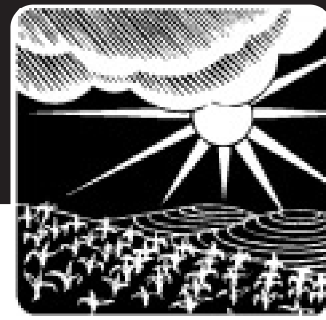

Fertilizing Pasture

Fertilization can be a profitable way to improve pasture. Production can usually be increased two to three times or more with a well planned fertilization and management program.

For grass pastures to be productive, first priority should be given to meeting nitrogen needs. Grasses require large quantities of nitrogen and respond vigorously when fertilized with this nutrient.

Grasses may also respond to phosphorus and potassium when supplies in the soil are low. However, response to applied phosphorus and potassium is not usually profitable unless nitrogen supplies are adequate.

Most pastures that have been grazed for many years will test very low to low in phosphorus. The potassium supply, however, is much more variable and sometimes potassium fertilization is not needed for grass pastures. Test soil to determine needs.

Legume-grass pastures normally do not need nitrogen. Legumes fix nitrogen from the air for their own use and for grass growing with the legume. If the forage stand is one-third or more legume, do not apply nitrogen fertilizer. If the legume portion is less than one-third, the grass in the mixture is likely to respond to nitrogen fertilizer.

Legume or legume-grass pastures have a higher requirement for phosphorus and potassium than do grass pastures. These two nutrients not only increase legume yields but also enhance disease resistance, winter hardiness, and longer stand life.

The use of limestone to reduce acidity is a profitable practice especially for legumes in the forage stand. Maintain a minimum soil pH of 6.5 for legume-grass stands. A soil pH of 6.0 is considered adequate for grass pastures.

Best results are obtained when limestone is plowed down or disked in. Topdressing established pasture is desirable if the pH is below 6.0 for grass pastures and below 6.5 for legume-grass stands. Since the limestone cannot be worked in, topdress with one-half the rate recommended by soil test, because the rate depends on the volume of soil to be neutralized.

Fertilizing Grass Pastures

What Kind of Nitrogen

Use only the dry forms of nitrogen or nonpressure solutions when topdressing. The dry forms include ammonium nitrate (33.5-0-0) and urea (45-0-0). The nonpressure solutions contain both ammonium nitrate and urea and range from 28 to 32 percent nitrogen.

Most research dealing with the response of grass pasture to nitrogen has been done with ammonium nitrate. Urea is now the most common material being used. Studies comparing urea with ammonium nitrate sometimes show a smaller response per unit of nitrogen from urea. As urea absorbs moisture and converts to the ammonium form, some ammonia produced during the transition may be lost into the air. Losses of 10 to 20 percent have been reported under some conditions.

Losses from urea are most likely to occur when urea is applied to grass growing on calcareous soils and/or during warm weather, and when several days elapse before rains move the material into the soil. In general, with the nitrogen rates and times of application suggested, response among nitrogen materials is usually similar. It is expected that urea will continue as an important material for fertilizing grass pastures.

Because of its low cost, there is interest in using anhydrous ammonia on pastures. Its use has been shown to be successful when properly knifed in and sealed. Spacing of the nitrogen bands should not exceed 20 inches. Special applicator knives for grass sod are available and should be used if possible with a coulter wheel ahead of each knife.

Expected Nitrogen Response

Unimproved Kentucky bluegrass pastures usually produce from .5 to 1.0 ton of dry forage per acre. Unfertilized tall grasses such as bromegrass, orchardgrass, tall fescue, and reed canarygrass range in dry forage yields from .75 to 1.5 tons per acre.

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Research in Iowa has shown that grass yields measured in terms of dry forage, cow-days of grazing, or live weight gains or yearling steers can be increased two to three times or more by fertilizing with nitrogen.

Fertilized Kentucky bluegrass yields can be expected to reach 3 tons of dry forage and 250 pounds of live weight gain per acre. Tall grasses under intensive management and fertilized with 240 pounds nitrogen per acre applied in split applications have exceeded 5 tons per acre of dry forage and 500 pounds of live weight gain per acre.

