

Fertilizing Cool Season Grasses and Grass/legume Mixtures

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Crop Series | Soil



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Successful establishment and sustained productivity of perennial grasses and grass/legume mixtures requires ongoing fertility management that begins well before planting and continues throughout the life of a stand. In Colorado, nitrogen (N) and phosphorus (P) are the two nutrients that must be considered for optimum productivity of grass and grass/legume mixtures. Except in rare cases (for example, sandy soils or fields that have been in long-term hay production), potassium (K) is generally not limiting in Colorado soils.

Soil fertility management during the establishment period of any perennial forage is different from what is required for an established stand. Accordingly, soil fertility management will be discussed in two sections: 'new seedlings' and 'established stands.'

Soil Sampling

It is much more effective to address nutrient deficiencies prior to planting than after a stand is established. For new seedlings, the soil should be tested well before field preparation to identify possible nutrient deficiencies and obtain fertility recommendations that will enhance seedling establishment. By doing so, nutrients can be incorporated prior to planting, which is especially important if P additions are required. For most established forage stands, sampling every three years is sufficient.

Proper sampling of a field is vital to obtaining accurate test results. A good sample consists of at least 15 to 20 soil cores taken one foot deep from randomly selected areas of the field. Avoid sampling areas that may

have misleading pockets of high or low fertility such as near old barns or feedyards, where fertilizers were previously banded, where soil types vary from the rest of the field, or where field history or management have differed. If such areas are large enough, they can be sampled and tested separately. Soil samples should be combined into one uniform, composite sample per field and allowed to air-dry by spreading the soil on clean paper or any other clean surface where it will not be contaminated. **Do not oven dry the soil** because this will change the test results. Once the sample has air-dried, ship the soil in a clean container to the soil test laboratory.

Soil testing can be done at [Colorado State University's Soil, Water, and Plant Testing Laboratory](#), or by a number of private labs, for a modest fee. For grass and grass/legume mixtures, the most relevant test measures are soil texture, organic matter content, pH, soluble salts, nitrate-nitrogen, phosphorus, and potassium, all of which are included in a routine test package. It is important to provide the soil testing lab with information on the crop to be grown and realistic yield goals so that accurate recommendations can be made. Realistic yield goals for well-managed irrigated grass or grass/legume mixtures in Colorado will be between 4 and 6 tons/ac. Depending on precipitation, yields will generally be less than 1.5 tons/ac under dryland conditions with many areas of the state having yield potentials below 1 ton/ac.

More detailed information on taking proper soil samples and interpreting the results can be found in the following fact sheets: [Soil Sampling \(0.500\)](#), [Soil Testing \(0.501\)](#), and [Soil Test Explanation \(0.502\)](#). These fact sheets are available online at www.ext.colostate.edu/pubs/pubs.html#crops.

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Quick Facts

- In Colorado, nitrogen and phosphorus are the two nutrients that must be considered for optimum productivity of cool season grass and grass/legume mixtures.
- It is much more effective to address nutrient deficiencies prior to planting than after a stand is established.
- In most situations, nitrogen is not recommended for establishing grass/legume mixtures because nitrogen stimulates grasses to the detriment of the legume.
- Care should be taken with any fertilizer containing ammonium or urea, as both of these can cause seedling injury if they come into direct contact with seed.

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Nitrogen Suggestions

New Seedlings

Irrigated Grasses

During establishment, grass seedlings require only small quantities of nitrogen (20-40 lbs/ac at planting) to stimulate tillering and growth. Applying more than is necessary during establishment can result in loss of nitrogen to the environment as well as increased weed pressure and competition which can reduce grass seedling survival. Following the initial harvest of newly-seeded grasses, an additional nitrogen application (40-50 lbs/ac) may be justified if further harvests are expected for the season. Late-summer or fall-seeded grasses that are well established can be fertilized with 60 to 80 lbs of N/ac the following spring.

