay following corn:

- When the farmer knew the amount of nitrogen in the manure applied.
- When the farmer did not know the amount of nitrogen in the manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from manure or manure and commercial nitrogen fertilizer to hay following corn following alfalfa:

- When the farmer knew the amount of nitrogen in the manure applied.
- When the farmer did not know the amount of nitrogen in the manure applied and applied additional commercial nitrogen fertilizer.

Figure 77 details the distribution of average nitrogen fertilizer rates in Minnesota from farmers that applied manure or manure and commercial nitrogen fertilizer to hay following alfalfa (HMQ-2, HQM-11, HMQ-12, and HMQ-17). The average nitrogen rate applied from manure or manure and commercial nitrogen fertilizer was 74 pounds per acre.

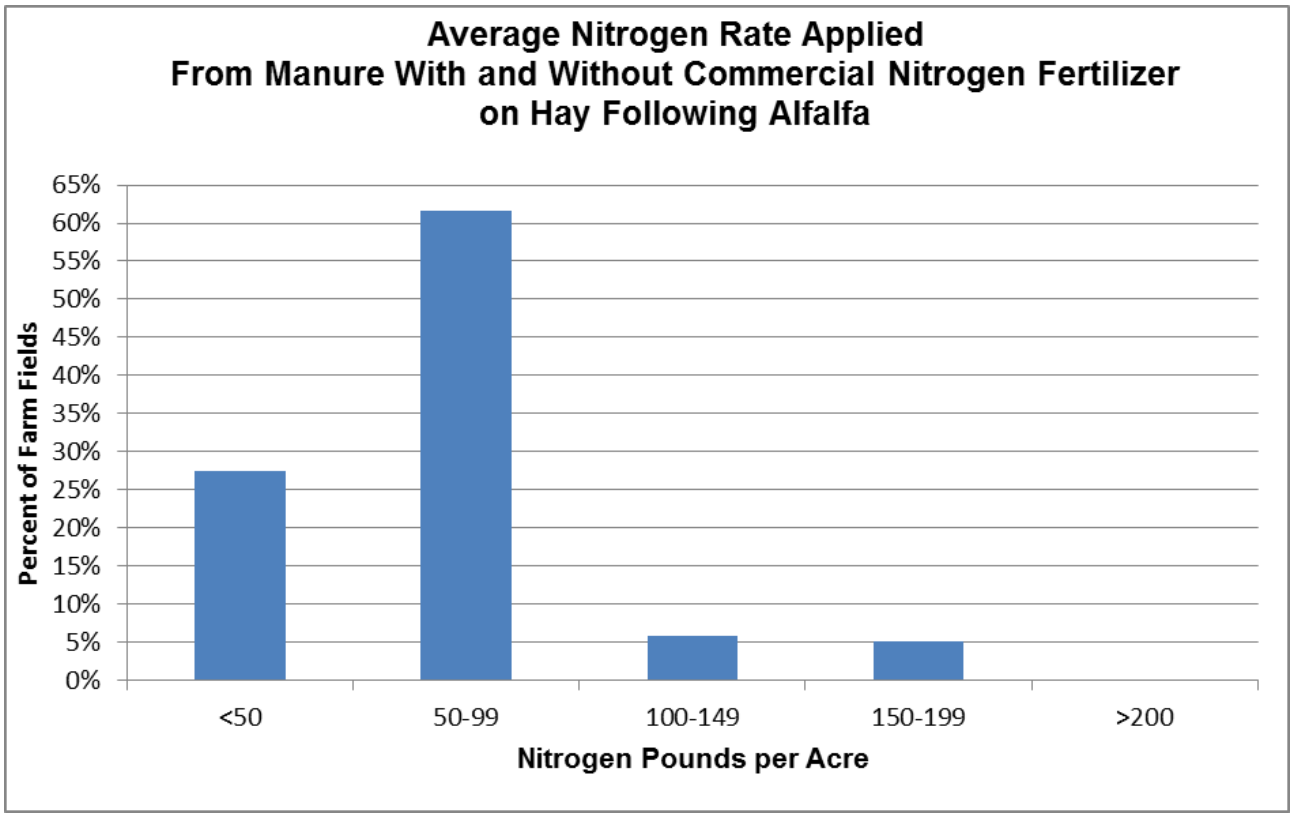

Figure 77. Average nitrogen rates applied to hay following alfalfa from manure or manure and commercial nitrogen fertilizer in Minnesota for 2018: 161 fields.

Figure 78 details the distribution of average nitrogen fertilizer rates in Minnesota from farmers that applied manure or manure and commercial nitrogen fertilizer to hay following alfalfa (HMQ-2, HMQ-11 and HMQ-12). The average nitrogen rate applied from manure was 79 pounds per acre.

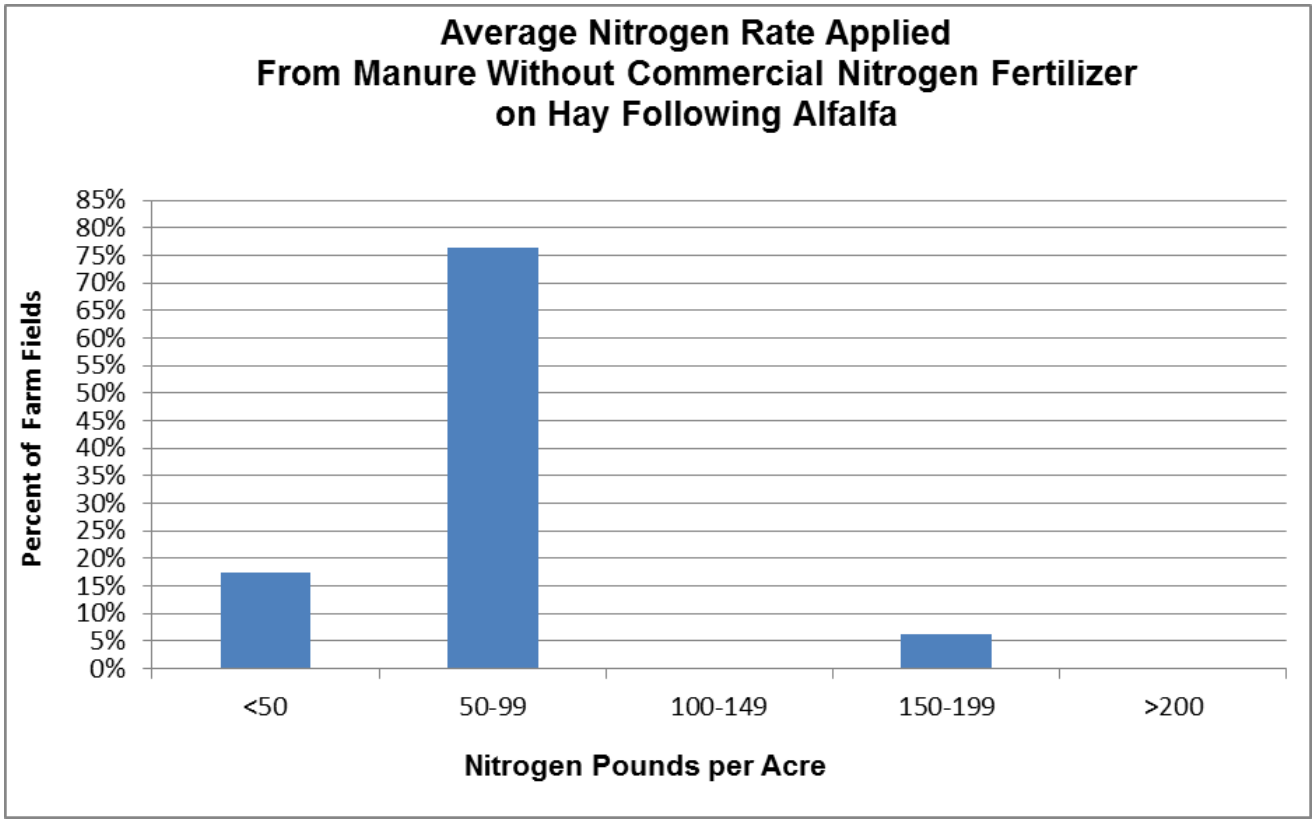

Figure 78. Average nitrogen rates applied to hay following alfalfa from manure in Minnesota for 2018: 130 fields.

Less than five responses reported nitrogen rates from manure and commercial nitrogen fertilizer to hay following alfalfa:

- When the farmer knew the amount of nitrogen in the manure applied.

Figure 79 details the distribution of average nitrogen rates in Minnesota from farmers that applied manure and commercial nitrogen fertilizer to hay following alfalfa when the farmer did not know the nitrogen of the manure application. (HMQ-2, HMQ-11, HMQ-16, and HMQ-17). Therefore, manure nitrogen was not included in the analysis when the quantity of nitrogen from manure applied to the field is not known. The average commercial nitrogen fertilizer rate was 59 pounds per acre.

