Nitrogen Management for Cereal Crops: General Fertilizer Recommendations

GHG Taking Charge Team Factsheet

Why do we need good nitrogen management?

Sound nitrogen management for cereal crops makes good economic sense. Optimal nitrogen fertilization is essential for achieving grain yield and quality targets and results in maximum economic return. Excess fertilization increases the risk of lodging and reduces net revenue.

Good nitrogen management also makes good environmental sense. Excess fertilizer nitrogen application increases environmental losses of nitrogen, including nitrate leaching to groundwater and emissions of nitrous oxide, a greenhouse gas.

Optimizing nitrogen management for cereals

Our goal in optimizing cereal nitrogen management is to match the nitrogen supply to the crop nitrogen demand. The amount of nitrogen required by the crop is determined by the level of crop growth – the greater the growth, the higher the crop demand for nitrogen. Crop growth is influenced by management practices such as cereal crop grown, variety and planting date, and also by soil and climatic conditions.

The nitrogen supply for a cereal crop comes from fertilizer, but also from manure and mineralization. Mineralization is the release of plant available nitrogen from soil organic matter and crop residues as a result of soil microbial activity. The optimal fertilizer nitrogen rate varies from field-to-field and from year-to-year due to variation in both crop nitrogen demand and soil nitrogen supply.

General nitrogen recommendations for cereals

This factsheet provides general fertilizer nitrogen recommendations for cereal crops. These recommendations require a soil test for organic matter content and a manure or compost analysis. If no manure or compost analysis is available, typical values for different types of manure or compost can be used.

How much fertilizer nitrogen to apply?

The general recommendation for fertilizer nitrogen rate (F_N) in kg N/ha is estimated by:

$$\mathbf{F_N = R - M_{AMM} - M_{ORG} - C - S}$$

where R is the crop N requirement based on the cereal crop grown, M_{AMM} is a credit for ammonium in manure or compost, M_{ORG} is a credit for organic nitrogen in manure or compost, C is a credit for the crop grown in the previous year, and S is a credit based on soil organic matter content.

This factsheet provides a series of six steps to calculate the fertilizer nitrogen recommendation using the General Nitrogen Recommendation Worksheet (page 3). Complete Table 3 to calculate the information you need from your manure or compost analysis before you begin. The worksheet considers manure applied in the spring before planting, and manure applied in the previous fall. Complete steps 2 and 3 for each manure or compost application.

Step 1: Calculate crop N requirement (R)

Choose the base value for calculating crop nitrogen requirement. Typical base values which would give maximum net revenue are given in Table 1. These values assume average values for grain yield, crop nitrogen uptake, crop value and fertilizer costs.

You can also calculate a base value for your own crop using Table 2. This calculation estimates crop nitrogen uptake from the yield and nitrogen concentration of grain and straw. The calculation also credits soil nitrogen supply. An average value for soil nitrogen supply following a non-legume crop is 70 kg N/ha. The calculation assumes that on average the cereal crop takes up 65% of the applied fertilizer nitrogen.

Note that the base value is chosen to maximize net revenue, not maximize grain yield. For example, maximum net revenue for feed barley commonly occurs at 90 to 95% of maximum yield, but which requires a fertilizer nitrogen rate 40% less than is required to obtain maximum yield.

A shorter crop growth period results in a lower crop demand for N. Adjust the base value downward for late planted spring cereal crops.

Step 2: Credit for manure ammonium (M_{AMM})

Manure or compost contains nitrogen in ammonium (NH_4) and organic forms. Compost may contain nitrogen in nitrate (NO_3) form, however no credit is given for this.

Nitrogen in ammonium form is readily available to the

Table 1. Typical base values to maximize net return for cereal crops

Crop	Base value in kg N/ha (lb N/ac)
Spring feed barley	70 (60)
Spring malting barley	50 (45)
Spring feed wheat	80 (70)
Spring milling wheat	135 (120)
Oats	50 (45)
Spring cereal underseeded	50 (45)
Winter feed wheat	90 (80)*
Winter milling wheat	135 (120)*
Winter rye	50 (45)*

*This does not include fertilizer nitrogen applied in fall prior to seeding. Apply 20 kg N/ha at seeding in fall following crops expected to have low residual soil nitrate (for example canola) or no fertilizer nitrogen following crops expected to have moderate or high residual soil nitrate (for example potatoes).

cereal crop. The amount of ammonium in manure varies with animal species, animal diet and manure storage conditions and therefore a manure analysis is recommended. Nitrogen loss through ammonia volatilization can occur very rapidly following field application of manure. Ammonia loss occurs most rapidly when manure is applied and not incorporated in dry, warm conditions. Ammonia losses are reduced if application is followed by rainfall or cool, damp weather. The availability of the ammonium in the manure or compost is estimated from Table 4 based on the method of application and time until incorporation. These are average values which are sensitive to climatic conditions.

