Growing and Harvesting High Quality Grasses for Dairy Cattle

Keith D. Johnson
Department of Agronomy
Purdue University

Abstract

Understanding growth and development of adapted forages that are part of the dairy cattle diet is important. Management, including fertilization, species and variety choice, weekly scouting and proper harvest timing, is critical if full benefit is to be realized. This article focuses on major differences among adapted species, with an emphasis on cool-season grasses and the agronomic principles necessary for most success to occur.

Soil Considerations

Soil types on the farm

Before getting too concerned about different grass species, it is imperative to learn more about characteristics of the soil where forages are to be grown. Drainage, topography, water holding capacity, organic matter (OM) content, and the presence or absence of a restrictive layer (fragipan) differ among soil types. The Natural Resources Conservation Service has a web-based tool called the Web Soil Survey (http://websoilsurvey.nrcs.usda.gov) that should be utilized to learn about the soils on the farm. Certain soil types will be adapted to some grass species better than others.

Soil testing and fertilization

Cool-season grasses need sufficient soil nutrients to grow and thrive. A near neutral pH is not necessary for growing a pure stand or mixture of cool-season grasses as it is with alfalfa.

However, if a legume is grown with the grass, the soil pH should be at the level necessary for legume growth and development.

Soil nutrient deficiencies are a leading cause of seeding failures and poor yields, so test soils in advance of seeding, and in general, every 3 or 4 years. However, soils with low buffer capacity that have sand, loamy sand, or sandy loam textures should be sampled every 1 or 2 years because pH and nutrient content can change rapidly in these soil types. To track pH and soil nutrient level trends over time, collect samples at the same time each year since levels can vary seasonally. Soils that are very high in phosphorus (P) and potassium (K) will not require additional application of these nutrients to attain high yields. Nitrogen is typically the yield-limiting nutrient when grasses are grown as a pure stand. One of the advantages of a grass-legume association is that the source of nitrogen for grass growth is provided by the legume and no commercial nitrogen fertilizer will need to be purchased.

The only way to accurately know the amount of limestone and fertilizer needed for a particular soil, located in a specific field, and that

---

1Contact at: 915 West State Street, Lilly Hall of Life Sciences, West Lafayette, IN 47907-2054, (765) 494-4800, FAX: (765) 496-2926, Email: johnsonk@purdue.edu
has been managed in different ways is to collect
and submit soil samples to a testing laboratory.
Recommendations like, “apply 300 lb of a blended
12-12-12 fertilizer per acre” should be ignored
because nutrients will either be under or over
applied. Sampling soils properly, interpreting test
results carefully, and applying recommended
nutrients is important to a sustainable forage system.
Recommendations for lime, nitrogen (N),
phosphorus (as P₂O₅), and potassium (as K₂O)
based upon soil test results are in Tables 1-3.

A good soil sample from a uniformly
managed area of 25 acres or less can be obtained
by taking one soil core per acre in a zigzag fashion.
A soils map with the use of the Web Soil Survey
can help locate different soil types in established
forages. In tilled land, surface color and soil texture
are good indicators of different soil types. Soil cores
taken within 200 ft of a gravel road or field borders,
or from other areas that are distinctly different from
the rest of the field, should be sampled separately.

Soil samples should be taken to a depth of
8 inches at least 6 months prior to establishing
forages. After establishment, take samples to a 4-
inch depth and periodically sample at the 4- to 8-
inch soil depth as soil nutrients can be more abundant
in the surface 4 inches.

Shipping moist samples to a soil testing
laboratory is acceptable, but very wet soil samples
should be air-dried or oven-dried (< 120°F) to
lower moisture before shipping. The analyses
requested should include pH and buffer pH,
available P, exchangeable K, calcium and
magnesium, and cation exchange capacity (CEC; a
measure of a soil’s nutrient-holding capacity and
resistance to change in pH; usually increases as clay
and OM content increase).

**Liming to adjust soil pH**

Proper soil pH is a basic requirement for
optimum plant growth, since pH affects the
availability of soil nutrients to plants. If soil test results
indicate that the soil is acidic (low pH), adding
limestone will be recommended. Preferably,
limestone should be applied at least 6 months before
seeding to ensure sufficient time to lower soil acidity
(i.e., raise the pH). If the soil test recommends 5 or
more tons of limestone per acre, apply half of the
limestone before the primary tillage and the other
half before a secondary tillage, to ensure more
uniform mixing of the limestone into the soil.

