**Nutrients**

Plants, like animals, have specific nutrient requirements for growth. Without these nutrients, plant productivity can be significantly reduced. Proper fertilization can improve soil fertility, thereby increasing forage quality and productivity.

Of the nutrients required by plants, some are required in greater amounts than others. Macronutrients are those required in the greatest amounts, and include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). Micronutrients, or those required in smaller amounts, include boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Z). Most soils already contain adequate levels of Ca, Mg, S and micronutrients. Therefore, fertilization for pasture and hay productivity focuses on N, P, and K, as well as pH, a measure of soil acidity which affects nutrient availability.

**Table 1: Nutrients, their role, and some common deficiency symptoms.**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Purpose/Role</th>
<th>Some Deficiency Symptoms</th>
<th>Other Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>Plant growth; synthesis of protein, nucleic acid, coenzymes, chlorophyll</td>
<td>Slow growth; small, light green or yellow leaves; discoloration starts at grass leaf tip &amp; progresses downward</td>
<td>Very mobile in soil; N leaching from excessive application can result in environmental damage; recommended to apply moderate levels annually in MN</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Promotes seedling growth; stimulates root development</td>
<td>Stunted growth; leaves darker than normal; presence of purple coloration along leaf margins</td>
<td>P binds to soil particles, making it less mobile in soil than N; fertilizer application should be based on soil testing; P can be high in areas with manure application.</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Plant growth, development, and persistence</td>
<td>Yellowing of leaves beginning at margins; lower leaves brown at tips</td>
<td>Fertilizer application should be based on soil testing; important nutrient for legume persistence.</td>
</tr>
</tbody>
</table>

**pH**

pH is a measure of soil acidity, and can affect the availability of nutrients in the soil. A pH of 7 is considered neutral; soil with a lower pH is acidic and those with a higher pH are basic. For most forages, nutrient availability is greatest when the soil pH is between 6.0 and 7.0. This range also provides an ideal environment for the soil bacteria responsible for organic matter decomposition. Legumes do best in soils with a pH of 6.0 to 6.5, while grasses can tolerate more acidic conditions (5.5 to 6.0).

Low soil pH is raised through the application of lime, based on soil test recommendations. For maximum effectiveness, lime should be incorporated into the root zone of the soil prior to pasture establishment. If lime cannot be incorporated into the soil, it can be top-dressed in the fall. Lime raises soil pH for several years, so annual lime application is typically not necessary.
SOIL TESTING
It is recommended to have your soil tested before planting a new pasture and every 2-3 years thereafter to identify nutrient deficiencies. Several commercial laboratories offer soil analysis, including the University of Minnesota (612-625-3101 or http://soiltest.cfans.umn.edu).

Recommendations for P and K are based on soil nutrient levels and crop yield potential. Basic soil tests do not reliably measure soil N because of its rapid mobility in the soil. Therefore, N recommendations are based on crop history as well as the expected yield of the current crop. Refer to Fertilizer Guidelines for Agronomic Crops in Minnesota BU-06240-S for more detailed information regarding fertilization rates.

FERTILIZER SOURCES
Inorganic fertilizers can be synthetic (manufactured), or mined and processed, to provide specific nutrients for plant growth. In contrast, organic fertilizers, such as manure or compost, must first be broken down by soil microorganisms before the nutrients become available for plant use.

Table 2: Characteristics of Inorganic and Organic Fertilizer

<table>
<thead>
<tr>
<th></th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic</td>
<td>Nutrients available immediately; known nutrient composition; nutrients more concentrated than in organic fertilizers</td>
<td>Nutrients subject to leaching; heavy applications can burn young plants or lead to an accumulation of nutrients in soil</td>
</tr>
<tr>
<td>Organic</td>
<td>Improves soil structure; slow release of nutrients as organic material degrades</td>
<td>Nutrients not immediately available; nutrient concentration unknown unless analyzed; nutrients can leach if manure is applied to soil surface</td>
</tr>
</tbody>
</table>

INORGANIC FERTILIZER
Several forms of synthetic fertilizers are commercially available. By law, the nutrient content of these products must be listed on the packaging. This information is often listed in the form of a three number code.

For example, a product labeled as 10-20-5 would contain 10% N, 20% P₂O₅ and 5% K₂O. Spreading 50 lbs of this material per acre would result in an application of 5 lbs N (50 lbs x 0.10 = 5 lb), 10 lbs P₂O₅, and 2.5 lbs K₂O per acre. Many commercial synthetic fertilizers contain only one or two nutrients (i.e. 0-46-0 or 18-47-0), so fertilizer selection should be based on specific nutrient deficiencies.

P and K are typically listed in their oxide form (P₂O₅ and K₂O); historically, this was how P and K levels were determined and reported. Accordingly, most soil test results report fertilization recommendations in terms of P₂O₅ and K₂O. If not, values of P₂O₅ and K₂O can easily be converted to P and K using the following equations:

\[
\% \text{ P}_2\text{O}_5 \times (0.44) = \% \text{ P} \\
\% \text{ K}_2\text{O} \times (0.83) = \% \text{ K}
\]

ORGANIC FERTILIZER
Manure can serve as an economical source of nutrients for pastures and hay fields. For example, N requirements in pastures may be as much as one-third less than the requirements in hay fields due to the recycling of nutrients through manure deposition during grazing.
The nutrient content of manure varies greatly and is dependent upon:
- Type and amount of bedding included with manure
- Manure storage conditions
- Age of manure
- Diet of animal

To determine the amount of manure to apply to a pasture of hay field, it is best to measure the nutrient content of the manure prior to application. Several laboratories routinely conduct manure analysis. Contact your local Extension office or the Minnesota Department of Agriculture for a listing of certified manure testing laboratories.

