



FERTILIZING PASTURE

Unlike fertilization of most field crops, pasture fertilization management is more often guided by goals for the pasture. Factors frequently considered include: 1) production needed for the animals; 2) time of forage needs; 3) grass or legume species present; and 4) expected methods of management. Pastures can be strategically and profitably managed by well-planned fertilization and production management programs.

Micronutrients are plant nutrients required in very small amounts and are adequately provided from the soil in Iowa. However, others, such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) are required in greater amounts and are commonly applied as fertilizer amendments. Soil sampling and testing are used to determine the availability of P and K nutrients, and the amount that might need to be added to make up for any deficiencies. If insufficient amounts are available in the soil or supplied with fertilizers or manure, both pasture and animal production may be restricted, and profitability may be limited. If nutrients are supplied in excess of plant needs, some excess nutrients may accumulate in the plants and in the soil, while others will be lost from the site through leaching and runoff.

It is important to emphasize that this publication refers to pastures and not to forage managed for hay or silage harvest. This distinction is of moderate importance for N fertilization, but is of utmost importance for P, K, and S fertilization. Estimates of P and K removal are considered for P and K management, and much more is removed with mechanical harvest than with grazing. Sulfur deficiency often is observed in alfalfa harvested for hay but seldom in pastures. See publication [CROP 3072–Sulfur Management for Iowa Crop Production](https://store.extension.iastate.edu/Product/14280), store.extension.iastate.edu/Product/14280.

IOWA STATE UNIVERSITY
Extension and Outreach

Sampling the Soil in Pasture

The best fertilization recommendations are based on soil test results, knowing the specific needs of the crop being grown, and results of fertilization research. Soil testing helps to identify fertilizer nutrient limitations and also often provides a guide for the amount of lime or fertilizer needed to correct deficiencies in soil pH or available nutrients. The key to soil testing is to collect a representative sample from the area of interest.

Soil pH and some nutrients will often vary with soil type. Fields with substantially different soil types should have separate sets of composite samples taken within major soil types. If not sampling by soil type, sample by 10-acre units. At the very least, each field, or paddock should be sampled separately.

Take multiple cores for each sample and avoid areas immediately surrounding urine or dung patches and near water sources, shade, mineral feeders, hay feeding areas, or any other area where animals may have congregated and created a nutrient buildup. For best P and K recommendations take samples to a depth of 6 inches. Lime recommendations are based on whether the liming material will be incorporated with tillage or broadcast on the soil surface. When planning to incorporate lime during seedbed preparation, sample for pH to a 6-inch depth. When sampling an existing pasture, take composite samples to a depth of 6 inches for P and K recommendations, and a separate set of composite samples at a 2 to 3-inch depth for pH and recommendations for rates of lime to be spread on the pasture surface. Although P and K tend to accumulate near the soil surface, a shallow sampling depth does not improve the value of soil testing, and existing field calibrations are based on a 6-inch depth.

For lime recommendations, a shallower sampling depth is better because top-dressed lime seldom will increase soil pH below a depth of about 3 inches, and attempting to change pH of a thicker soil layer may result in excess lime application. In general, soil samples should be obtained from pastures at least every three years, at about the same time of year. More information on how to take a representative soil sample can be found in publication [CROP 3108–Take a Good Soil Sample to Help Make Good Fertilizer Decisions](https://store.extension.iastate.edu/Product/3915), store.extension.iastate.edu/Product/3915.

Optimum Soil pH and Liming

Soil pH is a measure of soil acidity and indicates if liming is needed, whereas soil buffer-pH is used to determine the amount of lime to apply. The pH guidelines for pastures are largely determined by the species present and the grower's desire to maintain a grass-only pasture or a mixture of legume and grasses. Most forage crops grow best when the soil pH is 6.0. However, alfalfa and alfalfa-grass mixtures are more productive at a slightly higher soil pH (the pH recommendation for alfalfa in the NC region ranges between 6.8 and 6.9). Many plant nutrients are generally available to the plants at these desirable pH levels, and these levels are also considered to be beneficial to bacterial activity in the soil. Use soil testing to measure the current pH levels of your pasture soils and buffer-P to determine the amount of lime to apply. Additional information about optimum pH for forages and pastures and about estimating amounts of lime to apply can be found in the publication, [PM 1688—A General Guide for Crop Nutrient and Limestone Recommendations in Iowa](#), available at store.extension.iastate.edu/product/5232.