Step 3: Credit for manure organic nitrogen (M_{ORG})

Organic nitrogen in manure or compost is not readily available to the cereal crop. Some of the organic nitrogen is converted to plant available forms of nitrogen through mineralization. The amount of organic nitrogen which becomes plant available depends on the animal type and on the amount and type of bedding. The availability of organic nitrogen in manure or compost is estimated from Table 5

Table 3. Manure or compost analysis calculation table.

Enter values from your manure or compost analysis on an "as received" basis:

NH4-N (ppm) = _____ (101)

Nitrogen (%) = _____ (102)

Carbon (%) = _____ (103)

Calculate the following:

Organic N (ppm)

= [(line 102) x 10,000] - (line 101) = _____ (104)

C:N ratio = (line 103) ÷ (line 102) = _____ (105)

Table 2. Calculation to estimate base value based on crop nitrogen uptake.

Enter values to estimate base value instead of general values in Table 1 (***example shown for spring barley assuming soil nitrogen supply of 70 kg N/ha***):

Grain yield (tonnes/ha) = _____ (101) ***_3.5_ (101)***

Grain N conc. (%) = _____ (102) ***_1.6_ (102)***

Straw yield (tonnes/ha) = _____ (103) ***_6.0_ (103)***

Straw N conc. (%) = _____ (104) ***_1.0_ (104)***

Calculate the following:

Crop N uptake = 10 x [(line 101) x (line 102) + (line 103) x (line 104)] = _____ (105) ***_116_ (105)***

Base value = [(line 105) - (soil N supply)] / 0.65

= _____ (106) ***_71_ (106)***

based on the time of application and the carbon to nitrogen (C:N) ratio of the manure or compost.

Step 4: Credit for previous crop (C)

The previous crop grown can affect the availability of nitrogen for the cereal crop. Legume crops have the ability to fix nitrogen from the atmosphere in their root systems. Plant available nitrogen is released to the cereal crop through the decomposition of crop residues. The credit varies with the proportion of legume, legume species and age of stand in the previous cropping year. No credit is given for non-legume crops including potatoes, corn or cereal crops. Incorporation of annual ryegrass may reduce plant available soil nitrogen supply to the cereal crop.

Step 5: Credit for soil organic matter content (S)

The contribution of nitrogen from soil organic matter can be substantial. It will depend on soil and climatic conditions, past manure or compost applications, and previous crop rotations. Currently the amount of soil nitrogen mineralization which will occur during the growing season cannot be predicted accurately. Soils with high organic matter content generally have higher soil nitrogen mineralization than soils with low soil organic matter content.

Step 6: Calculate general fertilizer nitrogen recommendation (F_N)

The fertilizer nitrogen recommendation is in units of kg N/ha. This is the total amount of fertilizer nitrogen required by the cereal crop, but does not include fertilizer nitrogen applied in the fall at seeding for winter cereal crops.

When to apply the fertilizer nitrogen?

In general, fertilizer nitrogen applied before seeding primarily increases grain yield, and fertilizer nitrogen applied after tillering increases grain protein. Delayed fertilizer application may reduce yield potential in some years.

Cereal General Nitrogen Recommendation Worksheet

Step 1: Crop N requirement (R)

Enter base value (in kg N/ha) from **Table 1** or from **line 106 in Table 2**

R in kg N/ha = ... _____ **(1)**

Step 2: Credit manure or compost ammonium nitrogen (M_{AMM}) in kg N/ha

Enter manure or compost application rate:

in gallons/acre	_____ (a)	and (b) = 89,000
OR in m^3/ha	_____ (a)	and (b) = 1,000
OR in tons/acre	_____ (a)	and (b) = 445
OR in tonnes/ha	_____ (a)	and (b) = 1,000

Enter manure ammonium concentration in ppm (line 101 from **Table 3**) _____ (c)

Enter manure ammonium availability coefficient (from **Table 4**) _____ (d)