In Table 1, the liming rates for maintaining
established pastures are about half of what is
recommended for pasture or hay establishment
because established pastures are not tilled before
limestone application.

Most limestone recommendations are
based on a 9-inch plowing depth. If a mineral soil
(not a muck or peat soil) pH is more than 6.0 on
established grass pastures or hay fields, and more
than 6.6 on grass-legume pastures or hay fields, a
limestone application is not needed. The Shoemaker-McLean-Pratt (SMP) buffer pH (or
“lime index,” as it is commonly called in soil test
reports), measures how readily a soil’s pH will
change after a limestone application. Highly buffered
soils (soils with a high cation exchange capacity)
have lower lime index values and require more
limestone than soils with a low CEC.

If soil test results recommend a limestone
application and indicate that soil Mg is less than
150 lb/acre, consider applying dolomitic limestone
because it contains up to 22.6% magnesium
carbonate (MgCO₃). Applying dolomitic limestone
can address 2 issues at once, low soil pH and low
Mg levels.
Fertilization and rate of application

The N, P (as P$_2$O$_5$), and K (as K$_2$O) fertilizer application recommendations shown in Tables 2 and 3 depend on yield goals. Rates of P and K are lower for established pastures than they are for establishing or reestablishing pastures or hay fields or maintaining hay fields because grazing animals return nutrients to established pastures. One of the inherent advantages of rotational stocking over continuous stocking is that animal manure is more evenly distributed on the pasture surface. This means P and K are also distributed more evenly, which helps maintain soil fertility and forage health and saves money.

The N recommendations shown in Table 2 are for established grass pastures and hay fields at various yield goals. Realistic yield goals for most midwestern pastures and hay fields are 2 tons of DM per acre for Kentucky bluegrass and 4 tons of DM per acre for tall-growing, cool-season grass species, such as orchardgrass or tall fescue.

The P and K recommendations in Table 3 for established forages show that significantly higher K rates are needed for grass-legume than grass-only pastures since grasses are much more competitive for available K than legumes.

Established fields with more than 30% legumes require no additional N. However, N can be important to pasture establishment. For instance, 15 lb/acre of N at seeding should benefit a grass-legume stand being established on light colored soils with less than 3% OM, and on coarse-textured (sandy) soils. For establishing a grass-only pasture or hay field, apply 50 lb/acre of N prior to the last tillage before seeding on mineral soils.

Timing of fertilizer application

Application timing is just as critical as rate when it comes to N fertilization of perennial grasses. The best way to fertilize cool-season grasses is to apply half of the recommended N in very early spring (mid- to late March), with a quarter applied in late spring and the final quarter applied in late August or early September. This approach should improve cool-season grass summer production when the moisture received is average or above average and should improve late summer and early fall growth.

An alternative fertilization method is to apply two-thirds of the recommended N in very early spring (mid- to late March), with the remaining third applied in late August or early September. If only one N application is made each year, it should be a broadcast application in the very early spring. For perennial warm-season grasses, apply N when the grass breaks winter dormancy, typically in the latter half of April.

Apply P and K annually according to yield goal and whether the stand is pure grass or grass-legume mixture. Do not apply K fertilizer in the late winter or early spring. Generally, K is not yield limiting until early summer and can have higher uptake by roots in the spring than is necessary for plant growth. To reduce the risk of exposing animals to fertilizer, remove livestock from the fields to be fertilized until a significant rainfall dissolves the fertilizer particles into the soil.

Sources of N, P, and K

For grasses, especially under dry soil conditions, ammonium nitrate is the preferred N source because it is less likely to volatilize to N gas. However, it is difficult to locate ammonium nitrate for purchase. Urea can be used effectively without volatilization loss if application is made when the soil is moist or just before a rain. Some urea products also are formulated to have less volatilization loss. Ammonium sulfate contains readily available N but creates more soil acidity than other N fertilizers.
Understanding fertilizer analysis

Knowing how to read a fertilizer analysis is critical to determine rate of fertilizer application. That begins by understanding what the 3 numbers in a fertilizer analysis represent. For example, for a fertilizer analysis of “18-46-0,” the first number is the percentage of N, the second is the percentage of P₂O₅, and the third number is the percentage of K₂O.