Agricultural lime is the most commonly used product for neutralizing soil acidity and raising soil pH values, although other liming materials also can be used. However, not all materials having calcium will increase soil pH (e.g., gypsum). Pelleted lime or liquid lime, ground eggshells, and residuals from drinking water treatment plants are good liming sources. Apply all liming materials based on their Effective Calcium Carbonate Equivalent (ECCE) content.

Liming has been shown to be a profitable practice, especially when needed to establish and maintain legumes in forage stands. Soil of N-fertilized grasses can acidify very quickly, however, so don't underestimate the value of soil pH and buffer-pH testing for these pastures.

Fertilizing Grass Pastures

How Much Nitrogen to Apply and Timing

For grass pastures to be productive, first priority should be given to meeting N needs. Grasses respond quickly to N when other growing conditions are good. However, N fertilization is not as profitable if P and K supplies are inadequate.

Research in Iowa has shown that grass yield, measured in terms of dry forage, cow-days of grazing, or live weight gains of yearling steers, can be increased two to three times or more with adequate N fertilization. Unfertilized Kentucky bluegrass pastures usually produce from 0.5 to 1 ton of dry forage per acre. Unfertilized, cool-season, tall grasses such as bromegrass, orchardgrass, tall fescue, and reed canarygrass range in dry forage yields from 0.75 to 1.5

tons per acre. Kentucky bluegrass yields can be expected to reach 3 tons of dry forage and 250 pounds of live weight gain per acre when fertilized annually with 100 to 150 pounds of N per acre and P and K maintained at adequate levels. Tall grasses under intensive management have exceeded 5 tons per acre of dry forage and 500 pounds of live weight gain per acre when fertilized annually with up to 240 pounds N per acre, applied in split applications.

Not unlike cultivated row crops such as corn, a number of factors relate to N response in pastures. In addition to rates of N applied, key factors that cause variations include time of application, density of the sod, soil type, seasonal rainfall, manner of grazing, and year-to-year temperatures. Thus, pasture fertilizer suggestions tend to be general in nature, usually conservative, and not always the best for all conditions. For N fertilization to be economically beneficial, a yield increase must occur that will be large enough to pay for the fertilizer and other costs, and provide a profit. Producers should expect to make some adjustments to fit their own needs and conditions.

Timely N fertilization can help increase total production, extend spring grass growth into the early summer, and extend fall pasture production. Kentucky bluegrass and the more productive tall grasses such as smooth bromegrass, orchardgrass, tall fescue, and reed canarygrass, are "cool-season" grasses. Their greatest growth rates are in April, May, and June. Growth is often nearly at a standstill during hot weather and dry soil conditions that normally occur in July through August. As the weather starts to cool in late summer, and the moisture supply improves, growth of cool-season pasture grasses picks up again and continues into October. Adequate N must be available during spring to early summer and late summer to fall for best growth and grass yields.

"Warm-season" pasture grasses, such as switchgrass, big bluestem, and eastern gamagrass and annual warm-season grasses like sudangrass and others, produce most of their growth during June through August. Growth of warm season grasses slows with cooler conditions in September, and ceases after moderate frosts in October. Adequate N must be available during the summer months for best growth and yield of these grasses.

For a one time, annual, N application to grass pastures spring is the preferred timing to maximize N use efficiency and minimize N loss through leaching:

Kentucky bluegrass—April: 60 to 100 pounds of N per acre.

Tall cool-season grasses—April: 80 to 120 pounds of N per acre.

Warm-season grasses—late April to early May: 80 to 150 pounds of N per acre.



However, research has shown that N, in split applications, will improve efficiency of N used by pasture grasses and improve distribution of forage yield during the growing season. When splitting the seasonal N application for cool season grasses, apply some N in early spring and some again in August. Some producers also will apply a portion of the seasonal N in late May or early June. Success of a late spring/early summer application is dependent on adequate summer moisture and absence of excessive heat. A midsummer application is usually not recommended since growth is generally poor at this time of year for most cool season grasses.