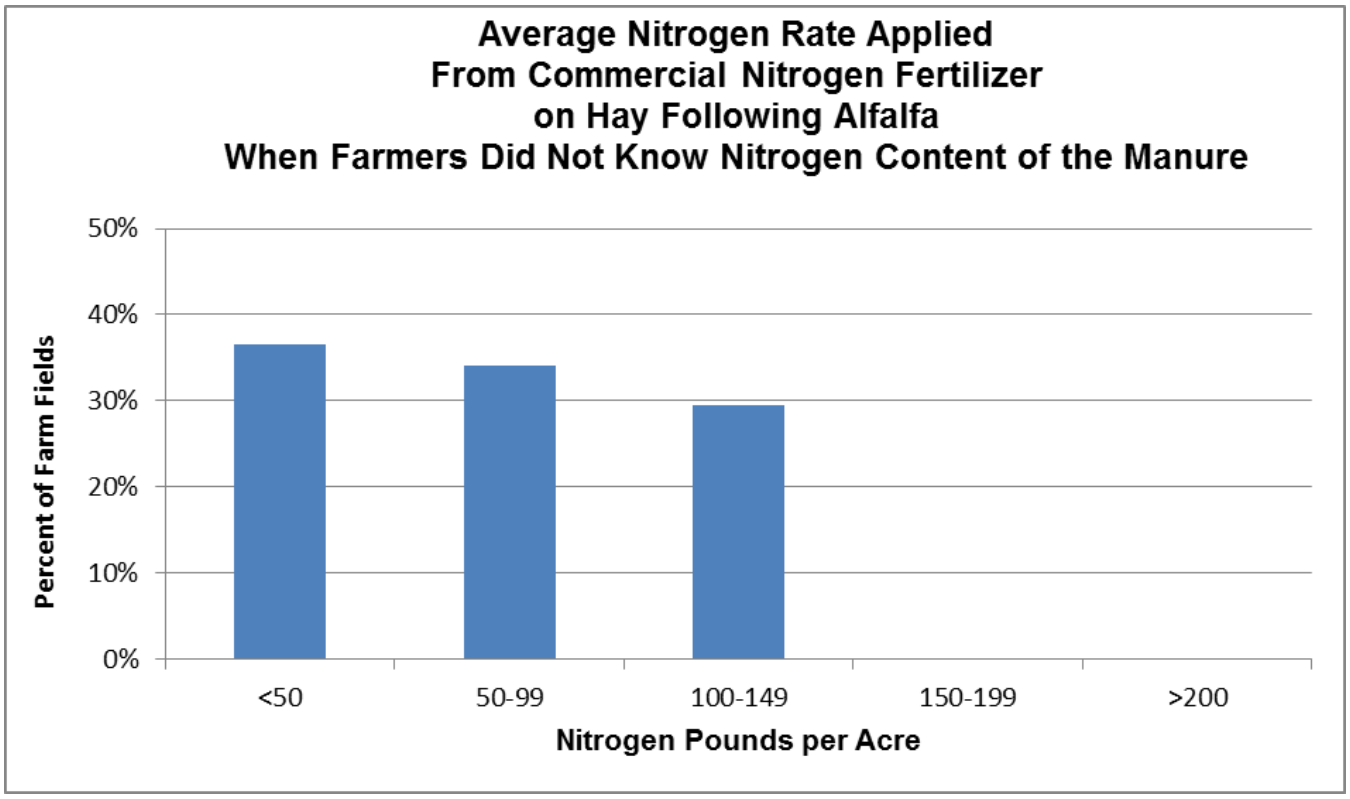

Figure 79. Average nitrogen rates applied to hay following alfalfa from commercial nitrogen fertilizer in Minnesota for 2018 when the manure nitrogen content is unknown: 118 fields.

Less than five responses reported nitrogen rates from manure or manure and commercial nitrogen fertilizer to hay following small grains:

- When the farmer knew the amount of nitrogen in the manure applied.
- When the farmer did not know the amount of nitrogen in the manure applied and applied additional commercial nitrogen fertilizer.

Figure 80 details the distribution of average nitrogen fertilizer rates in Minnesota from farmers that applied manure or manure and commercial nitrogen fertilizer to hay following other crops (HMQ-2, HQM-11, HMQ-12, and HMQ-17). The average nitrogen rate applied from manure or manure and commercial nitrogen fertilizer was 73 pounds per acre.

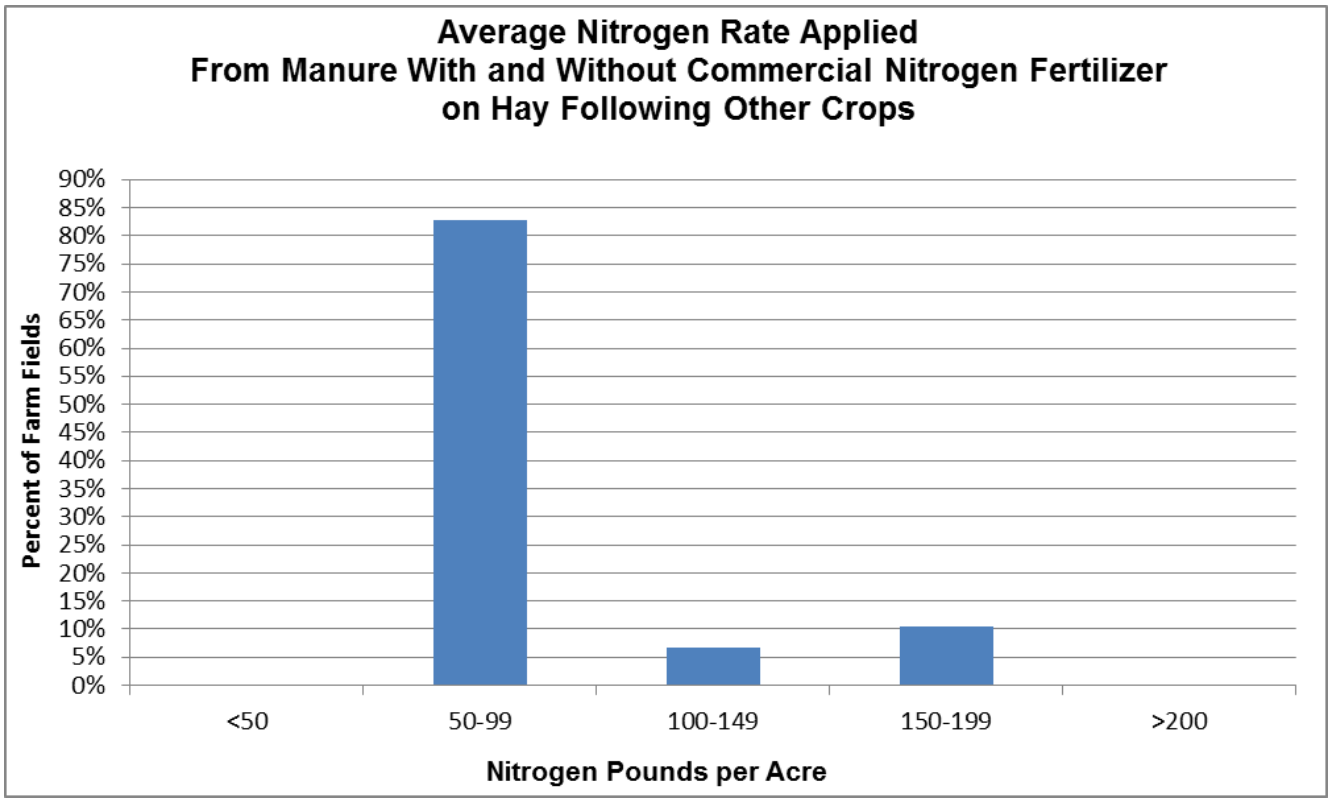

Figure 80. Average nitrogen rates applied to hay following other crops from manure or manure and commercial nitrogen fertilizer in Minnesota for 2018: 123 fields.

Figure 81 details the distribution of average nitrogen rates in Minnesota from farmers that applied manure without commercial nitrogen fertilizer to hay following other crops (HMQ-2, HMQ-11, HMQ-12, and HMQ-16). The average nitrogen rate applied from manure was 59 pounds per acre.

