SDSU Extension

iGrow Wheat

BEST MANAGEMENT PRACTICES

Chapter 11:
Nitrogen Management for Wheat Production

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In many fields, nitrogen (N) is the most limiting nutrient. The purpose of this chapter is to: 1) discuss the N cycle, 2) discuss how N fertilizer impacts wheat yields, 3) provide N fertilizer guidelines to maximize profitability, and 4) provide calculation examples.

Nitrogen cycle

Nitrogen (N) is present in various forms and passes from the atmosphere to the soil, living organisms, water, and then back into the atmosphere (Fig. 11.1). Industrial and atmospheric fixation processes can convert nitrogen gas (N_2) into inorganic N forms such as ammonium (NH_4+) and nitrate (NO_3-), which can be used by wheat. Some legume crops (e.g., alfalfa, clover, peas, and soybeans) in a symbiotic relationship with Rhizobia bacteria can also fix N2 into organic N, which is mineralized by microorganisms.

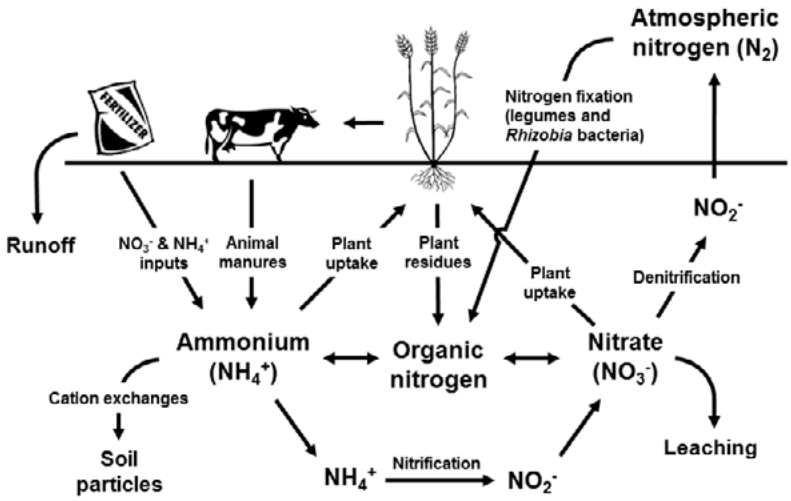

Figure 11.1. A schematic diagram showing nitrogen cycling in agricultural soils.
(Source: Sang Lee, SDSU)

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Soil or fertilizer inorganic N can be lost by leaching and denitrification before being utilized by wheat. For example, in some poorly drained soils, denitrification converts NO_3- to nitrous oxide (N_2O) or N_2, which is then lost to the atmosphere. Nitrous oxide (N_2O) is a concern because it is a greenhouse gas that traps approximately 298 times more heat than CO_2. Leaching of NO_3- to groundwater is most likely to occur in sandy soils and/or following large rainfalls. Volatilization losses of ammonia gas (NH_3) can occur when manure or urea [$CO(NH_2)_2$] is surface applied and not incorporated.

Nitrogen deficiency

Wheat requires N to produce organic molecules like amino acids, proteins, and nucleic acids. Pale green plants are indicative of N deficiencies (Fig. 11.2). Other symptoms include *chlorosis* (yellowing), which commences on lower leaves beginning at the leaf tips and works inward, reduced tillering, stunting, poor kernel fill, and low grain protein.

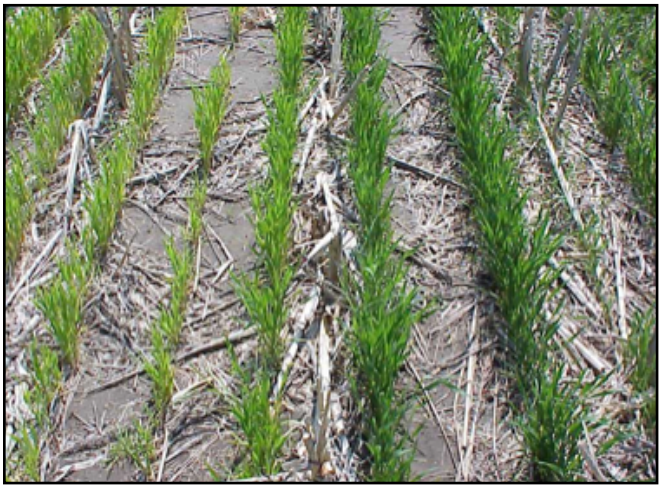

Figure 11.2. Nitrogen deficiency in wheat (N deficient rows on left with N sufficient rows on right). (Photo courtesy Jim Shroyer, KSU)

