Nova Scotia Agricultural College

Soil & Crop Improvement Association of Nova Scotia

fact sheet

Nitrogen, Phosphorous, and Potassium for Pastures

Pasture grasses and legumes, like all plants, need a good supply of nutrients to support healthy growth. Most of the nutrients required by plants are naturally supplied through the soil. However, nitrogen, phosphorous, and potassium are required by plants in such large amounts, that most of our soils are often deficient in one or all of these major elements. It is often necessary to supplement the soil with these nutrients through an application of manure or fertilizer.

NITROGEN

Why is nitrogen important?

- It is an essential component of proteins such as chlorophyll, which are necessary for plant growth
- It aids in the uptake of other nutrients
- It is involved in root growth and development
- It aids in the use of carbohydrates by the plant

Of all plant nutrients, nitrogen is required in the highest amounts. It is also the nutrient that is most often deficient because of the dynamic nature of its cycle in the soil and many pathways of loss.

Most of the nitrogen (N) in the soil is held in organic matter as organic nitrogen, a form that plants cannot use. Soil micro-organisms convert organic nitrogen into ammonium (NH_4^+) and nitrate (NO_3^-). Both NO_3^- and NH_4^+ are inorganic forms of nitrogen that can be used by plants, although NO_3^- is predominantly used.

Plants can also use nitrogen from the atmosphere through industrial fixation (chemical fertilizer production) and biological fixation. In biological fixation, nitrogen from the atmosphere is added to the soil by bacteria living in association with the roots of legumes. Legumes (e.g., clovers) are useful plants to have in a pasture because the nitrogen that is fixed is available to the legumes as well as nearby grasses.

We also need to be concerned about the pathways of nitrogen loss. Nitrogen can be lost from the soil in many ways. Nitrate is very soluble and may be lost to the groundwater through leaching. In wet conditions, nitrogen can be lost to the atmosphere when micro-organisms convert NO_3^- to N_2 gas. Other losses occur due to surface runoff and erosion, immobilization when soil micro-organisms convert NO_3^- and NH_4^+ back into an organic form, or the formation of ammonia gas. Crop uptake and harvest also remove nitrogen from the soil.

PHOSPHOROUS

Why is phosphorous important?

- It is an essential component of the compounds that store energy in plant cells and is critical for plant processes such as photosynthesis
- It is important for enhancing root growth and development
- It plays an important role in flowering, fruiting, seed formation, and crop maturation
- It is a structural part of all cell membranes and many other cellular components

Most of the phosphorous (P) in the soil is organic phosphorous held in organic matter or insoluble mineral phosphorous, but neither of these forms can be used by plants. In fact, plants can use less than 5% of the total phosphorous in the soil. Only soluble inorganic forms of phosphorous from the soil solution, $H_2PO_4^-$ and HPO_4^{2-}, can be taken up by plants.

Soluble inorganic phosphorous becomes available when soil micro-organisms convert organic phosphorous to $H_2PO_4^-$ and HPO_4^{2-}, or when phosphorous is dissolved from the surfaces of clays and minerals.

Phosphorous is not as readily lost from the soil as nitrogen, but there are many ways it may become unavailable for plant uptake. At pH levels below 6.0, iron (Fe^{2+}) and aluminium (Al^{3+}) ions can form compounds with soluble inorganic phosphorous. At pH levels above 7.0, compounds with calcium (Ca^{2+}) ions may be formed. These compounds make phosphorous unavailable. Immobilization when soil micro-organisms convert soluble phosphorous back into an organic form may also make soluble phosphorous unavailable. Soil

phosphorous is most available to plants between pH 6.0 and 7.0.

POTASSIUM

Why is potassium important?

- It is involved in the activation of enzymes that are responsible for many physiological plant processes
- It plays a role in nutrient and sugar transport in the plant
- It is essential for water regulation in the plant
- It is essential for increased winter hardiness of legumes

Plants take up potassium (K) in relatively large quantities. However, up to 98% of the potassium in the soil is tied up in minerals and cannot readily be used by plants. The remaining potassium occurs as soluble potassium in solution or is held on the surfaces of clays and minerals. Plants can only use soluble potassium in solution, K^+. As plants take up K^+, potassium from the surfaces of clays and minerals is released into solution and becomes available for plant uptake.