Phosphorus and K rate recommendations are always based on oxide formulations (P₂O₅ and K₂O); P₂O₅ (phosphate) contains 44% elemental P and K₂O (potash) has 83% elemental K. Nitrogen recommendations are always on an elemental basis. It’s important to remember that the actual fertilizer application rate varies according to the fertilizer’s analysis and the amount of the nutrient recommended.

Understanding a fertilizer’s analysis and soil test recommendations will result in proper fertilizer rate application. Misunderstandings can result in costly misapplications. For example, a soil test indicates the need for 200 lb/acre of potash (K₂O); but if the applicator were to apply 200 lb of muriate of potash, which is 0-0-60 or 60% K₂O, only 120 lb/acre of K₂O would be applied, not the 200 lb/acre of K₂O recommended.

Forage Considerations

Many forage choices

Many forage crops are adapted to a geographical region. When selecting which forages to grow, consider soil characteristics, nutritional needs of the cattle class being fed, and whether the crop is to be used long term, or as a supplemental or doublecrop forage.

Forages are classified as grasses, legumes, or forbs. In the upper midwest, the majority of a dairy cattle producer’s machine-harvested forage acreage should be a legume, such as alfalfa or red clover grown alone or with an adapted perennial cool-season grass. Excess K level, especially in legume forage, is not uncommon and should be monitored. Examples of cool-season grasses include tall fescue, orchardgrass, perennial ryegrass, smooth brome grass, and timothy.

Perennial warm-season grasses do not warrant use by lactating dairy cattle as the nutrient profile does not meet the demands of this class of cattle. Paddocks of vegetative, perennial warm-season grasses like big bluestem and indiangrass can complement acreage of cool-season grass/legume paddocks when replacement heifers are being pastured.

Winter small grains (such as wheat, rye, and triticale) and annual ryegrass are commonly used as winter cover crops. They can be harvested in the spring prior to planting corn or soybean. Spring oat is another small grain that can be used as forage when sown alone or as a companion crop when seeding perennial forages. Date of seeding spring oat in the upper midwest is very early spring or in August. Unlike winter small grains, spring oat will not survive cold temperatures in the fall.

Annual warm-season grasses might be considered where there is an opportunity to doublecrop following wheat grain harvest or after a first cutting of hay where the stand is determined to be less than desirable. Typical warm-season annual grasses include sudangrass, sorghum-sudangrass, pearl millet, and teff. Sudangrass and sorghum-sudangrass with the brown midrib trait would be preferred over non-brown midrib options as energy value and intake should be enhanced with the trait.

The most common forb (neither a grass nor a legume) utilized in ruminant livestock agriculture in the midwest is turnip. Inclusion of the small grain spring oat with turnip makes a good combination
since the turnip alone can exceed the energy requirement needed for grazing cattle and has less effective fiber than the turnip-oat mixture. Caution is advised to select turnip varieties that have been documented to have lower risk of imparting off flavor to milk.

Specifically, perennial cool-season grasses

Within adapted cool-season grasses, there are traits worthy of consideration before one selects the most right choice. Traits to consider include soil drainage, drought tolerance, fertility needs, pest resistance, forage quality, longevity of stand, length of growing season, date of pollen shed, and invasiveness. Table 4 provides detail about common cool-season grasses adapted to the midwest.

Within a specific cool-season grass, it is important to evaluate varieties carefully. Not only will there be potential differences in DM yield, but date of heading and resistance to disease organisms could be different. Date of heading is important as it is best to match flowering date of the selected grass variety with the flowering date of the selected legume. If the grass is earlier to mature than the legume, the quality of the resulting forage will be reduced if date of harvest is determined by legume morphology stage.

Nutrient Composition of Hay and Silage

The wellbeing of the cattle is highly correlated to a proper nutrition program. It is imperative that producers routinely sample and analyze stored forage feedstuffs so that a balanced ration can be prepared. Use of generalized feed composition tables for forages should not be used to balance a ration because forage quality is highly variable.

Updated information about hay probes, sampling procedure, where certified laboratories are located, and analytical procedures can be found at www.foragetesting.org.

Generalizations about cool-season grass forage quality as compared to legumes at a similar maturity stage is that they are lower in crude protein, similar in acid detergent fiber and digestibility, and higher in neutral detergent fiber, and thus, have lower intake level. Cool-season grasses are lower in lignin than legumes and have a higher final extent of digestion, but digestion rate is slower. Calcium and magnesium levels are lower in grasses than legumes.

