



Definition of Terms in the University of Minnesota Nitrogen Fertilizer BMPs January 31, 2022. Updated May 30, 2023.

For questions, please contact:

Jeppe Kjaersgaard

Pesticide and Fertilizer Management Division

651-201-6149

jeppe.kjaersgaard@state.mn.us

Introduction

The University of Minnesota nitrogen (N) fertilizer best management practices (BMPs) are outlined in publications available at www.mda.state.mn.us/nitrogenbmps. The BMPs relate broadly to the 4R principles i.e., the right rate, source, timing, and placement of nitrogen fertilizer and are based on extensive research conducted by the University of Minnesota.

Some of the terms used in the BMPs can be defined in different ways. This document outlines the definitions that will be used by the Minnesota Department of Agriculture (MDA) during dealership and farmer surveys to assess compliance with BMPs must be adopted on at least 80% of the cropland in certain drinking water supply management areas under the Groundwater Protection Rule (MR1573).

The definitions are listed alphabetically below.

The definitions are current per the date listed on the top of this page. The definitions may be updated if the N fertilizer BMPs from the University of Minnesota change.

Growing Degree Days

Some of the BMPs refer to corn crop growth stage which, in the absence of field observations, can be estimated using growing degree days (GDDs). The calculation of GDDs is shown in Box 1.

Box 1: Calculation of Growing Degree Days (GDD) for corn

GDDs for corn are calculated as $GDD = [(T_{min} + T_{max})/2] - 50$.

T_{min} is the minimum daily air temperature. If temperature is less than 50° F, use 50 as T_{min} .

T_{max} is the maximum daily air temperature. If temperature is greater than 86° F, use 86 as T_{max} .

Site-specific T_{min} and T_{max} can be obtained from:

- a nearby ag weather station,
- the U2U tool (mrcc.purdue.edu/U2U/gdd/), or
- GridMet (www.climatologylab.org/gridmet.html).

Definitions

BMP term	Corn height and crop development stage (from e.g. "...apply sidedress N before corn is 12 inches tall (V7 stage))
Definition	<p>Modern corn hybrids are normally taller than 12 inches at the V7 stage so V7 is likely to occur later than 12-inch height. The MDA will use the latest date at which the crop reaches 12 inches tall or V7 as the cutoff. Applications must occur prior to this date.</p> <p>Crop height is determined as the average height of the crop across the field. Corn plant height is determined by measuring from the soil surface to the arch of the uppermost leaf that is at least 50% emerged from the whorl.</p> <p>Corn vegetative development stage (Vn, where n is the number of leaves) is determined using the leaf collar method, where the growth stage is determined by counting the number of leaves with a visible collar beginning with the plant's first leaf.</p> <p>If corn height or corn development stage is not recorded, the MDA will estimate V7 crop development stage as follows (see Box 1 for calculation of GDDs):</p> <ol style="list-style-type: none"> 1) Time from planting to emergence is 120 cumulative GDDs. 2) V7 is estimated to occur 550 cumulative GDDs or 6 weeks after emergence, whichever is the latest date.

BMP term	Early sidedress
Definition	<p>Sidedress is a nitrogen fertilizer application along the side of crop rows after crop emergence. An early sidedress occurs after crop emergence and up to V4.</p> <p>Corn vegetative development stage (Vn, where n is the number of leaves) is determined using the leaf collar method, where the growth stage is determined by counting the number of leaves with a visible collar beginning with the plant's first leaf.</p> <p>If corn development stage is not recorded, the MDA will estimate V4 crop development stage as follows (see Box 1 for calculation of GDDs):</p> <ol style="list-style-type: none"> 1) Time from planting to emergence is 120 cumulative GDDs. 2) V4 is estimated to occur 300 cumulative GDDs or 3 weeks after emergence, whichever occurs latest.

BMP term	Incorporation of fertilizer
Definition	Fertilizer must be incorporate within 3 days to an average depth of 3 inches with light tillage or >0.25 inches of irrigation or rain. To achieve an average depth of 3 inches, tillage depth should be 6 inches.