Nitrogen rates

Nitrogen fertilizer prices have increased in recent years, thus the application of N fertilizer in excess of the plant requirement can decrease producers' potential profit and cause environmental problems. Whereas, applying too little N can reduce yields and wheat quality. Precision N management is necessary, therefore, to increase wheat production efficiency. Nitrogen rate recommendations for South Dakota wheat are based on yield goals, soil testing N levels, and cropping systems. The South Dakota State University (SDSU) current recommendation is 2.5 lbs of N per bushel, which is reduced by accounting for the various credits (Table 11.1). The amount of soil test nitrate-N (NO_3^--N), manure N credit, and legume credits (if grown within the previous 2 years) are subtracted from the total N required for yield goals.

Table 11.1. Nitrogen recommendation for wheat in South Dakota. (Gerwing and Gelderman 2005)

N fertilizer recommendation (lbs N/acre) = (2.5 x RYG) - STN - LC - MNC
RYG = Realistic yield goal (bu/a)
STN = Soil test N value (lb N/a, 2 feet)
LC = Legume credit (lb N/a)
MNC = Manure N credit (lb N/a)

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Soil N credit

The residual N credit is the amount of NO_3^--N contained in the surface 2 feet (24 inches). Since wheat is a short-season crop, N use by wheat is mainly from available soil N forms and depends less on organic N mineralization when compared to longer season crops such as corn or sunflowers. To determine an accurate soil N credit, the location and number of core samples are important. A general guideline for collecting soil samples is that between 15 to 20 cores should be composited from each uniform area that is sampled. To prevent mineralization (conversion of organic N to NH_4+ or NO_3-) and nitrification (conversion of NH_4+ to NO_3-), which will increase the soil test value, the field samples should be air dried or frozen within 12 hours of sampling. Additional information on methods of soil sampling is available in Gelderman et al. (2005).

Legume credits

The legume credit accounts for the amount of N that is mineralized from the previous crop. Legumes add N to the soil through symbiotic N fixation. Legume credits used in South Dakota are listed in Table 11.2. When seeding wheat into alfalfa and legume green manure crops using a no-tillage system, a half credit should be used in the current and following year (e.g., 50 lbs at 3-5 plants/sq ft) (Gerwing and Gelderman 2005).

Table 11.2. Legume nitrogen credits for nitrogen recommendations.

Previous crop	Nitrogen credit (lb/a)
Soybeans, edible beans, peas, lentils and other annual legumes.	40
Alfalfa and legume green manure crop (sweet clover, red clover, etc.)	
Plants/sq ft	
5 and greater	150
3 - 5	100
1 - 2	50
1 or less	0

Manure N credits

The amount of N available from manure depends on numerous factors including animal age, type of animal, storage characteristics, feed ratios, handling practices, and proposed application procedures. Due to these variations, the most accurate manure N credit is based on actual measured values. Additional background on collecting manure samples for nutrient analysis is available in NRCS (2002), Rieck-Hinz and Richard (2003), and Workman and Shapiro (2009).

Manure analysis should include inorganic (ammonia) and organic N (Gerwing and Gelderman 2005). Credit 35% of the organic N in manure with first-year application, and credit 50% of the organic N if manure had been applied for 2 or more years. Credit 98% of the inorganic N if liquid manure is injected below the soil surface. If manure is broadcast on the surface and incorporated within 24 hours, credit 90% of the inorganic N. When manure is not incorporated until 5 days after application, only 20% of the inorganic N should be used as a credit. If the manure is not sampled, N content estimation procedures are available in Gerwing and Gelderman (2005), Clay and Reitsma (2009) and Chapter 10.

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Calculating the N recommendation

Once the yield goal and all credits (soil N credit, manure N credit, and legume credit) are determined, the N fertilizer recommendation can be calculated. An example calculation for N recommendation is shown in Table 11.3.

Table 11.3. Sample N fertilizer calculations.