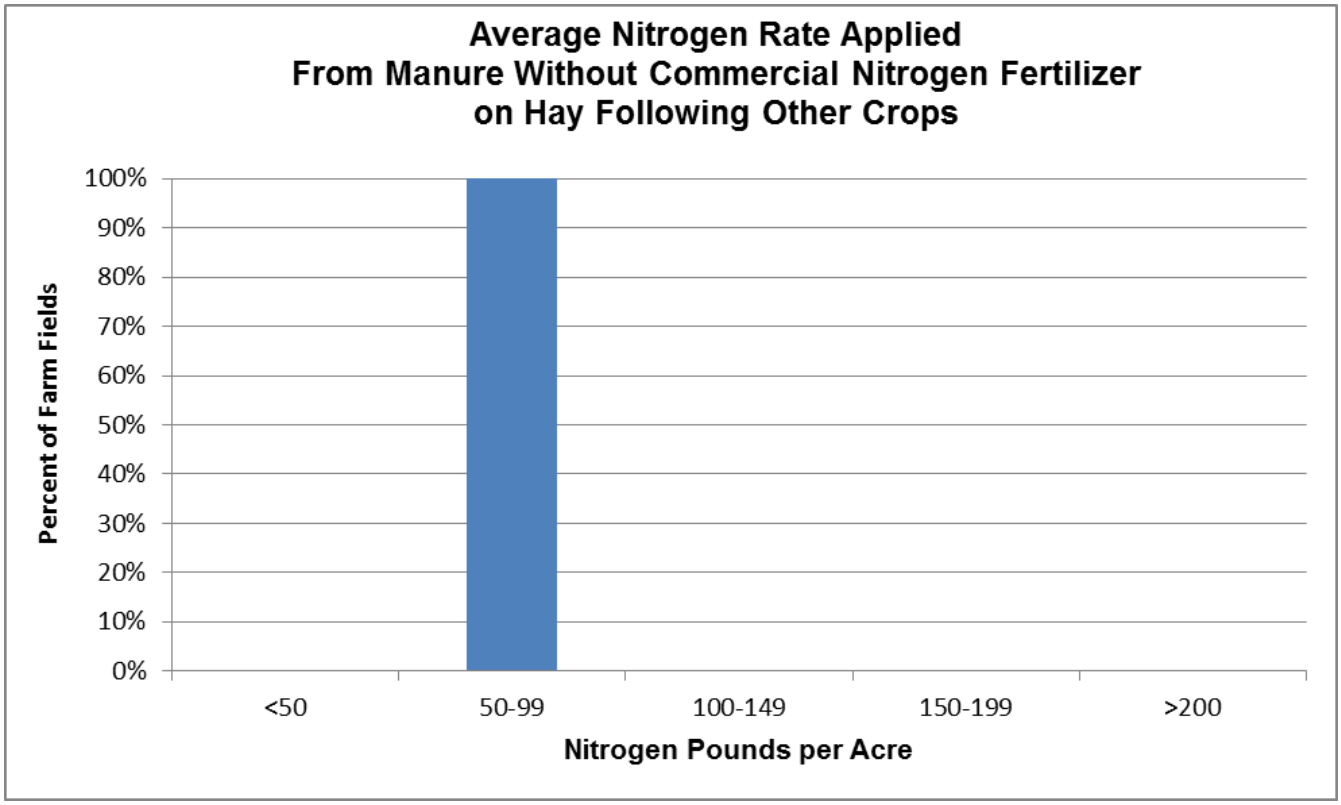

Figure 81. Average nitrogen rates applied to hay following other crops from manure in Minnesota for 2018: 85 fields.

Figure 82 details the distribution of average nitrogen rates in Minnesota from farmers that applied manure and commercial nitrogen fertilizer to hay following other crops when the farmer did not know the nitrogen of the manure application. (HMQ-2, HMQ-11, HMQ-16, and HMQ-17). Therefore, manure nitrogen was not included in the analysis when the quantity of nitrogen from manure applied to the field is not known. The average commercial nitrogen fertilizer rate was 44 pounds per acre.

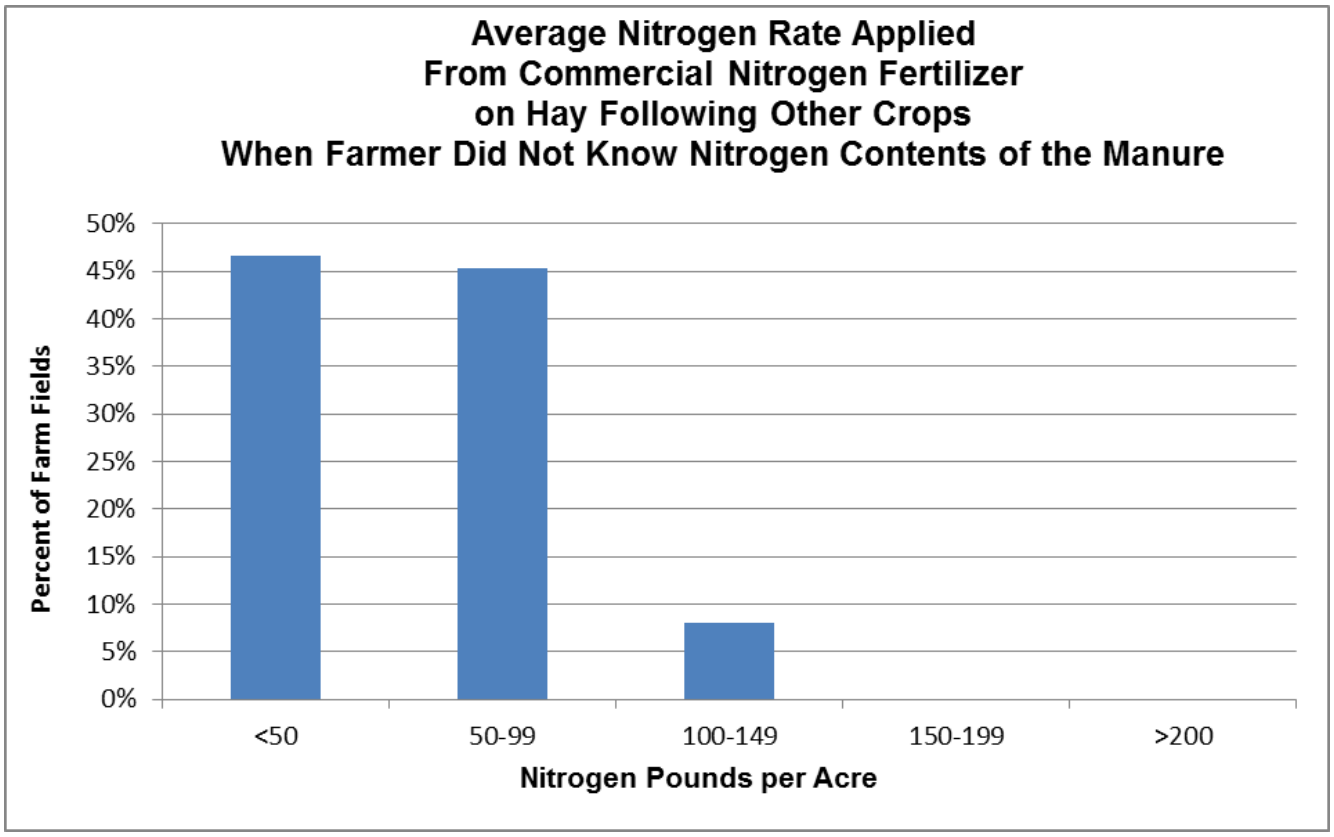

Figure 82. Average nitrogen rates applied to hay following other crops from commercial nitrogen fertilizer in Minnesota for 2018 when the manure nitrogen content is unknown: 147 fields.

No responses reported nitrogen rates from dairy manure or dairy manure and commercial nitrogen fertilizer to hay following soybeans:

- When the farmer knew the amount of nitrogen in the dairy manure applied.
- When the farmer did not know the amount of nitrogen in the dairy manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from dairy manure or dairy manure and commercial nitrogen fertilizer to hay following corn:

- When the farmer knew the amount of nitrogen in the dairy manure applied.
- When the farmer did not know the amount of nitrogen in the dairy manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from dairy manure or dairy manure and commercial nitrogen fertilizer to hay following corn following alfalfa:

- When the farmer knew the amount of nitrogen in the dairy manure applied.
- When the farmer did not know the amount of nitrogen in the dairy manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from dairy manure or dairy manure and commercial nitrogen fertilizer to hay following alfalfa:

- When the farmer knew the amount of nitrogen in the dairy manure applied.
- When the farmer did not know the amount of nitrogen in the dairy manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from dairy manure or dairy manure and commercial nitrogen fertilizer to hay following small grains:

- When the farmer knew the amount of nitrogen in the dairy manure applied.
- When the farmer did not know the amount of nitrogen in the dairy manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from dairy manure or dairy manure and commercial nitrogen fertilizer to hay following other crops:

- When the farmer knew the amount of nitrogen in the dairy manure applied.
- When the farmer did not know the amount of nitrogen in the dairy manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from beef manure or beef manure and commercial nitrogen fertilizer to hay following soybeans:

- When the farmer knew the amount of nitrogen in the beef manure applied.
- When the farmer did not know the amount of nitrogen in the beef manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from beef manure or beef manure and commercial nitrogen fertilizer to hay following corn:

- When the farmer knew the amount of nitrogen in the beef manure applied.
- When the farmer did not know the amount of nitrogen in the beef manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from beef manure or beef manure and commercial nitrogen fertilizer to hay following corn following alfalfa:

- When the farmer knew the amount of nitrogen in the beef manure applied.
- When the farmer did not know the amount of nitrogen in the beef manure applied and applied additional commercial nitrogen fertilizer.

Figure 83 details the distribution of average nitrogen fertilizer rates in Minnesota from farmers that applied beef manure or beef manure and commercial nitrogen fertilizer to hay following alfalfa (HMQ-2, HMQ-11, HMQ-16, and HMQ-17). The average nitrogen rate applied from beef manure or beef manure and commercial nitrogen fertilizer was 68 pounds per acre.