For clean-till seedings, pre-plant nitrogen is typically applied and lightly incorporated along with any needed phosphorus. Starter nitrogen can be banded below the seed; however, yield responses to starter nitrogen in grasses are often seen only in low fertility or cold soil conditions. Manures and composted manures can be broadcast and incorporated as a source of pre-plant nitrogen; however, N content and availability can vary considerably, so be sure to base application rates on results from a manure/compost test. Generally, most manures and composts are very low in N (< 2%).

Caution when Interseeding: No nitrogen should be applied at planting when interseeding grasses into an established sod. Nitrogen applied in this situation will only stimulate established grasses and increase competition to new seedlings.

Common commercial nitrogen fertilizer sources used during grass establishment include 30-10-0, urea (46-0-0), and ammonium sulfate (21-0-0-24S). There is some nitrogen contained in the commonly used phosphorus fertilizers, monoammonium phosphate (11-52-0) and diammonium phosphate (18-46-0), and that nitrogen should be considered when the soil test indicates that phosphorus is needed in addition to nitrogen. Care should be taken with any fertilizer containing ammonium or urea, as both of these materials can cause seedling injury if they are placed or come into direct contact with the seed.

Irrigated Grass/legume Mixtures

In most situations, nitrogen is not recommended for establishing grass/legume mixtures because N stimulates grasses to the detriment of the legume. A small amount of N at planting (20 to 30 lbs/ac) may be warranted if a legume with low seedling vigor, such as birdsfoot trefoil, is included in the mixture or if planting on sandy soils with low fertility. One of the advantages of including legumes in a mixture is that they fix atmospheric nitrogen, so be sure the legume seed is inoculated with the appropriate *Rhizobium* bacteria at time of planting to take full advantage of this process.

Dryland Grasses

Generally, nitrogen is not recommended for establishment of perennial dryland grasses. In Colorado, the uncertainty of rainfall events following seeding can result in significant losses of the applied N under dryland conditions, especially urea. More importantly, any additional nitrogen tends to stimulate weeds which compete more effectively for the small amount of soil moisture that is generally available. In some cases, residual soil nitrogen may be high enough that weeds become too competitive for successful grass establishment. A soil test can determine if efforts are needed to reduce residual N levels prior to seeding.

Established Stands

Irrigated Grasses

Irrigated cool season grasses require significant quantities of nitrogen (30 to 50 lbs/ton of yield) for optimum growth and productivity. Because N is taken up in large quantities by grasses and is very mobile in soils, most available soil N is either removed by plants or lost to the environment. As a result, there is little residual N available for growth of perennial grasses from one year to the next, meaning that N must be applied each year to achieve desired yields. Unless a field has an accumulation of manure from winter feeding or grazing, the majority of perennial grass fields will test low (0-6 ppm) in available nitrogen ($\text{NO}_3\text{-N}$). If your soil test comes back with a level of available $\text{NO}_3\text{-N}$ above 6 ppm, then N fertilizer application rates can be reduced by about 25 lbs/ac for every 6 ppm of $\text{NO}_3\text{-N}$.

There are numerous factors that can affect N-use efficiency of grasses. Factors such as over or under irrigating, deficiency of another nutrient (usually P), and late spring grazing after fertilization can all reduce N-use efficiency. With the current price of N, producers need to be as efficient as possible. There are numerous ways to determine N-use efficiency, but one of the most useful for producers is to calculate the pounds of additional forage the field produces per pound of applied N. These are the pounds of additional forage above what the field would normally produce had no N been applied. On average, producers can expect about 45 lbs of additional forage per pound of N applied from well-managed (i.e. adequate water, phosphorus, timing of harvest, etc.), cool season, irrigated grasses grown at lower elevations in Colorado. This level of efficiency is good for rates of application up to 100 lbs N/ac (sometimes up to 150 lbs N/ac). There are numerous reasons why this level of efficiency is seldom attained in high elevation (above 6000 ft) mountain hay meadows (see fact sheet [Fertilizing Mountain Meadows, #0.535](#)).