Wheat yield goal is 60 bu/a,
Soil testing N (NO_3-N in 2 feet depth) is 30 lb N/a,
Previous crop was soybeans,
Manure N credit (MNC) = 0,
N fertilizer source is urea with a fertilizer grade of (46-0-0),

Calculation for fertilizer required is:

$$\text{N recommendation (lbs/acre)} = \frac{2.5 \text{ lbs N}}{\text{bu}} \times \frac{60 \text{ bushels}}{\text{acre}} - \text{STN} - \text{LC} - \text{MNC}$$

$$\text{STN} = \frac{30\text{lbs}}{\text{acre}};\ \text{LC} = \frac{40 \text{ lbs}}{\text{acre}};\ \text{MNC} = \frac{0 \text{ lbs}}{\text{acre}}$$

$$\text{N recommendation} = \frac{150 \text{ lbs N}}{\text{acre}} - \frac{30 \text{ lbs } NO_3^- - N}{\text{acre}} - \frac{40 \text{ lbs}}{\text{acre}} - \frac{0 \text{ lbs}}{\text{acre}} = \frac{80 \text{ lbs N}}{\text{acre}}$$

$$\text{Urea (46\% N) required} = \frac{80 \text{ lbs N}}{\text{acre}} \times \frac{\text{lb urea}}{0.46 \text{ lbs N}} = \frac{174 \text{ lb urea}}{\text{acre}}$$

N materials, timing and placement

An N fertilizer program must consider the N source, timing, rate, and placement (Fig. 11.3, Table 11.4). The two nitrogen materials most commonly used in South Dakota wheat production are dry urea (46-0-0) and liquid urea ammonium nitrate (UAN). The UAN can vary from 28 to 32% N and consists of ½ urea, ¼ ammonium and ¼ nitrate-N. The density of UAN (28-0-0) is approximately 10.6 lbs/gal, thus one gallon of 28% UAN contains approximately 3 lbs of N.

The proper timing of N fertilizer is necessary for wheat production because the plants' demand for N is tied to its growth stage (see Chapter 3 for more details on growth stages). Winter wheat requires relatively low N amounts in the fall, while N uptake increases rapidly when wheat starts growing rapidly (Feekes 4-5) in the spring (Fig. 11.3). To meet this need, two N application options (a single application or a split application of N fertilizer) can be used. The first application can be made at planting, while the second should be applied prior to jointing or stem elongation (Feekes 4-5). It needs to be pointed out that N fertilizer should not be applied over snow.

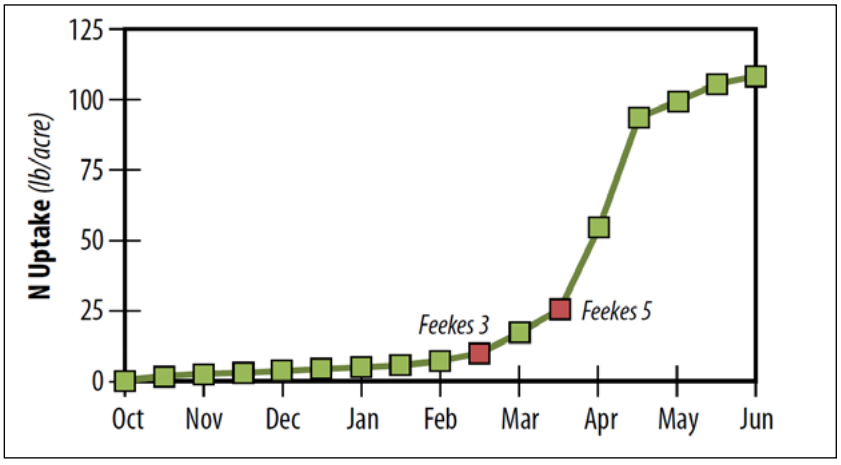

Figure 11.3. Nitrogen uptake by winter wheat over the growing season.
(Courtesy Murdock et al. UKY)

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For spring wheat, a similar approach can be followed, with a portion applied at planting and the remainder applied between V5 and jointing (Feekes 4-5) (Table 11.4). N applied too early can increase lodging and excessive tillering, while N applied too late can result in lower yields (Glover and Hall 2006; Ibrahim et al. 2006; Otteson et al 2007). Late season N applications do not impact yield and may only increase protein. Generally, below ground N bands are more effective than surface applications. Nitrogen placement and timing options are provided in Table 11.5.

Table 11.4. Nitrogen timing influence on spring wheat yield near Brookings, SD.

Nitrogen Timing[1]	N rate	Yield	Yield Increase
	lb/a	------ bu/a ------	
Check	0	47	0
Planting	50	70	23
Tillering	50	70	23
Jointing	50	65	18
Boot	50	59	12
Heading	50	48	1

[1] 28 lb N/a, 2 feet nitrate soil test, broadcast ammonium nitrate.

Table 11.5. Nitrogen management options for winter and spring wheat.

Season	Time of N application	N placement options.
Fall	Post-plant winter wheat	Delay until soil temperature < 50 °F.
		Avoid UAN, if leaching is possibility.
		Subsurface applications are more efficient.
Winter	Post-plant winter wheat	Avoid on sloping, frozen soils.
		Avoid application on snow-covered soils.
Early-mid spring	Winter wheat-post	Subsurface applications or incorporation are more efficient.
	Spring wheat-preplant/plant	Less volatilization losses when surface applied now (<60 °F temps) compared to later in spring.
Late spring	Post-plant	UAN banded is preferred over urea if surface applied.
		Consider urease inhibitor or poly-coated urea if surface applied.