BMP term	Irrigation water nitrogen credit																																																																																			
Definition	<p>Nitrate is commonly found at some concentration in irrigation water. Credit should be taken if the nitrate-N concentration in the irrigation water exceeds 10 mg/L (ppm) for irrigation water applied up to tasseling. Water analysis results should preferably be less than 3 years old. Nitrogen credits from irrigation water based on nitrate-N concentration and expected irrigation are in the table below.</p> <table border="1"> <thead> <tr> <th rowspan="2">Nitrate-N in irrigation water (mg/L)</th> <th colspan="6">Acre-inch of water applied between planting and tasseling</th> </tr> <tr> <th>2</th> <th>3</th> <th>4</th> <th>5</th> <th>6</th> <th>7</th> </tr> </thead> <tbody> <tr> <td></td> <td colspan="6" style="text-align: center;">Nitrogen Credit (lb. N/ac)</td> </tr> <tr> <td>10</td> <td>5</td> <td>7</td> <td>9</td> <td>11</td> <td>14</td> <td>16</td> </tr> <tr> <td>15</td> <td>7</td> <td>10</td> <td>14</td> <td>17</td> <td>20</td> <td>24</td> </tr> <tr> <td>20</td> <td>9</td> <td>14</td> <td>18</td> <td>23</td> <td>27</td> <td>32</td> </tr> <tr> <td>25</td> <td>11</td> <td>17</td> <td>23</td> <td>28</td> <td>34</td> <td>40</td> </tr> <tr> <td>30</td> <td>14</td> <td>20</td> <td>27</td> <td>34</td> <td>41</td> <td>48</td> </tr> <tr> <td>35</td> <td>16</td> <td>24</td> <td>32</td> <td>40</td> <td>48</td> <td>55</td> </tr> <tr> <td>40</td> <td>18</td> <td>27</td> <td>36</td> <td>45</td> <td>54</td> <td>63</td> </tr> <tr> <td>45</td> <td>20</td> <td>31</td> <td>41</td> <td>51</td> <td>61</td> <td>71</td> </tr> <tr> <td>50</td> <td>23</td> <td>34</td> <td>45</td> <td>57</td> <td>68</td> <td>79</td> </tr> </tbody> </table>	Nitrate-N in irrigation water (mg/L)	Acre-inch of water applied between planting and tasseling						2	3	4	5	6	7		Nitrogen Credit (lb. N/ac)						10	5	7	9	11	14	16	15	7	10	14	17	20	24	20	9	14	18	23	27	32	25	11	17	23	28	34	40	30	14	20	27	34	41	48	35	16	24	32	40	48	55	40	18	27	36	45	54	63	45	20	31	41	51	61	71	50	23	34	45	57	68	79
Nitrate-N in irrigation water (mg/L)	Acre-inch of water applied between planting and tasseling																																																																																			
	2	3	4	5	6	7																																																																														
	Nitrogen Credit (lb. N/ac)																																																																																			
10	5	7	9	11	14	16																																																																														
15	7	10	14	17	20	24																																																																														
20	9	14	18	23	27	32																																																																														
25	11	17	23	28	34	40																																																																														
30	14	20	27	34	41	48																																																																														
35	16	24	32	40	48	55																																																																														
40	18	27	36	45	54	63																																																																														
45	20	31	41	51	61	71																																																																														
50	23	34	45	57	68	79																																																																														

BMP term	Legume nitrogen credit
Definition	<p>Nitrogen credit from legumes is nitrogen supplied by the previous crop and is subtracted from the nitrogen fertilizer application rate. For the most up-to-date values to credit please see the following University of Minnesota publications:</p> <ul style="list-style-type: none"> - For corn: Fertilizing Corn in Minnesota¹. - For other crops: Fertilizer Guidelines for Agronomic Crops in Minnesota². <p>The nitrogen credits from crops prior to corn are listed in Appendix A.</p> <p>Specifically for corn following soybeans the following applies:</p> <ul style="list-style-type: none"> - Irrigated corn: Take N credit from soybeans (Appendix A) - Dryland corn: No soybean N credit is needed; it is already included in the N rate recommendations.

¹ Available at extension.umn.edu/crop-specific-needs/fertilizing-corn-minnesota

² Available at <https://conservancy.umn.edu/handle/11299/198924>

BMP term	Manure nitrogen credit
Definition	<p>Nitrogen credit from manure is accounting for N supplied by manure and is subtracted from the recommended N fertilizer application rate. Because some of the N in manure must be converted to a plant available form, credit is taken both the crop year of application (year 1) and the year after (year 2).</p> <p>Plant available N (PAN) is the amount of N available from manure and is calculated for year 1 and 2 as follows:</p> <ul style="list-style-type: none"> - PAN (Year 1) = N availability (table) x Total N (from manure analysis) - PAN (Year 2) = N availability (table) x Total N (from manure analysis) <p>Nitrogen availability varies by animal species and manure application method. An overview manure N availability for year 1 and 2 is in Appendix B.</p> <p>A laboratory analysis is the most reliable way to determine the total N content of manure. If no laboratory analysis is available, the “book values” listed in Appendix B can be used to estimate the total N content.</p> <p><i>While the book values for N content in Appendix B are a good starting point, actual values will vary substantially among livestock operations and storage facilities. Differences between the actual N content and the book values can cause substantial over or under application of N which may impact yields and water quality. When possible, actual manure test results should be used.</i></p> <p>If no laboratory analysis is available, the MDA will use the “book values” listed in Appendix B to estimate the total N content.</p>