Because there are many environmental and management factors that can affect yield responses to nitrogen, fertilizer recommendations must ultimately be tailored to each individual producer's situation based on their experience over time. As a general guideline, consider that most unfertilized irrigated grass hay fields will annually yield between 1 and 1.5 tons/ac. To determine how much N needs to be applied to achieve yields above this amount, use the efficiency value cited above of 45 lbs of additional forage per pound of N applied. For example, consider a 4 ton/ac yield goal in which the first 1.25 tons/ac is obtained without any N fertilizer. The balance of forage desired (5500 lbs/ac) would require about 120 lbs of N/ac (5500 lbs/45 lbs = 120 lbs N). To determine how much N needs to be applied to achieve other yield goals, you can simply add or subtract 45 lbs of N per ton of yield desired.

Most producers apply between 80-200 lbs N/ac annually to their grass hay fields. In Colorado, most grass hay fields are harvested 2 or 3 times per season. When taking multiple cuttings, nitrogen is most efficiently utilized through split applications. Typically, about half of the

N (between 80-100 lbs N/ac) is applied in early spring to take advantage of optimal growing conditions and the higher yield potential of cool season grasses. First cutting yields account for more than half of total annual production of cool season grasses. Following the first cutting, a smaller application (40-50 lbs N/ac) of N will stimulate regrowth and increase second cutting yields if water is plentiful. All cool season grasses suffer from 'summer slump' to some degree as summer temperatures increase. Species such as orchardgrass, meadow brome, tall fescue, perennial ryegrass, and creeping meadow foxtail will continue to grow if water is available (although at a slower rate) while species such as intermediate and pubescent wheatgrass, smooth brome, and timothy tend to go semi-dormant. If a third cutting is anticipated, another N application (40-60 lbs N/ac) can be applied in early to mid-August. If N is applied as a single spring application, rates should not exceed 100 lbs N/ac if the goal is to achieve higher N-use efficiencies.

Pasture Considerations: Annual N recommendations for irrigated cool season grass pastures are usually less than for hay. This is because 85 to 90 percent of the nutrients consumed by livestock are returned to the pasture in the manure and urine. Although a large percentage of the nutrients are redeposited, keep in mind that some are lost through volatilization while others are in organic forms not readily available to plants. The nutrients also end up being concentrated in the manure piles and urine spots in areas where the animals congregate. For these reasons, nitrogen is still required to increase pasture productivity. Newly established pastures require N additions similar to those for hay production. Over time, as the nutrients in

the manure begin to mineralize and cycle, the N application rate can be cut back. There is no hard and fast rule as to how much N rates can be reduced. Keeping good records on pasture productivity is key to determining appropriate N application rates. Keep in mind that dragging or harrowing pastures at least once per year can help break up manure piles and redistribute nutrients.

Nitrogen is best applied to grass pastures in small increments (40-60 lbs/ac) several times over the growing season. This is because grass plants take up available N very quickly once it moves into the root zone and translocate a substantial amount into aboveground growth. As animals graze, they remove a significant portion of the applied N. Nitrogen use efficiency can be significantly increased by applying N several times over the season. If using granular fertilizer such as urea, applying approximately a third of the annual rate 3 times over the season is ideal. If the pasture is irrigated using a sprinkler system with a fertilizer injector, then paddocks can be fertilized with liquid UAN more than three times during the season (basically spoon feeding the grasses). This is the ideal situation for applying N to irrigated pastures.