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Summary

In-season N application on grain yields and grain quality are dependent on seasonal and site-specific environmental and wheat growth conditions. The time window for applying in-season N for wheat post-plant is relatively short. If N is delayed until after tillering, the window can be only 1-2 weeks long. Relying on in-season N contains risk because: 1) wet conditions can prevent a timely application of the fertilizer, and 2) once the fertilizer is applied, rainfall is required to transport the N into the soil where it can be used by the plant.

The pre-plant N recommendations for spring wheat are dependent on many factors including soil texture, soil test N, labor and equipment needs, and variety (some varieties are very susceptible to lodging). If excellent growing conditions exist (good stands, tillering and soil moisture) before jointing and if it appears that actual yield could exceed yield goal, an in-season addition of 25 to 50 lbs of N can be considered. The market basis for high-protein wheat will also warrant consideration of in-season N applications. Application of N for winter wheat is usually made in the spring soon after greenup.

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Additional information and references

State	Fertilizer recommendations	Website
Nebraska	Fertilizer recommendations	http://cropwatch.unl.edu/web/wheat/soils
North Dakota	Fertilizer recommendations	http://www.ndsu.edu/fileadmin/soils/pdfs/sf882.pdf
Montana	Micro-nutrients	http://landresources.montana.edu/nm/Modules/Module7.pdf
Montana	N recommendation	http://landresources.montana.edu/nm/Modules/NM%203%20mt44493.pdf
Wyoming	Recommendation	http://uwadmnweb.uwyo.edu/soilfert/Pubs/Blaylock_etal_1996.pdf

Clay, D.E., and K.D. Reitsma. 2009. Soil fertility. In Clay, D.E., K.D. Reitsma, and S.A. Clay (eds). Best Management Practices for Corn Production in South Dakota. EC929. South Dakota State University, SDSU Extension, Brookings, SD.

Gelderman R., J. Gerwing, and K. Reitsma. 2005. Recommended soil sampling methods for South Dakota. FS 935. College of Agriculture and Biological Sciences, South Dakota State University, SDSU Extension, South Dakota Department of Agriculture, Brookings.

Gerwing, J., and R. Gelderman. 2005. Fertilizer recommendations guide. EC750. South Dakota State University, SDSU Extension, United States Department of Agriculture. Brookings, SD.

Glover, K., and R.G. Hall. 2006. Traverse: A new high yielding and fusarium head blight tolerant spring wheat. B749. South Dakota State University, Agricultural Experiment Station, USDA. Available at http://www.sdwheat2.org/files/TraverseB749.pdf

Ibrahim, A., T. Nleya, and J. Rickertsen. 2006. Alice: A high yielding hard white winter wheat. B753. South Dakota State University, Agricultural Experiment Station, USDA. Available at http://www.sdwheat2.org/files/Alice.pdf

Murdock, L., J. Grove, and G. Schwab. 1995. Fertilizer management. In Lee, C., and J. Herbek (eds). A Comprehensive Guide to Wheat Management in Kentucky. University of Kentucky, Cooperative Extension Service, Lexington, KY. Available at http://www.uky.edu/Ag/GrainCrops/ID125Section5.html

NRCS. 2002. Sampling manure for nutrient management. SD-NRCS-FS-36. Available at ftp://ftp-fc.sc.egov.usda.gov/SD/www/News/FactSheets/sampling.pdf

Otteson, B.N., M. Mergoum, and J.K. Ransom. 2007. Seeding rate and nitrogen management effects on spring wheat yield and yield components. Agron. J. 99:1615-1621.

Rieck-Hinz, A., and T.L. Richard. 2003. How to sample manure for nutrient analysis. PM 1558. Iowa State University Extension. Available at http://www.extension.iastate.edu/Publications/PM1558.pdf

Workmann, C.S., and C.A. Shapiro. 2009. Sampling manures for nutrient analysis. G1450. University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources, Lincoln, NE. Available at http://elkhorn.unl.edu/epublic/live/g1450/build/g1450.pdf

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Gelderman, R., and S. Lee. 2012. Nitrogen management for wheat production. In Clay, D.E., C.G. Carlson, and K. Dalsted (eds). iGrow Wheat: Best Management Practices for Wheat Production. South Dakota State University, SDSU Extension, Brookings, SD.

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