BMP term	Nitrogen stabilizer												
Definition	<p>There are multiple terms used for urease and nitrification inhibitors in the BMPs, and in some cases product trade names are used. MDA is developing a list of approved nitrification and urease inhibitors³. The terms are defined by MDA as follows:</p> <table border="1" style="width: 100%;"> <thead> <tr> <th>Term used in BMP bulletin</th> <th>Definition used by MDA</th> </tr> </thead> <tbody> <tr> <td>Nitrification inhibitor</td> <td>Any approved nitrification inhibitor or product with comparable benefits.</td> </tr> <tr> <td>N-Serve</td> <td>Any approved nitrification inhibitor or product with comparable benefits.</td> </tr> <tr> <td>Urease inhibitor</td> <td>Any approved urease inhibitor or product with comparable benefits.</td> </tr> <tr> <td>Agrotain</td> <td>Any approved urease inhibitor or product with comparable benefits.</td> </tr> <tr> <td>N stabilizer (N-serve)</td> <td>Any approved nitrification inhibitor or product with comparable benefits. [Note: The term N stabilizer is commonly used interchangeably for nitrification and urease inhibitors. Examination of the research by University of Minnesota used for developing the BMPs makes clear it refers to the use of a nitrification inhibitor.]</td> </tr> </tbody> </table>	Term used in BMP bulletin	Definition used by MDA	Nitrification inhibitor	Any approved nitrification inhibitor or product with comparable benefits.	N-Serve	Any approved nitrification inhibitor or product with comparable benefits.	Urease inhibitor	Any approved urease inhibitor or product with comparable benefits.	Agrotain	Any approved urease inhibitor or product with comparable benefits.	N stabilizer (N-serve)	Any approved nitrification inhibitor or product with comparable benefits. [Note: The term N stabilizer is commonly used interchangeably for nitrification and urease inhibitors. Examination of the research by University of Minnesota used for developing the BMPs makes clear it refers to the use of a nitrification inhibitor.]
Term used in BMP bulletin	Definition used by MDA												
Nitrification inhibitor	Any approved nitrification inhibitor or product with comparable benefits.												
N-Serve	Any approved nitrification inhibitor or product with comparable benefits.												
Urease inhibitor	Any approved urease inhibitor or product with comparable benefits.												
Agrotain	Any approved urease inhibitor or product with comparable benefits.												
N stabilizer (N-serve)	Any approved nitrification inhibitor or product with comparable benefits. [Note: The term N stabilizer is commonly used interchangeably for nitrification and urease inhibitors. Examination of the research by University of Minnesota used for developing the BMPs makes clear it refers to the use of a nitrification inhibitor.]												

³ Available at <https://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan/nitrogenmgmt/amts>

BMP term	Pop-up fertilizer
Definition	A small amount of nitrogen fertilizer placed in-furrow in direct contact with the seed.

BMP term	Sidedress fertilizer
Definition	A nitrogen fertilizer application along the side of crop rows after crop emergence. If corn emergence is not recorded, the MDA will estimate emergence stage as 120 cumulative GDDs from planting to emergence (see Box 1 for calculation of GDDs).

BMP term	Sinkhole
Definition	A surface depression caused by a collapse of soil or overlying formation above fractured or cavernous bedrock (MN 7020.0300). USDA Natural Resource Conservation Service (NRCS) Practice Standard 527: Karst Sinkhole Treatment outlines practices to protect sinkholes and reduce risk of groundwater contamination via sinkholes. Examples of practices are vegetative buffer, surface water flow control, nutrient management, and livestock exclusion.

BMP term	Split application
Definition	<p>A split application of N fertilizer includes one or more of the following:</p> <ol style="list-style-type: none"> 1. two or more nitrogen fertilizer applications during the crop growing season of which at least one is a sidedress or top dress application, 2. a fall/spring preplant/at-planting or starter nitrogen fertilizer application (including ammoniated phosphate such as MAP and DAP or micronutrient formulations containing nitrogen) and one or more nitrogen fertilizer sidedress or top dress applications, 3. fall or spring application of manure and one or more spring preplant/starter/sidedress or top dress nitrogen fertilizer applications, 4. alfalfa terminated within the last two years and at least one fall/spring preplant/at-planting/starter/sidedress or top dress application, or 5. adaptive nitrogen management with preplant or at-planting application of nitrogen fertilizer followed by in-season determination of crop nitrogen needs based on soil or plant tests. No more than 50% of the expected nitrogen application rate may be applied preplant or at-planting. <p>A fertilizer application for bullet points 1 and 2 must be 20 lb. N/acre or more. Multiple sidedress or top dress applications where less than 20 lb. N/acre is applied each time can be added together to meet the 20 lb. N threshold.</p> <p>Growing season is defined in MN Rule 1573 as the period from the time of planting to physiological maturity of the crop.</p> <p>Nitrogen fertilizer application in the fall and on frozen soils is restricted in vulnerable groundwater areas and in certain drinking water supply management areas with high levels of nitrate public water supplies. See the Minnesota Department of Agriculture’s website for more information (www.mda.state.mn.us/part-1-groundwater-protection-rule).</p>