For seasonal split N applications:

Kentucky bluegrass—April: 60 to 80 pounds N per acre; late spring: 30 to 50 pounds N per acre; and early to mid-August: 40 to 60 pounds N per acre.

Tall cool-season grasses—April: 80 to 120 pounds N per acre; late spring: 40 to 50 pounds N per acre; and early to mid-August: 60 to 80 pounds N per acre.

What Source of Nitrogen?

Dry forms of N include urea (45-0-0) and ammonium sulfate (21-0-0). Ammonium nitrate is also a dry N form that was once widely used, but is now generally unavailable. Non-pressure, urea-ammonium nitrate solutions (UAN, 28 and 32 percent N) also may be available.

Research has shown that during late fall, late winter, and early spring, there is little difference among the N sources commonly used for topdressing pastures. However, during the warm, summer months, there can be some volatilization loss of surface-applied dry urea or urea in UAN solution. On a warm, moist soil surface, urea rapidly converts to ammonium. In that conversion, pH increases and some ammonia is produced that can be lost into the air. Losses are greater with warm soil temperatures and no rainfall for several days. With warm soil temperatures, moist soil, high residue cover, and no rainfall for 7 to 10 days, N losses from urea can be as high as 20 to 30%. Loss from UAN is half that with urea as UAN contains only one-half urea. However, volatilization losses are greatly diminished if as little as 0.25 inches of rainfall occurred within a day or two after urea application. If volatile losses are a concern, then a urease inhibitor can be added to the urea or UAN application or use ammonium sulfate.

To avoid leaf-burn symptoms on grass forages, apply dry, granular N source when the leaf surface is dry. The small granules of dry fertilizer that are spread over an entire field should not be a problem with grazing livestock, but avoid leaving piles of granular N in the field, either from misapplication or improper equipment operation. Ingestion of significant quantities of N fertilizer can be a hazard to livestock attracted to it. Urea-ammonium nitrate fertilizer solutions frequently cause temporary leaf-burn symptoms.

The choice as to N fertilizer form to apply should be based on price differential, rainfall probability, and flexibility of application date.

Phosphorus and Potassium Rates for Grass Pastures

Most pastures that have been grazed and unfertilized for many years will test very low to low in P. The K supply, however, is much more variable, mainly in western Iowa. Test soil to determine P and K needs. Studies to measure the response of grass pastures to P and K indicate that yield responses to applied P and K are variable, and often small and smaller than for legume-grass mixtures. The higher yielding tall grasses will respond to more of these two nutrients than bluegrass, with its lower yield potential. Also, nutrient removal and the grass forage response to P and K application can be significant in well-managed rotational grazing systems.

In addition to yield response, P fertilization usually increases P concentration in the plant, increasing the nutritional value of the grazed forage to livestock.

The P and K rates in recommendations for grass pastures are based on species (higher for tall cool-season and warm-season grasses than for bluegrass), soil tests and expected nutrient removal from the field. General P and K recommendations are listed in Table 1.

Table 1. Annual phosphorus and potassium application rates for grass pastures.

Soil test category	Pounds per acre			
	Bluegrass		Tall grasses*	
	P ₂ O ₅	K ₂ O	P ₂ O ₅	K ₂ O
Very low	45	55	63	88
Low	35	40	43	68
Optimum	20	25	27	50
Higher	0	0	0	0

*Smooth bromegrass, orchardgrass, tall fescue, reed canarygrass, switchgrass, big bluestem, indiangrass, eastern gamagrass, sudangrass, and sorghum x sudangrass hybrids.

Use follow-up soil testing a minimum of every three years to adjust application rates. Rates recommended for the optimum soil-test category are designed to maintain soil-test levels over time, are based on nutrient removal and recycling, and should be adjusted for each field. The soil-test maintenance P and K application rates for pastures are lower than for harvested forages because a significant proportion of ingested P and K are recycled with feces or urine. Detailed information about grass hay and pasture P and K fertilization guidelines can be found in the publication, [PM 1688—A General Guide for Crop Nutrient and Limestone Recommendations in Iowa](https://store.extension.iastate.edu/product/5232), store.extension.iastate.edu/product/5232.