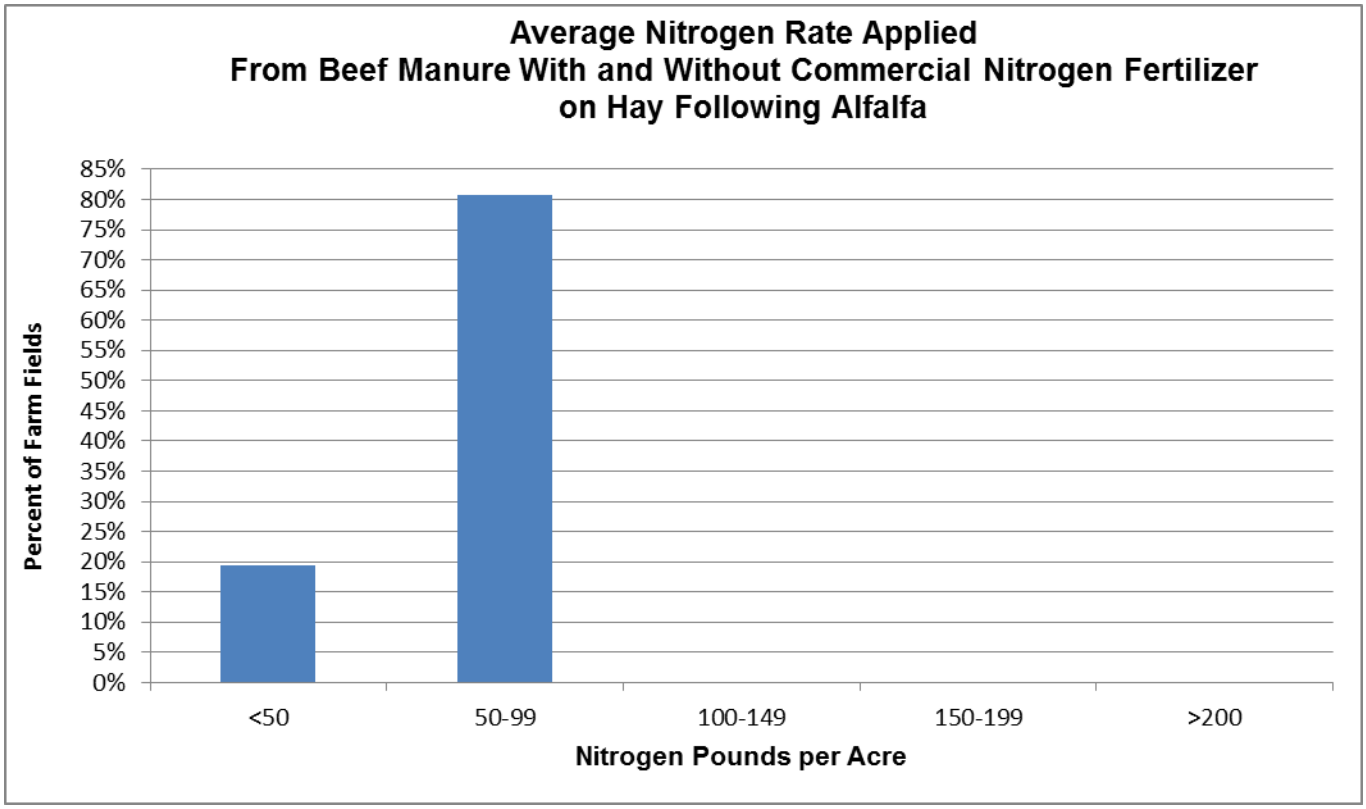

Figure 83. Average nitrogen rates applied to hay following alfalfa from beef manure or beef manure and commercial nitrogen fertilizer in Minnesota for 2018: 50 fields.

Less than five responses reported nitrogen rates from beef manure and commercial nitrogen fertilizer to hay following alfalfa:

- When the farmer knew the amount of nitrogen in the manure applied.

Figure 84 details the distribution of average nitrogen rates in Minnesota from farmers that applied beef manure without commercial nitrogen fertilizer to hay following alfalfa (HMQ-2, HMQ-11, HMQ-12, and HMQ-16). The average nitrogen rate applied from beef manure was 68 pounds per acre.

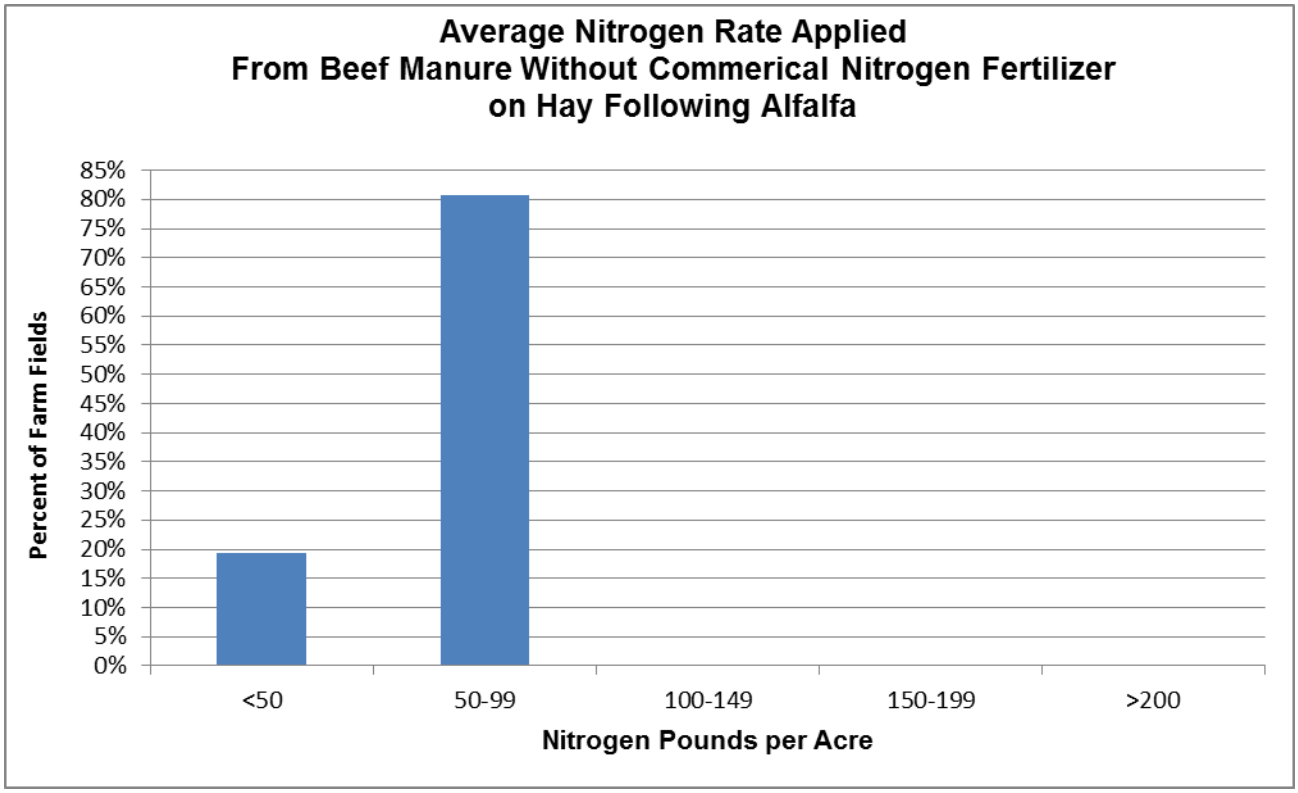

Figure 84. Average nitrogen rates applied to hay following alfalfa from beef manure in Minnesota for 2018: 50 fields.

Figure 85 details the distribution of average nitrogen rates in Minnesota from farmers that applied beef manure and commercial nitrogen fertilizer to hay following alfalfa when the farmer did not know the nitrogen of the beef manure application. (HMQ-2, HMQ-11, HMQ-16, and HMQ-17). Therefore, manure nitrogen was not included in the analysis when the quantity of nitrogen from beef manure applied to the field is not known. The average commercial nitrogen fertilizer rate was 66 pounds per acre.

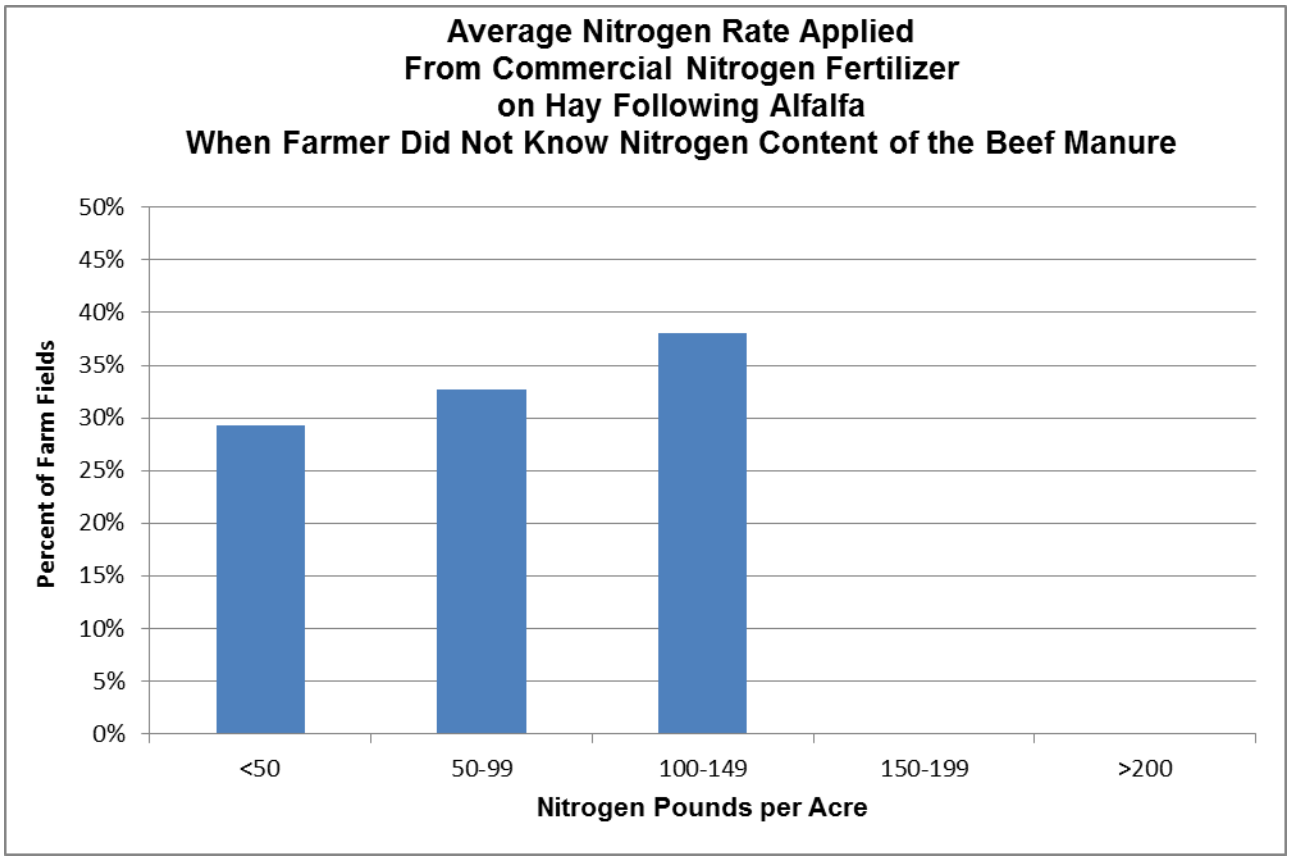

Figure 85. Average nitrogen rates applied to hay following alfalfa from commercial nitrogen fertilizer in Minnesota for 2018 when the manure nitrogen content is unknown: 91 fields.

