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.

In some cases, a Soil Mineral Nitrogen (SMN) test can be used to improve the general fertilizer nitrogen recommendation for cereal crops.

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 1 of the insert). 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 under New Brunswick conditions 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.

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

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).

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 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.

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)***

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 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.

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

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. In some fields, you may be able to improve this fertilizer nitrogen recommendation through use of the SMN test.

How does the Soil Mineral Nitrogen test work?

The Soil Mineral Nitrogen (SMN) test takes some of the guesswork out of making fertilizer nitrogen recommendations by providing a credit for the actual amount of plant-available nitrogen already present in the soil early in the growing season. Fertilizer nitrogen recommendations can be reduced when the credit for plant available nitrogen based on the SMN test is greater than the nitrogen credit estimated for the preceding crop plus manure using the general fertilizer nitrogen worksheet.

The SMN fertilizer recommendation (F_{SMN}) is estimated by:

$$\mathbf{F_{SMN} = R - SMN_{AMM} - SMN_{NIT} - S}$$

where R is the crop N requirement based on the cereal crop grown, SMN_{AMM} is a credit for soil ammonium, SMN_{NIT} is a credit for soil nitrate and S is a credit based on soil organic matter content.

When should I use the SMN test?

The SMN test provides a credit for carry-over of plant-available nitrogen from the previous growing season. Therefore, this test will be most effective when used under conditions where carry-over is likely to occur.

Carry-over is most likely to occur when the crop grown in the previous year was expected to result in moderate or high residual soil nitrate (for example corn, potatoes) and may also occur when the crop grown in the previous year was a legume crop (for example red clover). Carry-over is also more likely to occur when manure is used in the crop rotation and when fall and/or spring rainfall is below average.

Carry-over is likely to be limited where the crop grown the previous year was expected to result in low residual soil nitrate (for example a cereal crop or canola), or when fall and/or spring rainfall was above average. Under these conditions, carry-over would be expected to be minimal, and use of the SMN test is not recommended.

How should I use the SMN test?

- First confirm that your field is suitable for performing a SMN test as described above.
- Sample to 30 cm (1 ft) depth in early spring, before any fertilizer application. The sample can be taken as soon as it is possible to walk on the field.
- Take more than 10 soil cores per 5 ha field in order to get a representative soil sample.

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

- Keep the sample cool until it reaches the lab - a picnic cooler is a handy way to do this. The sample can also be frozen. If stored warm, nitrate concentration in the sample will increase and give a fertilizer nitrogen recommendation which is lower than required.
- Have the sample analysed for nitrate-N concentration and ammonium-N concentration in ppm.

How do I calculate my fertilizer nitrogen recommendation from the SMN test?

The fertilizer nitrogen recommendation is calculated using the SMN worksheet on page 2 of the insert using the following steps.

Step 7: Use the crop N requirement (R) from step 1.

Step 8: Credit for ammonium in SMN test

This credit is for soil ammonium present in the soil prior to the growing season. No credit is provided if soil ammonium concentration is 9 ppm or less. Credit is given for 65% of the soil ammonium present in the soil above 9 ppm.

Step 9: Credit for nitrate in SMN test

This credit is for soil nitrate present in the soil prior to the growing season. No credit is provided for soil nitrate concentrations of 4 ppm or less. Credit is given for all of the nitrate present in the soil above 4 ppm.

Step 10: Use the credit for soil organic matter (S) from Step 5.

Step 11: Calculate the SMN fertilizer nitrogen recommendation.

The fertilizer nitrogen recommendation is in kg N/ha.

Step 12: Compare the general fertilizer nitrogen recommendation to the SMN nitrogen recommendation.

Compare the general fertilizer nitrogen recommendation against the SMN test fertilizer nitrogen recommendation. **Choose the recommendation which is lower.**

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.

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 use of the SMN test, contact your local Crop Development Officer (1-888-NBAGRIC or 1-888-622-4742) or Nutrient Management Specialist (1-506-453-2109) with the New Brunswick Department of Agriculture and Aquaculture, or contact another agronomist, crop consultant or agri-environmental club coordinator.

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