M_{AMM} in kg N/ha = _____ (a) x _____ (c) x _____ (d) ÷ _____ (b) = ... _____ **(2)**

Step 3: Credit manure or compost organic nitrogen (M_{ORG}) in kg N/ha

Enter (a) and (b) from Step 2: _____ (a) _____ (b)

Enter manure organic N concentration in ppm (line 104 from **Table 3**)_____ (c)

Enter manure organic N availability coefficient (from **Table 5**) _____ (d)

M_{ORG} in kg N/ha = _____ (a) x _____ (c) x _____ (d) ÷ _____ (b) = ... _____ **(3)**

Step 4: Credit crop grown in the previous year (C)

	Alfalfa	Red clover (2nd yr)	Red Clover (seeding yr)	Soybean	Annual ryegrass
Less than 1/3 stand:	0	0	0	0	0
Between 1/3 and 2/3 stand:	40	20	10	0	0
More than 2/3 Stand:	80	40	20	10	-15

C in kg N/ha = (enter appropriate value from above) = ... _____ **(4)**

Step 5: Credit soil organic matter content (S)

Soil organic matter greater than or equal to 3.5%	15
Soil organic matter between 2.5% and 3.5%	0
Soil organic matter less than 2.5%	-15

S in kg N/ha = (enter appropriate value from above) = ... _____ **(5)**

Step 6: Calculate general fertilizer nitrogen recommendation (F_N) in kg N/ha

(Multiply F_N by 0.89 to get fertilizer nitrogen recommendation in units of lb N/ac)

F_N in kg N/ha = **(1) - (2) - (3) - (4) - (5) =** ..... _____ **(6)**

Table 4. Manure or compost ammonium nitrogen availability coefficients

	Liquid /semi-solid manure		Solid manure or compost	
Application	Spring / Summer	Fall	Spring / Summer	Fall
Injected	1.00	0.80	1.00	0.90
Incorporated 1 day	0.75	0.60	0.85	0.77
Incorporated 2 days	0.70	0.56	0.75	0.68
Incorporated 3 days	0.65	0.52	0.65	0.59
Incorporated 4 days	0.60	0.48	0.60	0.54
Incorporated 5 days	0.55	0.44	0.55	0.50
Not incorporated- bare soils	0.34	0.27	0.50	0.45
Not incorporated- pretilled soils	0.70	0.56	0.70	0.63
Not incorporated- crop residues	0.50	0.40	0.70	0.63
Not incorporated- standing crops	0.70	0.56	0.60	0.54
Not incorporated- late fall	---	0.60	---	0.68

For cereal crops grown for feed, apply all nitrogen fertilizer at seeding for spring cereals or in early spring for winter cereals.

For milling wheat, apply 75% of fertilizer nitrogen at seeding for spring wheat or in early spring for winter wheat, and apply the remaining 25% of the fertilizer nitrogen requirement after tillering (Zadok's growth stage 30) and before the flag leaf is fully emerged (Zadok's growth stage 37).

For winter cereals, apply an additional 20 kg N/ha prior to seeding in fall when seeding after crops expected to have low residual soil nitrate (for example canola). No additional fertilizer nitrogen is required when seeding a winter cereal crop following a crop expected to have moderate or high residual soil nitrate concentration, for example after a potato crop.

Good agronomy for cereal crops

Good agronomy is an important part of good nitrogen management. It is recommended that you do regular soil testing for phosphorus and potassium. For cereal crops, soil pH is optimal between 6.0 and 6.5. Practices which maintain and increase soil organic matter content are critical for maintaining optimal soil physical properties. Poor soil physical properties, for example low soil water holding capacity, can reduce crop yield potential.

Contacts:

For further information on these general fertilizer nitrogen recommendations, or on the PSNT or the SNT, contact the Soil and Feed Testing Laboratory, P.E.I. Dept. of Agriculture, Fisheries and Aquaculture (902) 368-5628 or Nutrient Management Specialists at (902) 894-0392 or (902) 368-6366 with the Prince Edward Island Department of Agriculture, Fisheries, and Aquaculture.

Table 5. Manure or compost organic nitrogen availability coefficients

Manure Type	Spring applied	Fall applied
Poultry manure:	0.30	0.30
Compost or other livestock manure:		
C:N < 15	0.20	0.30
C:N 15 to 25 (high in bedding)	0.10	0.10
C:N > 25 (very high in bedding)	-0.20	0.10

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