Not unlike cultivated row crops such as corn, the response of grasses to nitrogen is influenced by a number of factors that cause results to vary with different years and locations. In addition to rates of nitrogen, key factors that cause variations include time of application, thickness of stand, soil type, seasonal rainfall, manner of grazing, and overall management. Thus, pasture fertilizer suggestions tend to be general in nature, usually conservative, and not always the best for all conditions. Producers should expect to make some adjustments to fit their own needs and conditions.

For any rate of nitrogen fertilizer to be profitable, a yield increase must occur that will be great enough to pay for the fertilizer and other costs, and provide a profit.

Table 1 shows the response of bluegrass to nitrogen on a soil in northeast Iowa. Without nitrogen the yield was .73 tons of dry forage. Yields increased up to 2.34 tons per acre with 160 pounds of nitrogen per acre. The first 40 pounds of nitrogen produced 23 pounds of dry matter per acre for each pound of nitrogen applied. Each additional pound of nitrogen produced 19 to 21 pounds of dry forage per acre. This is a normal response for most of Iowa from up to 120 pounds of nitrogen per acre. Often, an additional 40 pounds (120 to 160 pounds) per acre will yield 15 to 18 pounds of additional air-dry forage per acre per pound of nitrogen.

Table 1. Response to nitrogen applied to Kentucky bluegrass, Fayette silt loam, Allamakee County, Iowa.

Nitrogen rate	Dry matter yield	Dry matter by 40 lb. N units
Lb./A	Tons/A	Lb./lb. N
0	0.73	--
40	1.19	23
80	1.56	19
120	1.93	19
160	2.34	21

Table 2 shows the response obtained by applying 160 pounds per acre of nitrogen to bluegrass on four different soil types in southern Iowa. Each value in the table is a 2-year average of 11 sites on each soil type. The dry matter yield of fertilized bluegrass varied widely among soil types ranging from 1.88 tons per acre to 3.10 tons per acre. This difference is mainly an expression of the yield potential of the soils. However, the amount of dry matter produced per acre per pound of nitrogen shows only a moderate variation ranging from 16 to 21 pounds.

Table 2. Response to fertilization of Kentucky bluegrass grown on four different soils in southern Iowa.

Soil series	Dry matter yields–2 yr. average		
	Nitrogen none	Nitrogen* 160 lb./A	Nitrogen response
	Tons/A	Tons/A	Lb./lb. N
Gundy	1.74	3.10	17
Clarinda	1.20	2.77	20
Weller	0.87	2.55	21
Keswick	0.58	1.88	16

*Each plot also received 35 lb. P_2O_5 and 32 lb. K_2O per acre.

Table 3 shows nitrogen response obtained from fertilizing an old stand of smooth bromegrass at Ames, Iowa. Yields of dry forage per acre ranged from 1.29 tons without nitrogen to 4.37 tons when fertilized with 240 pounds of nitrogen per acre. The first 60 pounds of nitrogen in this test produced 42 pounds of dry matter per acre for each pound of nitrogen. The second 60 pounds of nitrogen produced 21 pounds of forage per acre for each pound of nitrogen. An additional 120 pounds of nitrogen still produced 20 pounds of forage per acre for each pound of nitrogen.

Fertilizing bromegrass with nitrogen in several southern Iowa tests showed a response of up to 27 pounds of dry forage per pound of nitrogen for the first 120 pounds per acre of nitrogen. But on these soils with a low to moderate yield potential the second 120 pounds of nitrogen produced only 10 to 13 pounds of forage per acre for each pound of nitrogen.

Table 3. Response to nitrogen applied on smooth bromegrass, Nicollet silt loam. Ames, Iowa, 1972-74.*

Nitrogen rate	Dry matter yield	Dry matter by units of N	
		N unit	Yield
	Tons/A	Tons/A	Lb./lb. N
0	1.29	--	--
60	2.54	60	42
120	3.17	60	21
240	4.37	120	20

*From study conducted by J. R. George, Agronomy Dept., ISU.