Urea is the most common granular N fertilizer applied to perennial grasses while UAN is the most common liquid form. Urea is susceptible to volatilization if it lays on the soil surface for extended periods exposed to high temperatures, especially on the high pH, calcareous soils common in Colorado. For example, about a third of applied N was lost in the first eight days following application of urea fertilizer to a soil with a pH of 7.5 and surface temperature of 75°F. If at all possible, apply granular urea just before rainfall is

anticipated or just before irrigation (0.5 inches or more) to minimize volatilization losses. There is the option to purchase urea coated with a urease inhibitor that reduces N volatilization, but its effectiveness has not been tested on irrigated grass production in Colorado. Because it adds to the cost of urea, the added expense needs to be weighed against the 'potential' reduction in volatilization and subsequent improvement in N-use efficiency. Manures and composts are also excellent sources of nitrogen; however, N content and availability can vary considerably, so be sure to base application rates on results from a manure/compost test.

Irrigated Grass/legume Mixtures

Legumes fix their own N from the atmosphere, some of which becomes available to associated grass plants as the nodules slough off and decay over time. With the high price of N fertilizers, taking advantage of natural N fixation by planting grass/legume mixtures is a sound approach. Nitrogen can increase yields of grass/legume mixtures by stimulating the grass component at the expense of the legume. As little as 30-40 lbs N/ac can cause significant decreases in the percentage of legumes in the plant community. Therefore, application of N to mixtures comprised of more than 50 percent legumes is not recommended. The proportion of legume in the mixture naturally declines over time. Once it makes up 25 percent or less of the composition, stands can be fertilized with N based on the grass recommendations above.

Dryland Grasses

For cool season grasses grown under dryland conditions (e.g. smooth brome and crested, intermediate, and pubescent

Table 1: Suggested P rates for irrigated cool season grasses and grass/legume mixtures.

ppm P in soil				Fertilizer rate ¹ (lbs P ₂ O ₅ /ac)	
AB-DTPA test	NaHCO ₃ test	Mehlich-3 test	Relative level	Grass only	Grass/legume Mixtures
0-3	0-6	0-9	very low	60	90
4-7	7-14	10-21	low	40	60
8-11	15-22	22-33	medium	20	30
> 11	> 22	>33	high	0	0

¹Suggested rates will generally supply P for 2 to 3 years of production. The same rates are used for both new seedings and established stands.

wheatgrass), annual nitrogen applications are typically between 30 and 60 lbs/ac. The drier the area, the lower the N rate should be.

Phosphorus Suggestions

New Seedlings

Irrigated Grasses and Grass/legume Mixtures

Phosphorus is the second most common limiting nutrient in Colorado, after nitrogen. Phosphorus is not very mobile in the soil, so P fertilizers should be broadcast and incorporated into the root zone prior to planting to facilitate their availability. Because young plant roots need a ready supply of available phosphorus, banding of a starter fertilizer an inch below the seed (even in addition to a broadcast application) can often give seedlings a head-start. Preplant phosphorus applications based on soil test recommendations are usually adequate to cover crop needs for the first two to three years of production (Table 1).

The recommended soil analysis methods in Colorado are the AB-DTPA and Olsen sodium bicarbonate (NaHCO_3). The sodium bicarbonate test has roughly twice the extracting ability of the AB-DTPA test. Because fertilizer recommendations are based on the amount of extracted P, it is important to know which test has been used. Values for both tests are given in Table 1. The Mehlich-3 soil test is also becoming more commonplace for use in both acidic and alkaline soils. Several of the Nebraska labs are routinely running this test. The Mehlich-3 test extracts about 1/3 more P compared to Olsen's (Table 1). The Bray soil test should not be used on high pH soils; it will result in erroneously low levels of available soil P.

Most phosphorus is applied as one of three granular fertilizers: triple superphosphate (0-45-0), monoammonium phosphate (11-52-0), or diammonium phosphate (18-46-0). Some high-P starter fertilizers, such as liquid ammonium polyphosphate (10-34-0), can be used as well. Each of these forms of P fertilizers is equally effective, so base purchases on availability, cost per unit of P, and the need for N. Many manures and composts contain appreciable amounts of phosphorus and can be easily incorporated prior to seeding; however, P content can vary considerably, so be sure to base application rates on results from a manure/compost test.