No responses reported nitrogen rates from beef manure or beef manure and commercial nitrogen fertilizer to hay following small grains:

- When the farmer knew the amount of nitrogen in the beef manure applied.
- When the farmer did not know the amount of nitrogen in the beef manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from beef manure or beef manure and commercial nitrogen fertilizer to hay following other crops:

- When the farmer knew the amount of nitrogen in the beef manure applied.

Figure 86 details the distribution of average nitrogen rates in Minnesota from farmers that applied beef manure and commercial nitrogen fertilizer to hay following other crops when the farmer did not know the nitrogen of the beef manure application. (HMQ-2, HMQ-11, HMQ-16, and HMQ-17). Therefore, manure nitrogen was not included in the analysis when the quantity of nitrogen from beef manure applied to the field is not known. The average commercial nitrogen fertilizer rate was 45 pounds per acre.

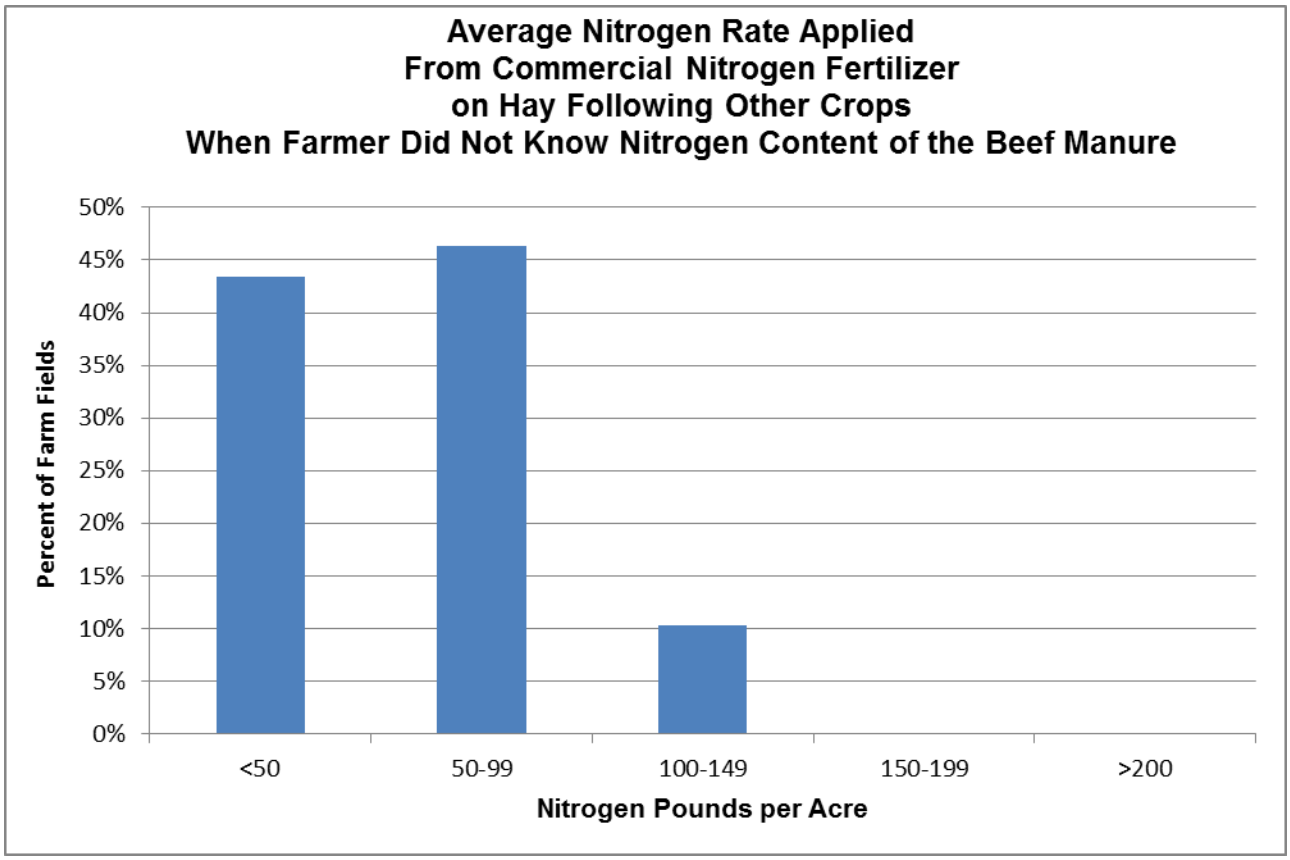

Figure 86. Average nitrogen rates applied to hay following other crops from commercial nitrogen fertilizer in Minnesota for 2018 when the manure nitrogen content is unknown: 115 fields.

No responses reported nitrogen rates from hog manure or hog manure and commercial nitrogen fertilizer to hay following soybeans:

- When the farmer knew the amount of nitrogen in the hog manure applied.
- When the farmer did not know the amount of nitrogen in the hog manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from hog manure or hog manure and commercial nitrogen fertilizer to hay following corn:

- When the farmer knew the amount of nitrogen in the hog manure applied.
- When the farmer did not know the amount of nitrogen in the hog manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from hog manure or hog manure and commercial nitrogen fertilizer to hay following corn following alfalfa:

- When the farmer knew the amount of nitrogen in the hog manure applied.
- When the farmer did not know the amount of nitrogen in the hog manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from hog manure or hog manure and commercial nitrogen fertilizer to hay following alfalfa:

- When the farmer knew the amount of nitrogen in the hog manure applied.
- When the farmer did not know the amount of nitrogen in the hog manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from hog manure or hog manure and commercial nitrogen fertilizer to hay following small grains:

- When the farmer knew the amount of nitrogen in the hog manure applied.
- When the farmer did not know the amount of nitrogen in the hog manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from hog manure or hog manure and commercial nitrogen fertilizer to hay following other crops:

- When the farmer knew the amount of nitrogen in the hog manure applied.
- When the farmer did not know the amount of nitrogen in the hog manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from poultry manure or poultry manure and commercial nitrogen fertilizer to hay following soybeans:

- When the farmer knew the amount of nitrogen in the poultry manure applied.
- When the farmer did not know the amount of nitrogen in the poultry manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from poultry manure or poultry manure and commercial nitrogen fertilizer to hay following corn:

- When the farmer knew the amount of nitrogen in the poultry manure applied.
- When the farmer did not know the amount of nitrogen in the poultry manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from poultry manure or poultry manure and commercial nitrogen fertilizer to hay following corn following alfalfa:

- When the farmer knew the amount of nitrogen in the poultry manure applied.
- When the farmer did not know the amount of nitrogen in the poultry manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from poultry manure or poultry manure and commercial nitrogen fertilizer to hay following alfalfa:

- When the farmer knew the amount of nitrogen in the poultry manure applied.
- When the farmer did not know the amount of nitrogen in the poultry manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from poultry manure or poultry manure and commercial nitrogen fertilizer to hay following small grains:

- When the farmer knew the amount of nitrogen in the poultry manure applied.
- When the farmer did not know the amount of nitrogen in the poultry manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from poultry manure or poultry manure and commercial nitrogen fertilizer to hay following other crops:

- When the farmer knew the amount of nitrogen in the poultry manure applied.
- When the farmer did not know the amount of nitrogen in the poultry manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from other sources of manure or other sources of manure and commercial nitrogen fertilizer to hay following soybeans:

- When the farmer knew the amount of nitrogen in the other sources of manure applied.
- When the farmer did not know the amount of nitrogen in the other sources of manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from other sources of manure or other sources of manure and commercial nitrogen fertilizer to hay following corn:

- When the farmer knew the amount of nitrogen in the other sources of manure applied.
- When the farmer did not know the amount of nitrogen in the other sources of manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from other sources of manure or other sources of manure and commercial nitrogen fertilizer to hay following corn following alfalfa:

- When the farmer knew the amount of nitrogen in the other sources of manure applied.
- When the farmer did not know the amount of nitrogen in the other sources of manure applied and applied additional commercial nitrogen fertilizer.

Less than five responses reported nitrogen rates from other sources of manure or other sources of manure and commercial nitrogen fertilizer to hay following alfalfa:

- When the farmer knew the amount of nitrogen in the other sources of manure applied.
- When the farmer did not know the amount of nitrogen in the other sources of manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from other sources of manure or other sources of manure and commercial nitrogen fertilizer to hay following small grains:

- When the farmer knew the amount of nitrogen in the other sources of manure applied.
- When the farmer did not know the amount of nitrogen in the other sources of manure applied and applied additional commercial nitrogen fertilizer.

