Nitrogen

Nitrogen (N) is the essential nutrient that most frequently limits corn yields in Colorado. Likewise, corn requires more added N from fertilizer or other sources than any other nutrient. Approximately 1.2 lbs N is required to produce one bushel of corn. Nitrogen management is also closely tied to irrigation management since N is mobile in the soil as nitrate (NO_3).

Good N management in corn involves making sure the crop has the right amount of available N at the right time. Therefore, timing of application is as important as amount, in certain situations.

Soil testing and crediting other N sources are the base practices for sound N management. Other tools that may increase N efficiency are tissue testing, irrigation water and manure analysis, and pre-sidedress soil nitrate testing (PSNT).

Nitrogen transformation in soil

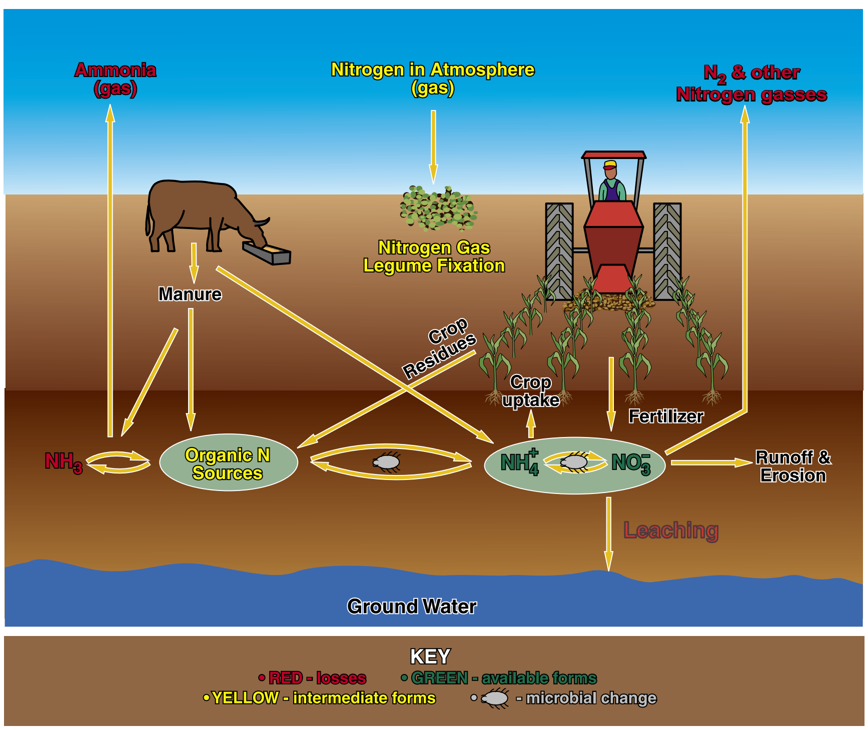

Figure 16. The nitrogen cycle in soil. Nitrogen is not a stable element in the environment and can exist in many forms.

- NO_3 and NH_4 become available from sources other than fertilizer and manure, such as crop residues and soil organic matter, legume fixation and atmospheric deposition.
- Added N fertilizer can become unavailable to corn through leaching, loss to gaseous forms (volatilization and denitrification), or conversion to organic N forms.

Nitrogen deficiency in corn. Appearing first on older leaves, yellowing starts at leaf tip and moves towards the base in a "V" pattern down the midrib.

Nitrogen in corn

- Plant takes up ammonium (NH_4^+) and nitrate (NO_3^-) forms.
- Nitrogen is mobile within plant & will move from older to younger tissues.
- NO_3 is very water soluble and moves easily (leaches) in soil.
- NH_4 is adsorbed to soil particles and does not readily leach.

Good N management programs begin with a representative soil sample.

- Sample to a minimum of 2 feet deep for best results.
- Take 15 to 20 cores from a uniform area (no more than 40 acres).
- Base yield expectation on the average yield history for each field (5 years), plus 5%.

BMP

Identify fields with a high potential for leaching or runoff and employ all appropriate BMPs on these fields to reduce contamination of water supplies.

Determining correct nitrogen application rates

Each bushel of corn harvested contains 0.80 to 0.90 pounds of N and each ton of silage contains approximately 7.7 pounds of N per ton silage (35% DM). However, research as shown that the following equations closely predict corn N requirements in most situations. Since the gross N requirement is based on yield goal, use an accurate yield history when determining N rate.

Use the CSU N requirement calculation below to compare recommendations from soil testing laboratories. If the recommendations vary greatly, ask the lab to explain their procedures for calculating N requirements.

Nitrogen fertilizer requirement =

1. Total N required for yield expectation:

   Grain: Total N needed = (yield expectation, bu x 1.2) + 35
   Silage: Total N needed = (yield expectation (wet weight basis), tons x 7.5) + 35

2. Subtract soil organic matter from total N required:

   Organic matter credit = (grain yield goal x 0.14) x % organic matter
   Organic matter credit = (silage yield goal x 0.85) x % organic matter

3. Subtract residual soil NO_3-N, in the top 2 feet of soil, from total N required:

   Soil NO_3-N credit = 8 x average soil NO_3-N

4. Subtract manure credit (see page 56, Table 8)

5. Subtract irrigation water credit (see Irrigation Nitrate Credit box, page 55)

   = Irrigation water NO_3-N ppm x 0.223 lbs. N/acre inch x inches irrigation water

6. Subtract legume credit (if any, see Table 7)

Example fertilizer N calculation

200 bu yield goal	No manure or legume
1.5% OM	12 ppm NO_3-N in soil
15 ppm NO_3-N irrigation water	

Total N needed = (200 bu x 1.2) + 35	= 275 lb N/A
organic matter credit: (200 bu x 0.14) x 1.5%	= -42
residual soil credit: 8 x 12 ppm NO_3-N	= -96
irrigation water credit: 1 ppm NO_3-N x 0.23 lb x 16” H_2O	= -55
Net N fertilizer required:	= 82 lbs N/A

Table 6. How to calculate average NO_3-N content across soil depths.