*Table 3: A 1,000 lb horse produces an average of 9.1 tons of manure each year. The average nutrient content of fresh manure is shown below*.  

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Average amount of nutrient in manure (1 horse per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>102 lbs</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>40 lbs</td>
</tr>
<tr>
<td>K₂O</td>
<td>84 lbs</td>
</tr>
</tbody>
</table>


Due to increased parasite loads, manure application on pastures (other than what the animal(s) deposits while grazing) is not recommended if stocking rate is less than 2 acres per horse. Grazed pastures should be dragged or harrowed regularly to break up and distribute the manure across the pasture. Manure collected from stalls or drylots can be applied to non-grazed areas, or composted and applied to grazed pastures. Also, applying manure with large amounts of straw or bedding to hay fields can lead to the material being raked up into future hay cuttings. Therefore, it is best to limit the amount of bedding material spread on hay fields.

Availability of nutrients in manure can affect rate of application. Most P and K in manure are present in the inorganic form; therefore, the availability of these two nutrients is similar to that in inorganic fertilizers. However, in manure, N is present in both organic and inorganic forms. While the inorganic N forms are immediately available to the plant, the organic forms must first be converted to inorganic forms. The rate of this conversion is variable and depends on environmental conditions.

While manure can provide an important supply of nutrients to pastures and hay fields, it may be necessary to supplement with a commercial fertilizer to fully meet the nutrient requirements of the forages.

**Application of Fertilizer**

Granular fertilizer is typically spread using a broadcast spreader. Several models are available. For smaller farms, walk-behind spreaders or those pulled by a garden tractor or attached to an ATV are ideal. Larger operations may opt to use PTO driven broadcast spreader attachments or wagon-type spreaders (Figure 1a). Liquid fertilizers are also available; these products are applied using a liquid sprayer.

![Figure 1: Fertilizer application using a wagon-type broadcast spreader (a); fertilizer visible on pasture surface (b).](image)

Follow label instructions regarding application rates. Fertilizer should not be spread in areas with standing water. It’s best to apply fertilizer just prior to a light rain; if rainfall is too heavy, it may wash away the fertilizer.

Following application, it will be necessary to restrict access (of the horses) to the fertilized pasture to prevent horses from inadvertently consuming the fertilizer (Figure 1b). Restrict horse...
access until at least ½ inch of rainfall, or for 2-3 weeks (in the absence of rainfall), until the fertilizer is no longer visible on the soil surface or plant leaf surfaces.

Fertilization will also stimulate weed growth. Mow regularly (in grass or grass-legume fields) or use a broadleaf herbicide (in grass-only fields) to control weeds.

**Timing of Fertilization**

Prior to stand establishment, soil should be tested; fertilizer and lime should be applied according to soil test results. After establishment, annual applications of N (at a rate of 90 lbs N/acre) are recommended to maintain grass stands in Minnesota. P and K typically only need to be applied every 2-3 years (based on soil analysis).

The timing of fertilizer application should match the growth pattern of the forage, making nutrients available to the plants when they’re most needed. Cool season grasses and legumes are most actively growing in late spring and early summer, so N, P, and K should be applied in early spring.

For pastures and hay fields containing grasses, split-applications of N are particularly useful in increasing productivity throughout the growing season (P and K do not need to be split applied because of their limited mobility in the soil). Nitrogen application in early spring helps boost summer production, while application in late summer (August) can help stimulate root development of cool-season grasses, resulting in a denser stand and extended fall grazing. For split application, it is recommended to divide the total amount of N needed into two applications, applying ¾ of the N in early spring and the remaining ¼ in late August.

**Pastures versus Hay Fields**

While the actual nutrient requirements of a grass (or grass-legume) grown for hay or for pasture do not differ, it may be necessary to apply greater amounts of fertilizer to hay fields. When animals graze a pasture, many of the nutrients are recycled back into the soil in the form of animal manure. However, when the forage is harvested as hay, the nutrients are completely removed from the field, increasing the likelihood of nutrient deficiencies in subsequent growth.

For a more detailed discussion of alfalfa fertilization, see the Extension Fact Sheet *Fertilizing Alfalfa in Minnesota* AG-FO-03814-C.

**Conclusions**

Proper soil fertility is one of the key factors in maximizing forage production in both pastures and hay fields. Soil testing every 2-3 years is necessary to identify nutrient deficiencies. While important to supply the plant with the nutrients necessary for growth, the application of excess nutrients is not only expensive, but can also lead to environmental pollution.

**Literature Cited:**


**Reviewers:** Dan Martens and Nathan Winter, University of Minnesota Extension.

**Photo Credits:** K. Martinson, PhD, Univ. of Minn.