No responses reported nitrogen rates from other sources of manure or other sources of manure and commercial nitrogen fertilizer to hay following other crops:

- When the farmer knew the amount of nitrogen in the other sources of manure applied.
- When the farmer did not know the amount of nitrogen in the other sources of manure applied and applied additional commercial nitrogen fertilizer.

Statewide Manure Use and Practices

Table 170 details the percent of respondents on manure applications using variable rate technology (HMQ-13).

Table 170. Manure applications using variable rate technology.

BMP Region	Manure Applications Using Variable Rate	Percent of Respondents
Northwestern	Yes	5
Northwestern	No	95
Irrigated and Non-irrigated Sandy Soils	Yes	11
Irrigated and Non-irrigated Sandy Soils	No	89
Southwestern and West Central	Yes	8
Southwestern and West Central	No	92
South Central	Yes	8
South Central	No	92
Southeastern	Yes	5
Southeastern	No	95
Statewide	**Yes**	**9**
Statewide	**No**	**91**

Table 171 details the percent of respondents who knew the manure application rate (HMQ-14)

Table 171. Farmer's knowledge of manure application rates

BMP Region	Knowledge of Manure Application Rates	Percent of Respondents
Northwestern	Yes	11
Northwestern	No	89
Irrigated and Non-irrigated Sandy Soils	Yes	28
Irrigated and Non-irrigated Sandy Soils	No	72
Southwestern and West Central	Yes	49
Southwestern and West Central	No	51
South Central	Yes	33
South Central	No	67
Southeastern	Yes	32
Southeastern	No	68
Statewide	**Yes**	**31**
Statewide	**No**	**69**

Table 172 details the application rate for liquid manure, if known by the farmer (HMQ-15 and HMQ-15A). No respondents reported liquid manure application rates in the Northwestern BMP region.

Table 172. Rates for liquid manure applications by region

BMP Region	Average Gallons per Acre
Irrigated and Non-irrigated Sandy Soils	6,298
Southwestern and West Central	4,331
South Central	6,939
Southeastern	4,262
Statewide	**5,404**

Table 173 details the application rate for solid manure, if known by the farmer (HMQ-15 and HMQ-15B).

Table 173. Rates for solid manure application by region

BMP Region	Average Tons per Acre
Northwestern	**
Irrigated and Non-irrigated Sandy Soils	2.55
Southwestern and West Central	3.90
South Central	2.81
Southeastern	**
Statewide	**2.98**

** Less than five responses

Table 174 details the percent of respondents who applied fertilizer on manured hay fields (HMQ-16).

Table 174. Commercial fertilizer applications on manured fields by region.

BMP Region	Application of Commercial Fertilizer to Manured Hay Field	Percent of Respondents
Northwestern	Yes	18
Northwestern	No	82
Irrigated and Non-irrigated Sandy Soils	Yes	15
Irrigated and Non-irrigated Sandy Soils	No	85
Southwestern and West Central	Yes	18
Southwestern and West Central	No	82
South Central	Yes	11
South Central	No	89
Southeastern	Yes	34
Southeastern	No	66
Statewide	**Yes**	**17**
Statewide	**No**	**83**

Table 175 details the average amount of nitrogen applied per acre to the manured hay field from commercial nitrogen fertilizer by livestock type (HMQ-17).

Table 175. Average amount of nitrogen from commercial fertilizer applied to manured hay fields by livestock type.

BMP Region	Animal Type	Average Nitrogen Rate From Commercial Fertilizer Pounds per Acre
Northwestern	All	**
Northwestern	Dairy	**
Northwestern	Beef	**
Irrigated and Non-irrigated Sandy Soils	All	45
Irrigated and Non-irrigated Sandy Soils	Beef	**
Irrigated and Non-irrigated Sandy Soils	Hog	55
Irrigated and Non-irrigated Sandy Soils	Other	**
Southwestern and West Central	All	46
Southwestern and West Central	Dairy	**
Southwestern and West Central	Beef	47
Southwestern and West Central	Hog	**
Southwestern and West Central	Other	**
South Central	All	**
South Central	Dairy	**
South Central	Beef	**
Southeastern	All	**
Southeastern	Dairy	**
Southeastern	Beef	**
Statewide	**All**	**46**
Statewide	**Dairy**	**34**
Statewide	**Beef**	**54**
Statewide	**Hog**	****
Statewide	**Other**	****

** Less than five responses

Table 176 details the average amount of nitrogen applied per acre to the manured hay field from manure and commercial nitrogen fertilizer by livestock type (HMQ-12 and HMQ-17).

Table 176. Average amount of nitrogen from commercial fertilizer applied to manured hay fields by livestock type.

BMP Region	Animal Type	Average Nitrogen Rate From Manure and Commercial Fertilizer Pounds per Acre
Irrigated and Non-irrigated Sandy Soils	All	**
Irrigated and Non-irrigated Sandy Soils	Beef	**
Southwestern and West Central	All	**
Southwestern and West Central	Dairy	**
Southwestern and West Central	Hog	**
Southeastern	All	**
Southeastern	Dairy	**
Statewide	**All**	**93**
Statewide	**Dairy**	****
Statewide	**Hog**	****
Statewide	**Other**	****

** Less than five responses

Table 177 details if the manure applied was from the farmer's livestock (HMQ-18).

Table 177. Origin of the manure in regard to livestock ownership source.

BMP Region	Manure From the Farmer's Livestock	Percent of Respondents
Northwestern	Yes	94
Northwestern	No	6
Irrigated and Non-irrigated Sandy Soils	Yes	91
Irrigated and Non-irrigated Sandy Soils	No	9
Southwestern and West Central	Yes	91
Southwestern and West Central	No	9
South Central	Yes	91
South Central	No	9
Southeastern	Yes	92
Southeastern	No	8
Statewide	**Yes**	**91**
Statewide	**No**	**9**

Table 178 when the manure was last tested for nutrients (HMQ-19).

Table 178. Date of last test for manure nutrient content.

BMP Region	Last Manure Test	Percent of Respondents
Northwestern	This Year	0
Northwestern	Last Three Years	14
Northwestern	Over Three Years Ago	6
Northwestern	Don't Test	80
Irrigated and Non-irrigated Sandy Soils	This Year	8
Irrigated and Non-irrigated Sandy Soils	Last Three Years	7
Irrigated and Non-irrigated Sandy Soils	Over Three Years Ago	6
Irrigated and Non-irrigated Sandy Soils	Don't Test	79
Southwestern and West Central	This Year	15
Southwestern and West Central	Last Three Years	10
Southwestern and West Central	Over Three Years Ago	14
Southwestern and West Central	Don't Test	61
South Central	This Year	12
South Central	Last Three Years	8
South Central	Over Three Years Ago	10
South Central	Don't Test	70
Southeastern	This Year	11
Southeastern	Last Three Years	18
Southeastern	Over Three Years Ago	3
Southeastern	Don't Test	68
Statewide	**This Year**	**10**
Statewide	**Last Three Years**	**9**
Statewide	**Over Three Years Ago**	**7**
Statewide	**Don't Test**	**74**

Soil Testing in the Last Five Years

Table 179 details the type of soil test the farmer used in the last five years (HMQ-20). The percent of respondents can equal greater than 100 percent due to some farmers conducting multiple soils tests within the five year time frame.

Table 179. Types of soils tests used in the last five years

BMP Region	Type of Soil Testing	Percent of Respondents
Northwestern	Traditional	31
Northwestern	Grid	4
Northwestern	Zone	0
Northwestern	None	65
Irrigated and Non-irrigated Sandy Soils	Traditional	21
Irrigated and Non-irrigated Sandy Soils	Grid	7
Irrigated and Non-irrigated Sandy Soils	Zone	4
Irrigated and Non-irrigated Sandy Soils	None	68
Southwestern and West Central	Traditional	21
Southwestern and West Central	Grid	12
Southwestern and West Central	Zone	5
Southwestern and West Central	None	62
South Central	Traditional	17
South Central	Grid	11
South Central	Zone	2
South Central	None	70
Southeastern	Traditional	27
Southeastern	Grid	12
Southeastern	Zone	6
Southeastern	None	55
Statewide	**Traditional**	**22**
Statewide	**Grid**	**9**
Statewide	**Zone**	**4**
Statewide	**None**	**65**

Appendix 1. MASS Data Sheet

Survey questions for fertilizer and manure start after the farmer is questioned about pesticide use.

Fertilizer Use Questions Field 1 2018 Crop Season

FIELDS MP102 Part 1 (Wheat Field 1)

Wheat All Question 1 Total Crop Acres How many acres of wheat did you plant?

Wheat Fertilizer Question 1 Wheat Acre Do you have a wheat field without manure? Yes No

Setup Statement Verify Acres Think about your largest wheat field that you planted in 2018 without any manure.

Wheat Fertilizer Question 2 Wheat Irrigated Was this field irrigated? Yes No

Wheat Fertilizer Question 3 Wheat Prev Crop What was the crop grown on this field in 2017 before the 2018 wheat crop? (Not including cover crop)?

Prev Crop =

Soybeans (1) "Soybeans",

Corn (2) "Corn",

Alfalfa (3) "Alfalfa",

Small Grains (4) "Small Grains",

Other (99) "Other"

Wheat Fertilizer Question 4 If Corn Planted What was the crop harvested from this field in the 2016 season, before the last two crops? Yes, no, DK, RF

Wheat Fertilizer Question 5 No Manure How many acres were in your largest wheat field in 2018?