Dryland Grasses

Although nitrogen is not recommended during establishment of dryland grasses, phosphorus can be beneficial if the soil test level comes back in the 'very low or low' category. Apply and incorporate 40 lbs P_2O_5 /ac prior to seeding. This amount will generally supply adequate P for 3+ years, depending on precipitation and subsequent yields.

Established Stands

Irrigated Grasses

Following establishment, grasses may require added P every 2 to 3 years to account for crop removal. Always base P application rates on current soil test recommendations. The same application rates are recommended for new seedlings and established stands (Table 1). Test soils in early fall so P fertilizers can be topdressed prior to winter if needed. Phosphorus moves slowly in soil under most conditions; therefore, applying fertilizers during this time allows the P to move into the soil through winter freeze/thaw processes and snowmelt where it can be taken up by the fine branch roots near the soil surface. Note that the probability of forages responding to topdressed P is greater on soils testing 'very low to low' in extractable P. If available, topdressing compost is also most effective in the fall after the final cutting.

Irrigated Grass/legume Mixtures

Adequate available P is extremely important for maintaining the legume component in grass/legume mixtures. Legumes require about 50% more P compared to grasses. Therefore, if legumes make up 25% or more of the stand composition, apply 50% more P than for a grass only stand (Table 1).

Dryland Grasses

For maintenance of established dryland grass stands, apply P based on periodic soil tests at half the rate for irrigated grasses in Table 1 (i.e. 30, 20, or 10 lbs P_2O_5 /ac for levels of very low, low, and medium, respectively).

Potassium Suggestions

Most Colorado soils are relatively high in extractable potassium. Consequently, few crop responses to K fertilizers have been reported. It is important, however, to realize that hay production, which removes the entire plant, removes large quantities of potassium. This could result in K deficiencies in soils with a long history of forage production.

Soil testing is the only way to know for sure whether soil K levels are adequate. Suggested K rates are given in Table 2; these rates are for three years of production of grasses and grass/legume mixtures under irrigated conditions.

The main K fertilizer is potash (KCl, 0-0-60). For new seedlings, broadcasting and incorporating potassium fertilizers into soils testing low in K prior to planting is the usual method of application. Potassium fertilizers can be topdressed on established stands if the soil test indicates it is needed.

Sulfur Suggestions

Most Colorado soils contain adequate levels of sulfur (S), so soil tests for available S are not routinely performed. Legumes have a high S requirement (a 4 ton/ac alfalfa crop removes 20 lbs S/ac). Therefore, levels of available S may decrease over time and potentially become limiting in situations of high producing grass/legume mixtures where the legume component makes up

Table 2: Suggested K rates for irrigated cool season grasses and grass/legume mixtures.

ppm K in soil AB-DTPA or NH_4OAc	Relative level	Fertilizer rate ¹ lbs K_2O /ac
0-60	low	60
61-120	medium	40
> 120	high	0

¹Suggested rates are for 3 years of production. The same rates are used for both new seedlings and established stands.

over 50% of the composition. The greatest potential for S deficiency would be on sandy soils low in organic matter. Irrigation water from most surface waters and some wells often contains appreciable sulfate-sulfur ($\text{SO}_4\text{-S}$), so irrigated soils are usually supplied with adequate S. However, some well waters, as well as snowmelt water, are low in $\text{SO}_4\text{-S}$, so water samples should be analyzed in addition to soil samples if S deficiency is suspected. Sulfur should not be needed if irrigation water contains more than 6 ppm $\text{SO}_4\text{-S}$ or if the soil test is greater than 8 ppm $\text{SO}_4\text{-S}$. If needed, apply 30 to 40 lbs S/ac.

Other Nutrients

There have been no confirmed deficiencies of boron (B), copper (Cu), iron (Fe), manganese (Mn), or zinc (Zn) in perennial cool season grasses or grass/legume mixtures for forage production in Colorado.