BMP term	Starter fertilizer
Definition	Nitrogen fertilizer applied with or near the seed at planting or before emergence. Exact position is not implied. The purpose of the starter fertilizer is to enhance early crop growth and development.

BMP term	Top dressed fertilizer
Definition	A surface application of N fertilizer after crop emergence, including fertigation. If corn emergence is not recorded, the MDA will estimate emergence stage as 120 cumulative GDDs from planting to emergence (see Box 1 for calculation of GDDs).

BMP term	Weed and feed
Definition	The combined application of an herbicide and N fertilizer.

Appendix A – Legume Nitrogen Crediting

Nitrogen credits from legumes and other crops prior to corn are summarized in Table A1.

Table A1. Nitrogen credits for previous, full season crop for first-year corn.

Previous crop	First-year N credit (lb. N/ac)
Soybean (irrigated corn only)*	30
Alsike clover, birdsfoot trefoil, grass/legume hay, grass/legume pasture, fallow, red clover	75
Barley, buckwheat, canola, corn, grass hay, grass pasture, oats, potatoes, rye, sorghum-sudan, sugar beet, sunflower, sweet corn, vegetables, wheat	0
Edible bean, field pea	20
Alfalfa (pure alfalfa stand or alfalfa-grass mixture with more than 50% alfalfa)	See Table A2 for N rate guidelines

*No N credits for soybean need to be taken for dryland corn; it is already included in the N rate recommendations from the University of Minnesota available at extension.umn.edu/crop-specific-needs/fertilizing-corn-minnesota

Table A2. Nitrogen application guidelines for first- and second-year corn following a pure stand alfalfa or alfalfa-grass mixture with more than 50% alfalfa.

Soil texture	Irrigation or non-irrigated	Alfalfa stand age, year	Alfalfa termination season	N rate, first-year corn (lb. N/acre)	N rate, second-year corn (lb. N/acre)
Sands and sandy loams	Irrigated	1	Fall or spring	140-170	
		2 or more	Fall or spring	70-150	
	Non-irrigated	1	Fall or spring	40-80	80-120
		2 or more	Fall or spring	0-20	0-80
Loams and silt loams	Both	1	Fall or spring	40-80	80-120
		2 or more	Fall	0-20	0-80
		2 or more	Spring	0-40	0-80
Clays, clay loams and silty clay loams	Both	1	Fall or spring	40-80	80-120
		2 or more	Fall	0-20	0-80
		2 or more	Spring	0-40	0-80

Appendix B – Manure Nitrogen Crediting

Table B1. Nitrogen (N) availability (%) for the crop year of application (year 1) and the year after (year 2) based on livestock type and method of application.

		Broadcast + incorporate >96 hours	Broadcast + incorporate 12-96 hours	Broadcast + incorporate 0-12 hours (including double disks)	Injection with sweeps	Injection with knife or coulter
Livestock type and Year	Application year	N available/year	N available/year	N available/year	N available/year	N available/year
Beef	1	25%	45%	60%	60%	50%
Beef	2	25%	25%	25%	25%	25%
Dairy	1	20%	40%	55%	55%	50%
Dairy	2	25%	25%	25%	25%	25%
Swine	1	35%	55%	75%	80%	70%
Swine	2	15%	15%	15%	15%	15%
Poultry	1	45%	55%	70%	n/a	n/a
Poultry	2	25%	25%	25%	n/a	n/a

Table B2. Standard values (“book values”) of nitrogen (N) concentration of liquid and solid manure⁴. When possible, actual manure analysis results should be used in place of these estimates.

Livestock type	Liquid lb. N/1000 gal.	Solid lb. N/ton
Swine - Farrowing	15	14
Swine - Nursery	25	13
Swine - Gestation	25	9
Swine - Finishing	58	16
Dairy - Cows	31	10
Dairy - Heifers	32	10
Beef - Cows	20	7
Beef - Finishing Cattle	29	11
Chicken - Broilers	63	46
Chicken - Layers	57	34
Turkey – Toms	53	40
Turkey – Hens	60	40

⁴ From Manure Management in Minnesota (WW-03553, U of M Extension 2012), available at https://www.researchgate.net/publication/309202336_Manure_Management_in_Minnesota