Wheat Fertilizer Question 6 Ave Yield What was the average yield of this field over the last 3 wheat crops? Bushels per Acre, DK, RF

Wheat Fertilizer Question 7 Fert Applied Was any commercial nitrogen fertilizer applied to this wheat field in 2018? Please include fall applications in 2017 for the 2018 crop year. Yes No

Wheat Fertilizer Question 8 Var Rate Was any commercial nitrogen fertilizer applied on this field at more than one rate or a variable rate? If yes, use a field average. Yes, No, DK, RF

Setup Statement Var Rate Please use a field average for all fertilizer rate questions

Wheat Fertilizer Question 9 Total N What was the total amount of nitrogen applied PER ACRE on this field? Pounds per Acre, DK, RF

Wheat Fertilizer Question 9b Fert Type What type of fertilizer was used to supply the majority of the nitrogen applied to this field?

Wheat Fertilizer Question 10 N Inhibitor Did you use a nitrogen inhibitor or stabilizer on this field?

LeadIn3 I will now ask you for all your commercial fertilizer applications made on this field for the 2018 crop year, again including any 2017 fall applications of commercial fertilizer. This will include all fall applications in 2017 and all 2018 applications including preplant applications, starter/planter applications and post plant applications. **Explanation of the table below.** Farmers were questioned about the fertilizer applications through a table questionnaire listed below.

Questions for each application included:

What type of fertilizer or nutrient was used for the application?

What was the quantity applied in the application?

What was the unit of the application?

When was the application made?

Or, if the farmer knew the actual amount of nutrients applied

How many pounds of nitrogen was in the application?

How many pounds of phosphorus was in the application?

How many pounds of potash was in the application?

How many pounds of sulfur was in the application?

Wheat Fertilizer Question Table Fert Rate

***[Wheat]* Field 1**

Line		2 MATERIALS USED [Enter percentage analysis or actual pounds of plant nutrients applied per acre.] [Show Common Nutrients or Fertilizers in Respondent Booklet.]				3 What quantity was applied per acre? [Leave this column blank if actual pounds of nutrients were reported.]	4 [Enter material code.] 1 Pounds 12 Gallons 19 Pounds of actual nutrients	5 When was this applied? 1 In the fall before seeding 2 In the spring before seeding 3 At seeding 4 After seeding	6 How was this applied? [Refer to code list above.]
		N Nitrogen	P_2O_5 Phosphate	K_2O Potash	S Sulfur				
01	Fall of 2017] Application 1	31	32	33	34	36	37	38	39
02	Fall of [2017] Application 2	31	32	33	34	36	37	38	39
03	Spring/Summer [2018] Application 1	31	32	33	34	36	37	38	39
04	Spring/Summer [2018 Application 2	31	32	33	34	36	37	38	39
05	Spring/Summer [2018] Application 3	31	32	33	34	36	37	38	39
06	Spring/Summer [2018] Application 4	31	32	33	34	36	37	38	39
07	Spring/Summer[2018] Application 5	31	32	33	34	36	37	38	39

FIELDS MP102 Part 1 (Hay Field 1)

Hay All Question 1 Total Crop Acres How many acres of hay did you harvest?

Hay Fertilizer Question 1 Hay Acre Do you have a hay field without manure? Yes No

Setup Statement Verify Acres Think about your largest hay field that you planted in 2018 without any manure.

Hay Fertilizer Question 2 Hay Irrigated Was this field irrigated? Yes No

Hay Fertilizer Question 3 Hay Prev Crop What was the crop grown on this field in 2017 before the 2018 hay crop? (Not including cover crop)?

Prev Crop =

Soybeans (1) "Soybeans",

Corn (2) "Corn",

Alfalfa (3) "Alfalfa",

Small Grains (4) "Small Grains",

Other (99) "Other"

Hay Fertilizer Question 4 If Corn Planted What was the crop harvested from this field in the 2016 season, before the last two crops?

Prev Crop =

Soybeans (1) "Soybeans",

Corn (2) "Corn",

Alfalfa (3) "Alfalfa",

Small Grains (4) "Small Grains",

Other (99) "Other"

Hay Fertilizer Question 5 No Manure How many acres were in your largest hay field in 2018?

Hay Fertilizer Question 6 Fert Applied Was any commercial nitrogen fertilizer applied to this wheat field in 2018? Please include fall applications in 2017 for the 2018 crop year. Yes No

Hay Fertilizer Question 7 Var Rate Was any commercial nitrogen fertilizer applied on this field at more than one rate or a variable rate? If yes, use a field average. Yes, No, DK, RF

Setup Statement Var Rate Please use a field average for all fertilizer rate questions

Hay Fertilizer Question 8 Total N What was the total amount of nitrogen applied PER ACRE on this field? Pounds per Acre, DK, RF

Hay Fertilizer Question 8b Fert Type What type of fertilizer was used to supply the majority of the nitrogen applied to this field?

Hay Fertilizer Question 9 N Inhibitor Did you use a nitrogen inhibitor or stabilizer on this field?

LeadIn3 I will now ask you for all your commercial fertilizer applications made on this field for the 2018 crop year, again including any 2017 fall applications of commercial fertilizer. This will include all fall applications in 2017 and all 2018 applications including preplant applications, starter/planter applications and post plant applications. **Explanation of the table below.** Farmers were questioned about the fertilizer applications through a table questionnaire listed below.

Questions for each application included:

What type of fertilizer or nutrient was used for the application?

What was the quantity applied in the application?

What was the unit of the application?

When was the application made?

Or, if the farmer knew the actual amount of nutrients applied

How many pounds of nitrogen was in the application?

How many pounds of phosphorus was in the application?

How many pounds of potash was in the application?

How many pounds of sulfur was in the application?

Hay Fertilizer Question Table Fert Rate

***[Hay]* Field 1**

Line		2 MATERIALS USED [Enter percentage analysis or actual pounds of plant nutrients applied per acre.] [Show Common Nutrients or Fertilizers in Respondent Booklet.]				3 What quantity was applied per acre? [Leave this column blank if actual pounds of nutrients were reported.]	4 [Enter material code.] 1 Pounds 12 Gallons 19 Pounds of actual nutrients	5 When was this applied? 1 In the fall before seeding 2 In the spring before seeding 3 At seeding 4 After seeding	6 How was this applied? [Refer to code list above.]
		N Nitrogen	P_2O_5 Phosphate	K_2O Potash	S Sulfur				
01	Fall of 2017] Application 1	31	32	33	34	36	37	38	39
02	Fall of [2017] Application 2	31	32	33	34	36	37	38	39
03	Spring/Summer [2018] Application 1	31	32	33	34	36	37	38	39
04	Spring/Summer [2018 Application 2	31	32	33	34	36	37	38	39
05	Spring/Summer [2018] Application 3	31	32	33	34	36	37	38	39
06	Spring/Summer [2018] Application 4	31	32	33	34	36	37	38	39
07	Spring/Summer[2018] Application 5	31	32	33	34	36	37	38	39

Manure Use Questions Field 1 2018 Crop Season

FIELDS MP102 Part 1 (Wheat Field 1)

LeadIn1, I will now ask you about a wheat field that was applied with manure for the 2018 growing season.

Wheat Manure Question 1 Wheat Manure Do you have a wheat field that was applied with manure for the 2018 crop, including manure applied in the fall of 2017?

Wheat Manure Question 2 Wheat Manure What was the crop grown on this field in 2017?

Prev Crop =

Soybeans (1) "Soybeans",

Corn (2) "Corn",

Alfalfa (3) "Alfalfa",

Small Grains (4) "Small Grains",

Other (99) "Other"

Wheat Manure Question 3 Wheat Manure Was alfalfa the previous crop grown in 2018 (before the 2017 corn crop you previously mentioned)?

Wheat Manure LeadIn1 Think about your largest wheat field you planted in 2018 with manure applied for the 2018 growing season. I will now ask you questions about that specific field. All following questions will be in relation to that specific field.

Wheat Manure Question 4 Wheat Manure How many acres were in your largest wheat field?

Wheat Manure Question 5 Wheat Manure What was the average wheat yield of this field over the past three wheat crops?

Wheat Manure Question 6 Wheat Manure Did the whole wheat field receive manure?

Wheat Manure Question 7 Wheat Manure What is the main source of manure used on the field?

Dairy (1) “Dairy”,
Beef (2) “Beef”,
Hog (3) “Hog”,
Poultry (4) “Poultry”,
Other (5) “Other”,
Do Not Know (99) “Don’t Know

Wheat Manure Question 8 Wheat Manure Was the manure applied solid or liquid?
(1) Solid : Solid
(2) Liquid : Liquid

Wheat Manure Question 8A Wheat Manure [If liquid] What was the method of application of liquid manure on this field?
(1) SweepInjection : Sweep Injection
(2) KnifeInjection : Knife Injection
(3) DiscInjection : Disc Injection
(4) Broadcast1 : Broadcast Incorporation within one day
(5) Broadcast2_to_4 : Broadcast Incorporation within two to four days
(6) Broadcast_Over_4 : Broadcast Incorporation after 4 days
(7) NoBroadcast : Broadcast No Incorporation

Wheat Manure Question 8B Wheat Manure [If solid] What was the method of application of liquid manure on this field?
(4) Broadcast1 : Broadcast Incorporation within one day
(5) Broadcast2 : Broadcast Incorporation within two to four days
(6) Broadcast4 : Broadcast Incorporation after 4 days
(7) NoBroadcast : Broadcast No Incorporation

Wheat Manure Question 9 Wheat Manure Was the manure applied on an approximate date or over a period of time?
(1) ApproximateDate : Approximate Date
(2) Period_of_Time : Over a period of time

Wheat Manure Question 9a Wheat Manure What was the approximate date the manure was applied?