Potassium is also not readily lost from the soil. Soluble potassium may be removed from the soil and held in mineral complexes in a form that is not available for plant uptake. This potassium may slowly become available to plants over time.

NUTRIENT RECOMMENDATIONS: HOW THEY ARE GENERATED FOR YOUR FARM

Sampling your soil provides important information about phosphorous and potassium content. When you send a soil sample from your pasture to the lab for soil testing, you will get a soil test report that provides information about the available phosphorous and potassium levels in the soil. Phosphorous is reported as P_2O_5 and potassium is reported as K_2O on a soil test. A rating will also accompany the nutrient levels to indicate whether levels are low (L-, L, L+), medium (M-, M, M+), high (H-, H, H+), or excessive (E).

What do the soil test ratings mean? Ratings describe nutrient levels in the soil as well as whether adding nutrients will result in a profitable yield response

Low	Profitable yield response in almost all cases
Medium	Profitable yield response in most cases
High	Profitable yield response is rare
Excessive	Not profitable and there may be an environmental risk or reduced crop yield.

Table 1 indicates the ranges in P_2O_5 and K_2O for each soil test rating. These ratings are specific to pasture soils, as they are based on the nutrient requirements of a pasture. The ratings for another crop will be different.

Table 1 Soil test nutrient levels for each rating for pastures

Rating	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
L-	X	0 – 102	0 – 62
L	X	103 – 122	63 – 92
L+	X	123 – 141	93 – 121
M-	X	142 – 165	122 – 156
M	X	166 – 188	157 – 196
M+	X	189 – 215	197 – 236
H-	X	216 – 266	237 – 307
H	X	267 – 329	308 – 411

Note that there is no rating for N. Soil tests in Nova Scotia do not report soil N because N availability varies considerably during the growing season with changing soil conditions. Researchers are studying whether mineralization potential of soils will be a useful indicator for predicting how much N may be available from organic matter during the pasture season. Currently N recommendations are made on the expected plant demand for N.

H+	X	330 – 411	412 – 514
E	X	412 - 617	515 - 668

Example: A soil test reports the nutrient levels in a pasture soil are 115 kg/ha P_2O_5 and 163 kg/ha K_2O. From Table 1, this means the level of phosphorous is **L** and the level of potassium is **M**. In this case adding nutrients would most likely be profitable.

Your soil test, if the crop to be grown has been indicated (e.g., grass pasture, mixed pasture, or native pasture), will also provide the required nutrient applications for nitrogen, phosphorous, and potassium. The required nutrient applications are based on the rating for each nutrient given on the soil test report and the nutrient requirements of the crop. In the case of nitrogen, the required application is based on general nutrient requirements for pasture grasses and legumes (the expected plant demand for N).

What kind of pasture do you have? Recommended nutrient applications depend on soil test ratings as well as the type of pasture.	
Grass pasture	More than 80% grass content
Mixed pasture	20-30% legume content
Native pasture	No controlled grazing management or added fertility

Table 2 Nutrient application requirements for grass pasture, mixed pasture, and native pasture

Rating	Grass Pasture			Mixed Pasture			Native Pasture		
	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
L-	160	120	185	60	120	185	100	75	75
L	160	110	180	60	110	180	100	60	60
L+	160	95	155	60	95	155	100	50	50
M-	160	85	140	60	85	140	100	40	40
M	160	75	125	60	75	125	100	30	30
M+	160	65	115	60	65	115	100	25	25
H-	160	55	95	60	55	95	100	20	20
H	160	40	40	60	40	40	100	20	20
H+	160	0	0	60	0	0	100	0	0
E	160	0	0	60	0	0	100	0	0

Table 2 indicates the required nutrient applications based on the soil test ratings for grass pasture, mixed pasture, and native pasture. Note that the nitrogen application recommendations are the same regardless of the rating for phosphorous and potassium. This is because there is no soil test for nitrogen. Application recommendations are based on general pasture plant requirements for nitrogen.