Profit From Nitrogen Use

These studies indicated that fertilizing grass with nitrogen can be profitable. For example, assume that nitrogen costs 25¢ per pound and forage is worth 3.75¢ per pound ($65 per ton). If a pound of nitrogen produces 20 pounds of dry forage per acre, the return would be 65¢ worth of forage for 25¢ spent for nitrogen. This is a return of over $2.60 for each dollar spent for nitrogen. Because 20 pounds of less of high quality forage should provide a pound of animal live weight gain, the cost of a pound of gain is comparable to the 25¢ spent for nitrogen, which further illustrates the opportunity-cost provided by adequate nitrogen fertilization.

Another illustration of the profit potential from fertilizing pasture is shown in table 4. This example uses the response data for bromegrass shown in table 3 and applies both the cost of fertilizer and the cost of owning and utilizing the pasture. It is evident that fertilizer, especially nitrogen, significantly increased pasture cost. The increased yield from fertilizer, however, offsets the added cost and reduced forage cost per acre with each added increment of nitrogen.

It is shown in table 4 that the cost of producing 20 pounds of dry forage was 45¢ without nitrogen compared with only 29¢, 28¢, or 27¢ when fertilized with 60, 120, or 240 pounds of nitrogen per acre, respectively. The return per pound of nitrogen was greatest with the first 60 pounds of nitrogen applied. This is about 42 additional pounds of forage for each pound of N applied, as shown in table 3. In this example, however, the application of additional nitrogen continued to give excellent yield responses for each pound of N with the most profitable return (forage produced per dollar invested) from the 240-pound rate of nitrogen per acre.

Table 4. Nitrogen response and returns from fertilizing smooth bromegrass on Nicollet silt loam, Ames, Iowa.

Nitrogen rate	Dry matter yield	Annual pasture cost(1)	Forage cost(2)
Lb./A	Tons/A	$/A	¢/20 lb.
0	1.29	58	45
60	2.54	73	29
120	3.17	88	28
240	4.37	118	27

(1)From ISU publication AG-96. Includes nitrogen at 25¢ lb.
(2)Assumes that 20 lb. forage DM = 1 lb. live weight gain on yearling steers.

Nitrogen Rates

Suggested nitrogen rates for bluegrass and tallgrass pastures are presented in table 5. The rates are lower for western Iowa than for the rest of the state. This reflects a difference in rainfall—26 to 30 inches annual precipitation in western Iowa, compared with 30 to 34 inches or more for the rest of the state.

Table 5. Nitrogen application rates for grass pasture.

Area	Lb./A of N*	
	Bluegrass	Tallgrass
NW Iowa	60	90
Western Iowa	70	100
Other areas	80	120

*Additional N up to double these rates can be used, but as a split application.

The rates of 60 to 120 pounds of nitrogen per acre as shown in table 5 are considered moderate rates and are best applied as a single application. Additional nitrogen—up to double these rates—can be used in a split application. Consider the higher rates when grass stands are thick; some type of rotation grazing is practiced and the moisture supply looks favorable. Even with continuous grazing, additional nitrogen will be beneficial although rotational grazing will maximize forage yield response. Applying high annual rates of nitrogen in at least two applications will allow better use of the nitrogen and more total yield for the year.

P-K Rates

Studies to measure the response of grass pastures to phosphorus and potassium are limited. Available data indicate that responses are variable, usually small, and occur only when nitrogen is adequate.

In addition to yield response, phosphorus fertilization usually increases phosphorus in the plant that could be an aid to animal nutrition. Both phosphorus and potassium tend to encourage volunteer white clover in pastures that can be a plus to yield and quality.

Small increases in grass yields from phosphorus and potassium may be related to the fact that much of these nutrients is returned to the soil in the urine and droppings from the grazing animals. Furthermore, grasses have an extensive fibrous root system that enhances nutrient uptake.