The timing of P and K applications can be flexible when the soil-test is in the optimum category and the main objective of the fertilization is to maintain soil-test values over time and assure high productivity. However, application in the fall or early spring is recommended when soil-test values are very low or low to enhance early growth during favorable growing conditions. The estimated needed P rate can be applied once every two years, except with very steep slopes when the risk of surface runoff is very high.

Fertilizing Mixed Legume-Grass Pastures

Nitrogen Fertilization

Nodulated legumes can capture N gas from the air and symbiotically “fix” it in plant-available forms for their own use and for grass growing in mixtures with the legume. If the legume portion is less than one-third, the grass in the mixture is likely to respond significantly to added N fertilizer at rates described for grass pastures. If the forage stand is one-third or more legume, no additional N fertilizer application is generally recommended.

Research has shown that sometimes maximum production of a mixed legume-grass pasture is attained with added fertilizer N in addition to atmospheric N fixed by the legumes, even when the legume portion is higher than about one-third. However, such a practice seldom results in increased profitability and likely will reduce legume proportion and persistence. Nitrogen fertilizer will stimulate cool-season grass growth and give the grasses a competitive advantage. If the majority of this N fertilizer is applied in the spring, the N-fertilized grasses are quite competitive and the legume proportion in the mixtures is reduced. If the goal is to maintain the legume in the stand, then limit the competitiveness of the associated grasses by splitting high N rates between spring and late summer.

Phosphorus and Potassium for Legume-Grass Pastures

Legume or legume-grass pastures have a higher requirement for P and K than do grass pastures. Adequate P and K are essentials for legume establishment, stand maintenance, and satisfactory yields. These two nutrients maintain legume yields, and also enhance disease resistance, winter hardiness, and longer stand life. Fertilizer P and K should be applied to reach and maintain an optimum soil test level.

The P and K rates used in recommendations for mixed legume/grass pastures are listed in Table 2.

Table 2. Annual phosphorus and potassium application rates for mixed legume-grass pastures.

Soil test category	Pounds per acre			
	Alfalfa-Grass		Clover/Trefoil Grass	
	P ₂ O ₅	K ₂ O	P ₂ O ₅	K ₂ O
Very low	80	145	57	93
Low	60	125	43	73
Optimum	48	118	27	50
Higher	0	0	0	0

Rates recommended for low-testing categories are based on species needs and soil testing. Rates for the optimum soil-test category are designed to maintain soil-test levels over time, are based on nutrient removal and recycling, and should be adjusted for each field. The recommended maintenance P and K application rates (optimum category) for pastures are lower than for harvested forages because a significant proportion of ingested P and K are recycled with feces or urine. More information about hay and pasture P and K fertilization guidelines for legume-grass pastures can be found in the publication, [PM 1688–A General Guide for Crop Nutrient and Limestone Recommendations in Iowa](https://store.extension.iastate.edu/product/5232), store.extension.iastate.edu/product/5232.

Much of the P and most of the K in the consumed forage are returned in the urine and droppings of the grazing animals. The distribution of these nutrients, however, can be highly variable, often concentrated around watering tanks or under shade trees. When droppings are heavy in the main part of the pasture, spreading with a drag harrow can be helpful. Thoughtful and targeted soil testing and application of P and K fertilizer, where needed, can help to achieve an adequate fertility level in all areas of the pasture.

The time of application for P and K on legume-grass pastures is not critical when the soil-test values are in the optimum category or higher, and, fall (for next year), early spring, or August applications are possible. However, application in the fall or early spring is recommended when soil-test values are very low to enhance early legume growth during favorable growing conditions, especially alfalfa and birdsfoot trefoil. Applications can be made each year, or can be doubled and applied every other year.