It is important to understand that a similar cool-season grass grown in a warm or cool environment would have lower forage quality in the warm environment as lignin and fiber concentrations are higher. Caution is advised when evaluating response of livestock when fed forage without knowledge of where and when the crop being fed was harvested because of this environmental influence upon forage quality. Cool-season grass harvest should be timed before late boot stage, if high quality forage is the goal.

Evaluate Weekly

Potential concerns and forage growth should be evaluated weekly. Just like cattle, the well-being of the forage should be monitored often. Grazing to a height less than 4 inches should be avoided as the meristem tissue of highly productive forage plants can be damaged and result in less productive forages and weed encroachment. The only time overgrazing should be allowed is in the late fall when a pasture will have legumes reintroduced in late winter. There has been expressed concern regarding mowing height of orchardgrass, as many stands have been depleted more quickly than what would be expected. Orchardgrass stores nutrient reserves in lower stem bases, and if cut too low, less than 3 to 4 inches, length of stand could be reduced.

Weeds, insects, and disease concerns should be monitored as fields are scouted. Get a positive identification of pests so proper control
measures can be considered and accomplished. Some weeds can be harmful to livestock if consumed.

If herbicides are used to control weeds, be aware of the harvest restrictions and crop rotation interval associated with the products that are candidates for use. Most herbicides used to control broadleaf weeds unfortunately will be harmful to legumes growing in association with a grass. Carefully consider whether the negative impact of the weeds present is more concern than the positive value of legumes in the forage stand.

Monitor the population of various insect pests and determine if their numbers warrant control. Harvest timing, genetic resistance, reducing other stress levels to the plants, and insecticide applications are approaches that can be used to minimize insect damage. Beneficial insects and infection of the detrimental insect with certain microorganisms can keep damage below the economic threshold.

Fungicide use on established forage crops is typically not a best management practice. The best approach to reducing plant disease is to select varieties that have resistance to diseases that are common to the crops selected and the soil where sown.

**Conclusions**

Managing forages properly is important to the well-being of livestock and the sustainability of the dairy enterprise. Value of the crop is affected by management provided. Utilizing best management practices is essential.

**Resources**

Much of the information was used with permission and adapted from: Cow-Calf Production in the U.S. Corn Belt. MWPS-66. Currently in production. 2011.© MWPS (Midwest Plan Service), Iowa State University, Ames, IA., [www.mwps.org](http://www.mwps.org).


Table 1. Recommended agricultural limestone application rates for grass and grass-legume pastures.¹

<table>
<thead>
<tr>
<th>Buffer pH (lime index)</th>
<th>Mineral Soils (less than 20% organic matter)</th>
<th>Soil pH &lt; 6.0 Grass Only</th>
<th>Soil pH &lt; 6.6 Grass-Legume</th>
<th>For Renovation/Maintenance</th>
<th>Tons of Limestone/Acre Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;70</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>68 to 70</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 66</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For Establishment/Reestablishment

<table>
<thead>
<tr>
<th>Tons of Limestone/Acre Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 70</td>
</tr>
<tr>
<td>69 to 70</td>
</tr>
<tr>
<td>68</td>
</tr>
<tr>
<td>67</td>
</tr>
<tr>
<td>66</td>
</tr>
<tr>
<td>65</td>
</tr>
<tr>
<td>&lt; 65</td>
</tr>
</tbody>
</table>

¹These recommendations are based on certain assumptions about previous limestone applications, tillage depth, and limestone quality. Adjust rates for the following:

a. If limestone was applied within the last year, subtract the amount applied in the previous application from the amount recommended here.

b. The establishment/reestablishment rates are based on a 9-inch tillage depth. Adjust rates by 10% for every inch of difference in tillage depth (decrease rate by 10% for an 8-inch depth, increase by 10% for a 10-inch depth). Do not adjust rates by more than 30% (3 inches).

c. Rates are based on 25 to 30% of the limestone passing through a 60-mesh sieve. If your liming product’s fineness differs, check with your Extension Educator, crop consultant, or fertilizer representative for the appropriate adjusted rate at that level of fineness.

d. If you need to apply more than 5 tons/acre, a split application is recommended. Broadcast the first half and plow it down. Broadcast the second half and incorporate with a secondary tillage.