Since fertilizing grass pastures can be expected to produce large responses from nitrogen and small responses from phosphorus and potassium, it is suggested that the major share of the fertilizer dollar should be spent for nitrogen. More phosphorus and potassium should be used with high nitrogen rates rather than low nitrogen rates because greater yields are expected. Also, the higher yielding tallgrasses will respond to more of these two nutrients than bluegrass with its lower yield potential.

The phosphorus and potassium rates used in making recommendations based on soil tests are listed in table 6. These rates should be used when first starting a pasture fertilization program. If a soil test is not available, apply at least 40 pounds each of P_2O_5 and K_2O per acre for bluegrass and 60 pounds each per acre for tall cool- and warm-season grasses. For subsequent years, follow the rates suggested in the following section, Time and Rate of Fertilizer Application, or retest and follow suggestions in table 6. Iowa studies show that grass pastures on soils testing medium or higher in phosphorus and potassium do not consistently respond to added phosphorus and potassium fertilization.

Table 6. Annual phosphorus and potassium application rates for grass pastures.

Soil test class	Lb./A*			
	Bluegrass		Tallgrass	
	P_2O_5	K_2O	P_2O_5	K_2O
Very low	40	40	50	50
Low	30	30	40	40
Medium	0	0	0	0
High	0	0	0	0

*An additional 10 to 20 lb. of P_2O_5 per acre should be added on calcareous soils.

Time and Rate of Fertilizer Application

Bluegrass and the tallgrasses mentioned are cool-season grasses. They make their major growth during May, June, and up to about mid-July. Growth is nearly at a standstill during hot weather and dry soil conditions that normally occur from mid-July through August. As the weather starts to cool in late August and the moisture supply improves, growth picks up again and continues into October. Adequate nitrogen must be available during these two periods of spring to early summer and late summer to fall for best growth and top grass yields.

Perennial warm-season grasses start growth about the first week in May. Consider applying nitrogen in late April before other fieldwork. Early spring N fertilization can stimulate growth of undesirable cool-season grass species. Producers should consider applying AAtrex in early spring to control undesirable cool-season species. See Pm-569, *Warm-Season Grasses for Hay and Pasture,* and Pm-601a, *Weed Control in Small Grains, Pastures and Legume Forages* for more details. Most producers graze warm-season grasses from mid-June through August. There is little fall regrowth and a second nitrogen application would be of doubtful value.

Following are some suggested annual application rates and times of application. It is assumed that soil test levels are at least in the low to medium category.

For a single-one time application:

Kentucky bluegrass—April: 60 to 80 pounds of nitrogen per acre.
Tall cool-season grasses—April: 80 to 120 pounds of nitrogen per acre.
Warm-season grasses—late April to early May: 80 to 150 pounds of nitrogen per acre.

For high nitrogen rates in a split application:

Kentucky bluegrass—April: 60 to 80 pounds nitrogen, 20 pounds P_2O_5 and 20 pounds K_2O per acre. Early to mid-August: 40 to 60 pounds nitrogen per acre.
Tall cool-season grasses—April: 80 to 120 pounds nitrogen, 30 pounds P_2O_5 and 50 pounds K_2O per acre. Early to mid-August: 60 to 80 pounds nitrogen per acre.

Timing applications of phosphorus and potassium is not critical. Many farmers apply them once each year along with a nitrogen application. If nitrogen is always applied separately, it might be more convenient to double the phosphorus and potassium rate, apply it in early spring or fall, and let it last for 2 years.

When grass production is increased by fertilization, a producer must 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 cut some for storage or allow some growth to accumulate for later grazing. Another alternative is to reduce the acreage of cool-season grasses and establish summer pasture species on that acreage for grazing during July and August. Alternatives include sudangrass, sudan-sorghum hybrids, switchgrass, birdsfoot trefoil-grass to be held for midsummer, or alfalfa-grass cut once for hay. This has the added advantage of resting the cool season pastures during midsummer. The rest period will improve vigor and yield of the cool season grasses and boost fall grazing.