Example: A soil test reports the nutrient levels in a pasture soil are 115 kg/ha P_2O_5, which is rated L, and 163 kg/ha K_2O, which is rated M. Looking at Table 2 for a **grass** pasture, this means the nutrient application requirements are 110 kg/ha phosphorous (P_2O_5) and 125 kg/ha potassium (K_2O).

Fertilizer recommendations in Nova Scotia are based on soil test calibration data from studies conducted in Nova Scotia over the past 50 years as well as information gained from studies conducted in other locations such as Ontario. The information from other regions has been modified to better reflect Nova Scotia conditions.

The current approach to fertilizer recommendations, in general, is to fertilize based on crop need. As such, fertilizer applications are meant to replace the nutrients taken up from the soil by the plant. Another more traditional approach to fertilizer recommendations was to attempt to build up nutrient levels in the soil beyond simply those required to replace the nutrients that are taken up by the plant.

There is a need to update our understanding of the nutrient status of Nova Scotia soils and how current plant varieties and production practices respond to nutrient additions, and to use this information to reassess the basis for our fertility recommendations.

Soil Testing

The soil testing laboratory analyses soil samples for nutrient content and then uses the information in Tables 1 and 2 to determine the nutrient applications that are required. Information about the nutrient levels and required nutrient applications are provided in a soil test report. Soil testing is important for developing an effective soil fertility plan for your pastures. **Nutrient applications of any form should be based on a soil test**. If you are going to apply manure to your pasture, it is recommended to have the manure tested to determine the nutrient content. This will help determine how the manure can be utilized most effectively.

If you have not soil tested your pastures, the following general recommendations may be used to determine approximate nutrient requirements. It is strongly recommended that you soil test your pastures to determine more accurate nutrient requirements.

Table 3 General nutrient recommendations

Timing of Application	Nutrient Requirements (kg/ha)		
	N	P_2O_5	K_2O
> 85% Grass			

• Early spring	50	0	0
• Mid-June	50	15	45
• Early September	50	15	45
70-85% Grass			
• Early spring	47	47	47
• Mid-June	42	12	36
> 30% Legumes			
• Early spring	20	20	40

GENERAL RECOMMENDATIONS

- Having a recent soil test is important. Soil test every three years to monitor the fertility of the soil. Consult a forage specialist to discuss your pasture fertility needs.
- Base all nutrient applications on soil test information.
- To reduce nutrient loss, apply recommended rates of nutrients.
- Employ best management practices for manure application to reduce nitrogen losses.
- Calibrate fertilizer and manure spreading equipment to make applications more accurate.
- Time nutrient applications with plant demand to encourage plant uptake rather than nutrient loss.
- Maintaining an actively growing pasture sod will help reduce nutrient losses to the environment.
- Split applications of nitrogen will reduce the occurrence of excess nitrogen in the soil which may be lost to the environment.
- Grasses require more nitrogen than legumes. As the legume content of a pasture increases, the need for applied nitrogen decreases.
- If the legume content of the pasture is 30% or more, additional nitrogen is not needed. Applied nitrogen will suppress nitrogen fixation.
- Legumes require more soil phosphorous and potassium than grasses. Adequate potassium and phosphorous is important to maintain legume content.
- Under good rotational grazing management, enough potassium is supplied by the grazing livestock. Soil tests will show this. If fertilizer is used, consider a blend with high nitrogen and phosphorous but low potassium.
- Manage soil pH to promote phosphorous availability. It is most available to plants between pH 6.0 and 7.0.
- Fertilizer use efficiency (FUE) is pH dependent. At pH 6.0, FUE is 80%. At pH 5.0, it is less than 50%.

ADDITIONAL RESOURCES

AgraPoint Extension Central
www.extensioncentral.com

Atlantic Forage Guide
www.extensioncentral.com/index.php?option=com_docman&task=cat_view&gid=214&Itemid=32

Nutrient Cycling in Pastures: Livestock Systems Guide
attra.ncat.org/attra-pub/PDF/nutrientcycling.pdf

Nutrient Management Planning Study Guide
nsac.ca/cde/courses/Agriprof/nmp-guide.asp

Pasture Production
www.omafra.gov.on.ca/english/crops/pub19/pub19toc.htm

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