e. You may substitute 2 cubic yards of marl containing at least 70% calcium carbonate equivalent for 1 ton of standard agricultural ground limestone.
Table 2. Nitrogen (N) recommendations for established grass-only pasture and grass-only hay production

<table>
<thead>
<tr>
<th>Crop Use</th>
<th>Recommendation When Per-Acre Yield (Dry Matter Basis) Is:</th>
<th>lb N/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 tons</td>
<td>4 tons</td>
</tr>
<tr>
<td>Grass Pasture</td>
<td>55</td>
<td>100</td>
</tr>
<tr>
<td>Grass Hay</td>
<td>75</td>
<td>140</td>
</tr>
</tbody>
</table>

1These recommendations are adjusted to credit the value of livestock manure based on 10 pounds of N is recycled per ton of forage dry matter produced.

Table 3. Phosphorus (P₂O₅) and potassium (K₂O) recommendations (lb/acre)² for grass-only and grass-legume pasture renovation/maintenance and establishment/reestablishment.¹

<table>
<thead>
<tr>
<th>Soil Test</th>
<th>P₁ Exchangeable K Level</th>
<th>Renovation/Maintenance Levels</th>
<th>Grass-Only Pasture Recommendation When Per Acre Yield (Dry Matter Basis) Is:</th>
<th>Grass-Legume Pasture Recommendation When Per Acre Yield (Dry Matter Basis) Is:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 tons</td>
<td>4 tons</td>
</tr>
<tr>
<td>0-10</td>
<td>0-80</td>
<td>Very low</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>11-20</td>
<td>81-150</td>
<td>Low</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>21-30</td>
<td>151-210</td>
<td>Medium</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>31-50</td>
<td>211-300</td>
<td>High</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>51+</td>
<td>301+</td>
<td>Very high</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

¹The renovation/maintenance recommendations are adjusted to credit the value of livestock waste based on 85% of the P and 50% of the K is recycled in the forage dry matter. No adjustments are made when the soil test is very low.
²2 lb/acre = 1 part per million.
³Establishment/re-establishment values should be used when harvesting as hay or silage.
Table 4. Soil and Other Considerations for Selected Cool-season Grass Forages.¹

<table>
<thead>
<tr>
<th>Species</th>
<th>Soil pH</th>
<th>Soil Drainage²</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky Bluegrass</td>
<td>5.8 to 6.5</td>
<td>SPD</td>
<td>Excellent quality, low yield, drought intolerant. Sod forming.</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>5.5 to 8.2</td>
<td>SPD</td>
<td>Use late-maturing varieties when legumes are a component of a mixture. Select varieties with disease resistance. Bunchgrass.</td>
</tr>
<tr>
<td>Reed Canarygrass</td>
<td>5.8 to 8.2</td>
<td>VPD</td>
<td>Do not seed near natural wetlands. Use low-alkaloid varieties. Harvest immature stages for best animal performance and to stop seed escape to natural wetlands. Many consider it an invasive species. Sod forming.</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>5.6 to 6.2</td>
<td>SPD</td>
<td>Excellent quality, drought intolerant, quick establishment. There are canopy growth differences among varieties (compact or tall). Annual ryegrass is actually a weak perennial. Bunchgrass.</td>
</tr>
<tr>
<td>Smooth Bromegrass</td>
<td>5.8 to 6.5</td>
<td>SPD</td>
<td>Do not harvest regrowth too quickly between harvests (less than 6 weeks) or the stand can be depleted. Less productive at mid-season compared to tall fescue or orchardgrass. Sod forming.</td>
</tr>
<tr>
<td>Tall Fescue</td>
<td>5.0 to 8.5</td>
<td>SPD</td>
<td>Use low-endophyte or friendly endophyte varieties only. Drought tolerant, stockpiles well. Sod forming bunchgrass.</td>
</tr>
<tr>
<td>Timothy</td>
<td>5.4 to 6.2</td>
<td>SPD</td>
<td>Compared to other cool-season grasses, timothy is late to mature, and there is less production after first harvest. Winter hardy but not long-lived. Bunchgrass.</td>
</tr>
</tbody>
</table>

¹From Purdue Extension publications AY-328 and ID-317.
²SPD = Somewhat poorly drained; VPD = Very poorly drained.