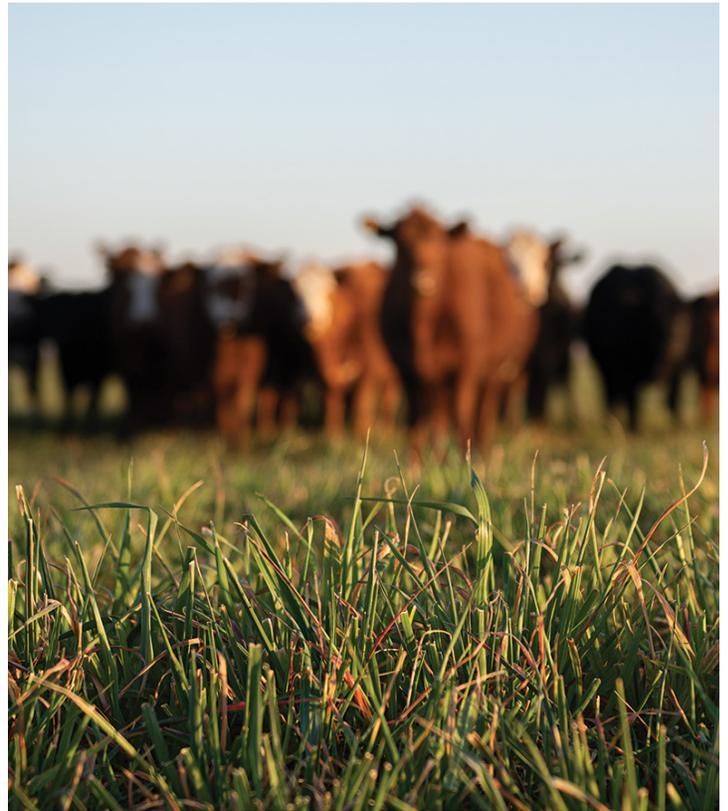


Other Considerations for Improved Pasture Management

For best fertilizer response, delay spring grazing until grasses and legumes have begun to grow vigorously. Also, avoid close, continuous grazing through the grazing season. Maintain some leaf area at all times so that plants can intercept adequate sunlight to achieve productive growth. If possible, have several pastures so livestock can be moved for efficient forage use, and to provide sequential rest or recovery periods for the pasture species. The rest period will improve vigor and yield of the cool season grasses and boost fall grazing.

Early spring N fertilizer can lead to a greatly increased pasture production. A producer should be prepared to use the forage when it is produced. However, it doesn't all have to be grazed at that time. It may be convenient to harvest some for storage as hay or silage, or, to allow some growth to accumulate for later grazing. Another alternative may be to establish either perennial or annual warm-season pasture species on a portion of the cropland for grazing during July and August. These summer forage alternatives include annual species such as sudangrass, sudan-sorghum hybrids, or perennial species such as switchgrass, big bluestem, or eastern gamagrass. Regrowth of mixed legume-grass hay meadows also can be used for midsummer grazing. Providing alternative grazed forage during the summer months has the added advantage of providing a period of rest or recovery for the cool season pastures during midsummer.

Nitrogen fertilizer is a high cost item in pasture improvement. An alternative for reducing the need for fertilizer N is to establish legumes in existing grass pastures. Legumes can be established in grasses by interseeding or frost seeding. Adequate P and K fertilization is always important for legume establishment, but is especially the case when interseeding of frost-seeding legumes. For more information see ISU Extension and Outreach publications [PM 1097–Interseeding and No-till Pasture Renovation](https://store.extension.iastate.edu/product/4420), [store.extension.iastate.edu/product/4420](https://store.extension.iastate.edu/product/4158), and [PM 856–Improving Pasture by Frost Seeding](https://store.extension.iastate.edu/product/4158), store.extension.iastate.edu/product/4158. Including legumes in grass pastures improves pasture quality and usually provides more forage in midsummer. Keep in mind, however, that legume-containing pastures require more careful management than allgrass pastures. Grazing must be controlled to maintain legume plant vigor, and enhance disease resistance and winter survival. Few herbicides are labeled for mixed grass-legume pastures, so weeds are harder to control. In addition, greater P and K required to maintain legume-grass pastures and a periodic reseeding of legumes may be needed to offset some of the N cost required for all-grass pastures.



Conclusion

The best returns from pasture fertilization will depend on effective utilization through well-managed livestock and forage programs. Fertilization is important in any efficient, highly productive forage program. Years of research and farmer experience have demonstrated large increases in days of grazing, annual gain, or milk production per acre by fertilizing low yielding pastures. Also, rotational grazing, with sequential rest or recovery periods during the grazing season are important if fertilizer benefits are to be fully realized.

Authors

Prepared by Antonio P. Mallarino, professor of agronomy and extension specialist, Stephen K. Barnhart, and John E. Sawyer. Revised March 2023.