Wheat Manure Question 9b Wheat Manure When was the manure applied?
(1) Daily : Daily
(2) Weekly : Weekly
(3) Monthly : Monthly
(4) Other : Other

Wheat Manure Question 10 Wheat Manure Prior to the manure application for the 2018 season, when was the last application of manure on this field? (Fall applications in 2017 would be for the 2018 season.)

Wheat Manure Question 11 Wheat Manure How many miles are from manure storage or source to the field?

Wheat Manure Question 12 Wheat Manure Do you know the actual amount of nitrogen applied from this manure? Yes No

Wheat Manure Question 13 Wheat Manure What is the total nitrogen applied from the manure as pounds per acre?

Wheat Manure Question 14 Wheat Manure Was the manure on this field applied using variable rate technology? Yes No

Wheat Manure Question 15 Wheat Manure Do you know that manure application rate in gallons per acre or tons per acre?
(1) Gallons_per_Acre : Gallons per acre
(2) Tons_per_Acre : Tons per acre

Wheat Manure Question 16 Wheat Manure What was the application rate on this field in gallons per acre or tons per acre?

Wheat Manure Question 16A Wheat Manure What was the unit?
(1) Gallons_per_Acre : Gallons per acre
(2) Tons_per_Acre : Tons per acre

Wheat Manure Question 17 Wheat Manure Did you also apply commercial fertilizers to this field for the 2018 crop year?

Wheat Manure Question 18 Wheat Manure What was the total amount of nitrogen applied per acre to this field from commercial fertilizers for the 2018 crop year, including all sources. Don't forget the starter may include nitrogen as well as phosphorus or sulfur sources.

Wheat Manure Question 19 Wheat Manure Was this manure from your own farm operation?

Wheat Manure Question 20 Wheat Manure When was the last time your manure was tested for nutrient content?
(1) This_Year : This year (include a previous year application for the current crop year)
(2) Last_3_Years : Last 3 years
(3) Over_3_Years : Over 3 years ago
(7) Dont_Test : Don't Test

Wheat Manure Question 21 Wheat Manure What type of soil sampling did you use on this field? (Include all types used in the last 3 years).
(1) Traditional : Traditional
(2) Grid_ : Grid
(3) Zone : Zone
(4) None : No soil sampling done on this field in the last 3 years

FIELDS MP102 Part 1 (Hay Field 1)

LeadIn1, I will now ask you about a Hay field that was applied with manure for the 2018 growing season.

Hay Manure Question 1 Hay Manure Do you have a Hay field that was applied with manure for the 2018 crop, including manure applied in the fall of 2017?

Hay Manure Question 2 Hay Manure What was the crop grown on this field in 2017?

Prev Crop =

Soybeans (1) "Soybeans",

Corn (2) "Corn",

Alfalfa (3) "Alfalfa",

Small Grains (4) "Small Grains",

Other (99) "Other"

Hay Manure Question 3 Hay Manure Was alfalfa the previous crop grown in 2018 (before the 2017 corn crop you previously mentioned)?

Hay Manure LeadIn1 Think about your largest Hay field yoplanted in 2018 with manure applied for the 2018 growing season. I will now ask you questions about that specific field. All following questions will be in relation to that specific field.

Hay Manure Question 4 Hay Manure How many acres were in your largest Hay field?

Hay Manure Question 5 Hay Manure Did the whole Hay field receive manure?

Hay Manure Question 6 Hay Manure What is the main source of manure used on the field?

Dairy (1) “Dairy”,
Beef (2) “Beef”,
Hog (3) “Hog”,
Poultry (4) “Poultry”,
Other (5) “Other”,
Do Not Know (99) “Don’t Know

Hay Manure Question 7 Hay Manure Was the manure applied solid or liquid?
(1) Solid : Solid
(2) Liquid : Liquid

Hay Manure Question 7A Hay Manure [If liquid] What was the method of application of liquid manure on this field?
(1) SweepInjection : Sweep Injection
(2) KnifeInjection : Knife Injection
(3) DiscInjection : Disc Injection
(4) Broadcast1 : Broadcast Incorporation within one day
(5) Broadcast2_to_4 : Broadcast Incorporation within two to four days
(6) Broadcast_Over_4 : Broadcast Incorporation after 4 days
(7) NoBroadcast : Broadcast No Incorporation

Hay Manure Question 7B Hay Manure [If solid] What was the method of application of liquid manure on this field?
(4) Broadcast1 : Broadcast Incorporation within one day
(5) Broadcast2 : Broadcast Incorporation within two to four days
(6) Broadcast4 : Broadcast Incorporation after 4 days
(7) NoBroadcast : Broadcast No Incorporation

Hay Manure Question 8 Hay Manure Was the manure applied on an approximate date or over a period of time?
(1) ApproximateDate : Approximate Date
(2) Period_of_Time : Over a period of time

Hay Manure Question 8a Hay Manure What was the approximate date the manure was applied?

Hay Manure Question 8b Hay Manure When was the manure applied?
(1) Daily : Daily
(2) Weekly : Weekly

(3) Monthly : Monthly
(4) Other : Other

Hay Manure Question 9 Hay Manure Prior to the manure application for the 2018 season, when was the last application of manure on this field? (Fall applications in 2017 would be for the 2018 season.)

Hay Manure Question 10 Hay Manure How many miles are from manure storage or source to the field?

Hay Manure Question 11 Hay Manure Do you know the actual amount of nitrogen applied from this manure? Yes No

Hay Manure Question 12 Hay Manure What is the total nitrogen applied from the manure as pounds per acre?

Hay Manure Question 13 Hay Manure Was the manure on this field applied using variable rate technology? Yes No

Hay Manure Question 14 Hay Manure Do you know that manure application rate in gallons per acre or tons per acre?
(1) Gallons_per_Acre : Gallons per acre
(2) Tons_per_Acre : Tons per acre

Hay Manure Question 15 Hay Manure What was the application rate on this field in gallons per acre or tons per acre?

Hay Manure Question 15A Hay Manure What was the unit?
(1) Gallons_per_Acre : Gallons per acre
(2) Tons_per_Acre : Tons per acre

Hay Manure Question 16 Hay Manure Did you also apply commercial fertilizers to this field for the 2018 crop year?

Hay Manure Question 17 Hay Manure What was the total amount of nitrogen applied per acre to this field from commercial fertilizers for the 2018 crop year, including all sources. Don't forget the starter may include nitrogen as well as phosphorus or sulfur sources.

Hay Manure Question 18 Hay Manure Was this manure from your own farm operation?

Hay Manure Question 19 Hay Manure When was the last time your manure was tested for nutrient content?
(1) This_Year : This year (include a previous year application for the current crop year)
(2) Last_3_Years : Last 3 years
(3) Over_3_Years : Over 3 years ago
(7) Dont_Test : Don't Test

Hay Manure Question 20 Hay Manure What type of soil sampling did you use on this field? (Include all types used in the last 3 years).
(1) Traditional : Traditional
(2) Grid_ : Grid
(3) Zone : Zone
(4) None : No soil sampling done on this field in the last 3 years

Appendix 2. History of Data Collection & Process

NASS has a long history of providing statewide crop and production statistics. Over the last decade, NASS has also become an important information source for pesticide and fertilizer use. Several joint pilot projects evolved with the financial assistance from Environmental Protection Agency (EPA) and were conducted from 2001-2003. These pilots were essential to the final methodology used in this report.

The first pilot[62] was conducted in 2001 by expanding the existing Agricultural Resource Management Study (ARMS) developed by NASS. The normal number of participating Minnesota corn farms in an ARMS survey is about 150. The pilot increased the number of personal interviews to approximately 600 and most of the enhancements were focused on the southern third of the state. The pilot provided reliable regionally enhanced data on pesticide product choices and application rates. Additionally, primary sources of pesticide management, scouting, timing, and other pesticide management related information was obtained.

In neighboring North Dakota, the USDA, NASS, the North Dakota Field Office, and North Dakota State University Extension had already established a strong tradition in collecting statewide pesticide use by using NASS telephone enumerators. With the goal of expanding to a statewide scale while reducing costs, a second pilot[63]was developed. MDA and NASS used many techniques from the North Dakota program, but decided to expand the level of detail by including pesticide application rates. Historically, most mail or telephone style surveys have been unsuccessful at quantifying pesticide rates. Due to the numerous formulations, different application rates and units of measure (i.e. Active Ingredient (AI) can be expressed in pounds, ounces, pints or quarts), complications can quickly develop. Another major complicating factor may result due to the farmer using the services of a commercial pesticide applicator. If the farmer did not apply the product, the likelihood that the farmer would be familiar with the product and rate decreases significantly.

The second pilot survey was conducted in 2003 to test two methods of collecting pesticide rate information. "Method One" was conducted in Douglas County with 150 randomly selected farm operators. Operators were interviewed over the phone by the NASS enumerators. If the operator did not know the pesticides and/or rates, no additional follow-up work was conducted and the data was limited to information that was provided. "Method Two" was used in neighboring Grant County, where another 150 farm operators were contacted, and when farm records were incomplete, follow-up calls were made to the pesticide dealer to complete the survey. The number of surveys with complete data sets significantly increased with the additional assistance from the dealerships. Eighty-three percent of the surveys were complete in Grant County, where dealer follow-up calls were made, compared to forty-six percent in Douglas County. Equally impressive was the overall support by the local dealerships.

[62] "Expanded Minnesota Agricultural Statistics Pesticide Use Data", 2003, by NASS and MDA.
[63] Unpublished data. From the September 20, 2003 EPA Report.