Soil layer sampled	Sample thickness	Measured NO_3-N	Calculations
--------inches----------		------------ppm----------	
0 - 8	8	20	8 x 20 = 160
8 - 24	16	8	16 x 8 = 128
			288/24" = 12ppm

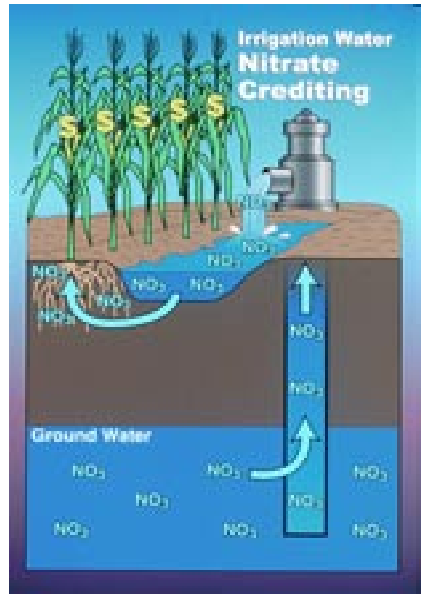

Figure 17. Crediting nitrate is a BMP that protects ground water.

How to calculate irrigation water nitrate credit

1. Determine the nitrate-nitrogen (ppm NO_3-N) content of the irrigation well water by field test kits or laboratory analysis. Initially, sample water twice a year to account for seasonal variability, and then annually.
2. Estimate the amount of water to credit. Most N uptake in corn occurs by milk stage (R3). Therefore, credit water applied before mid-August. Reasonable water credits in Colorado are: Northeast Colorado, 15 inches; Central High Plains, 17 inches; Southern High Plains and Arkansas Valley, 19 inches. Use the following equation to determine credit:

NO_3-N ppm x 0.23* x H_2O inches = N credit (lbs/acre)

* an acre-inch of water contains 0.23 lbs of N for each ppm of NO_3-N

* 1 ppm =1 mg/L

- Groundwater in irrigated areas along the South Platte and Arkansas Rivers frequently contains greater than 10 ppm NO_3-N. That amounts to over 27 lbs/ acre foot of water applied.
- Crediting irrigation water NO_3-N towards a N requirement can help remove nitrate from groundwater and lowers fertilizer costs.

Legume Credit

Table 7. Nitrogen credits for previous legume crop.

Legume Crop	Stand Quality		lb N/A credit*
Alfalfa	60-100%	(4-6 plants per sq. ft.)	100 - 140
	30 - 60%	(3-4 plants per sq. ft.)	70 - 100
	0 - 30%	(0-3 plants per sq. ft.)	0 - 70
Dry beans			25

*Based upon a 3rd year stand or older.

Table 8. Approximate N credits for various solid manure sources in Colorado.

Manure	% H_2O	lb N/ton credit*	
		----dry----	--as is--
Beef	32	13	9
Dairy	46	9	5
Swine	82	22	4

* N credit for 1st crop year following application. For the second and third years use 1/2 and 1/4 of the first year N credits, respectively.

For more information, see CSU Bulletin 568A, BMP's for Manure Management.

BMP

Incorporate manure as soon as possible after application to minimize volatilization losses, reduce odor, and prevent runoff.

Phosphorus fertilizer or manure should not be applied to soils testing 'very high' for soil P.

Limit solid manure application on frozen or saturated ground to fields not subject to runoff. Liquid effluent should not be applied to frozen or saturated ground.

Plant permanent vegetation strips around the perimeter of surface water and erosive fields to catch and filter nutrients and sediments in surface runoff.

Manure

Livestock manure is an excellent nutrient source for corn production. Although manure is typically applied to meet nitrogen requirements, it also contains significant amounts of phosphorus, potassium, zinc and iron. Manure also improves soil tilth, water holding capacity, and infiltration.

While manure offers many benefits for soil health and fertility, it also poses risks. Continuous over-application of manure can result in increased salinity, degradation of surface water from phosphorus runoff, or groundwater contamination by nitrate. Growers should always apply manure based upon crop nutrient need determined by soil testing and reasonable yield goals. Use the Colorado P-index to determine appropriate application rates where soil test P is high or runoff may occur.

Table 9. Approximate manure rates needed for desired N application rate. Use the formula on page 54 to determine the N requirements and match to the desired N application in the left hand column.

Nitrogen content of manure						
Desired N application:	------- lbs of total N per ton manure (fresh weight basis) -------					
	8	13*	18	23**	28	28
(N lbs/acre)	Tons of manure per acre to apply for desired nitrogen application					
60	19	12	8	7	5	5
80	25	15	11	9	7	6
100	31	19	14	11	9	8
120	38	23	17	13	11	9
140	44	27	19	15	13	11
160	50	31	22	17	14	12
180	56	35	25	20	16	14
200	63	38	28	22	18	15

$$\text{Tons to apply} = \frac{\text{Desired N application}}{(\text{total N content} \times 0.4)}$$

*Average N content for Dairy manure in Colorado (wet weight)
** Average N content for beef manure in Colorado (wet weight)
Source: Cattle Manure Application Rates, CSU Extension Fact Sheet 0.561

Manure application