P-K for Legume-Grass Pasture

The value of having legumes in pasture along with grass is illustrated in table 7. In this study when a good stand of birdsfoot trefoil or alfalfa was present in the stand, the legume increased yields equivalent to 120 pounds per acre of nitrogen applied on straight grass. The legume-grass pastures were fertilized with phosphorus and potassium according to soil test. The soil type and environmental conditions in this study are similar to those in northeast Iowa.

Table 7. Beef production from improved pastures, Lancaster, Wisconsin.[1]

Pasture	Fertilizer applied[2]	Liveweight gain lb./A
Unimproved bluegrass	None	100[3]
Bluegrass, redtop, timothy	P-K	201
Bluegrass, redtop, timothy	N-P-K	310
Bluegrass, redtop, timothy, trefoil	P-K	314
Brome-orchard	N-P-K	298
Brome-orchard-alfalfa	P-K	313

(1)From 4-state cooperative research, reported by University of Wisconsin.
(2)N = 120 lb./A P-K according to soil test.
(3)Estimated from long-term averages.

Annual phosphorus and potassium fertilization rates according to soil test levels are shown in table 8. Fertilizer should be applied to reach and maintain a medium to high level in the soil. Adequate phosphorus and potassium are essentials for legume establishment, stand maintenance, and satisfactory yields.

Table 8. Annual phosphorus and potassium application rates for legumegrass patures.

Soil test class	Lb./A*	
	P_2O_5	K_2O
Very low	50	50
Low	40	40
Medium	30	30
High	0	0

*Increase 20 lb./A for calcareous soils.

Much of the phosphorus and most of the potassium in the consumed forage is 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. Soil tests at last every 3 years can help to achieve an adequate fertility level in all areas of the pasture.

Time of application for phosphorus and potassium on legume-grass pastures is not critical. However, early spring or August applications are favored. Applications can be made each year, or you can double the rates and apply every other year.

Other Considerations

Fertilizer will stimulate weed growth as well as grasses and legumes in a pasture. Clip to control weeds or spray grass pastures with 1 to 1 1/2 pounds of 2,4-D per acre.

Spring spraying is the most effective time to kill susceptible annual broadleaf weeds. Fall spraying will be most effective in controlling susceptible winter annual, biennial, and perennial broadleaf species that are in the rosette stage.

Even with 2,4-D, it may be necessary to clip once to control hard-to-kill weeds. Legume pasture cannot be sprayed because 2,4-D will injure all legumes; only clip this type. Eliminating weeds will allow grass and legume stands to thicken faster, and more of the soil nutrients and water will be available for the desirable pasture species. For more information on pasture weed control see Iowa State University Cooperative Extension Service pamphlet Pm-601a, *Weed Control in Small Grains, Pastures, and Legume Forages.*

For best fertilizer response, delay spring grazing until grasses and legumes are well started. Avoid overgrazing. Maintain some leaf area at all times so that plants can intercept adequate sunlight to achieve productive growth. If possible, have several pastures so cattle can be moved for efficient forage use. Building fences and providing water are vital if fertilizer benefits are to be fully realized. Only in this way can grasses and legumes develop strong root systems and carry on growth process that allow yield potential to be met.

Nitrogen fertilizer is a high cost item in pasture improvement. An alternative for eliminating or reducing the need for nitrogen is to establish legumes in existing grass pastures. Legumes can be established in grasses by interseeding or frost seeding. For details on these techniques, see Pm-1097, *Interseeding and No-till Pasture Renovation,* and Pm-856, *Improving Pasture by Frost Seeding.*

In addition to reducing nitrogen needs, legumegrass pastures improve pasture quality and usually provide more grazing in midsummer. Keep in mind, however, that legume-containing pastures require more careful management than straight grass pastures. Grazing must be controlled to maintain plant vigor and enhance disease resistance and winter survival. Weeds are harder to control since herbicide use is limited. Compared with grass greater phosphorus and potassium needs plus the need for periodic reseeding may offset much of the nitrogen cost required for straight grass.

In Conclusion

Fertilization is of prime importance 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. On dry matter yields alone, expect at least a $2 return for each $1 spent for fertilizer. Nevertheless, best returns from pasture fertilization will depend on effective utilization through well-managed livestock and forage programs.

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