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Section I

Irrigated Pasture/Mountain Meadows

Chapter 6

Fertility Management

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Irrigated Pastures and Hayfields

Soil Testing

Making fertilizer recommendations without a soil test is, at best, a "shot in the dark". Soil tests provide important information on pH, salinity, soil texture, and availability of nitrogen (N), phosphorus (P), potassium (K), and other nutrients. A soil test is only as good as the sample used to perform the test, so careful soil sampling is essential for accurate fertilizer recommendations. A composite soil sample needs to be taken and should represent a uniform field area. Exclude small areas within a field that are obviously different. These can be sampled separately if they are large enough to warrant special treatment. A single composite soil sample should represent no more than 40 irrigated or 100 dryland acres.

Use a systematic sampling scheme and a minimum of 15 subsamples throughout the field, regardless of acreage. The subsamples should be thoroughly mixed in a clean plastic bucket. Take one pint of soil for the composite sample.

Sampling depth for pastures or hay crops should be eight to twelve inches. It is best to use a soil sampling probe, but a shovel can be used if it is free of rust. Sample most fields every year for nutrient analyses or until enough history is obtained to sample every other year. Perennial grass pastures and hay fields will always need nitrogen, but the amount of nitrogen needed for a set yield goal can only be determined with a soil test. Thoroughly air dry all soil samples within 12 hours after sampling.

Nitrogen: Nitrogen is the most important nutrient that must be applied to sustain yields of forage grasses over time. It will almost always be limiting in perennial grass stands. Nitrogen is generally applied in the spring to maximize production during that growing season.

Nitrogen can be applied in the fall, but there are several potential drawbacks that must be considered to avoid environmental impacts and economic losses. The first negative impact could come from runoff and/or leaching (i.e. movement below the root zone) losses during the winter or early spring, since nitrogen is water soluble. Secondly, nitrogen applied in the fall followed by fall moisture could allow cool-season grasses to take up and use a portion of the nitrogen that was intended for production during the next spring and summer. The third possible way to lose benefits from fall applied nitrogen for the following year's hay crop would be in situations where spring grazing is followed by a hay crop in mid-summer. Basically, grass plants utilize a portion of the fall applied nitrogen for early spring growth which is then grazed off by livestock. This leaves plants short of nitrogen to maximize regrowth for a hay crop later in the summer. Finally, when using fertilizer sources such as urea, some of the nitrogen could be lost into the atmosphere through volatilization before it has a chance to move into the soil.

Although there are some potential drawbacks to fall fertilization of grasses with nitrogen, there are some potential positive benefits as well that should be considered. If

the field will not be grazed by livestock in the spring, then applying nitrogen in the fall can be beneficial by stimulating bud development. The more buds that are stimulated in the fall, the more grass tillers that will be produced in the spring which can lead to increased yields. Smooth brome is one species that responds well to fall fertilization. For pastures grazed in the spring, applying nitrogen in the fall can stimulate earlier spring green up which can lead to greater spring productivity.

In irrigated hayfields where more than one cutting per season can be obtained, nitrogen needs can be as high as 180 lbs/ac per season. All 180 lbs/ac of nitrogen should not be applied at one time, but in split applications starting in the spring and after each cutting. No more than 100 lbs/ac should be applied per application to prevent potential "burning" (i.e. leaf browning) of the grass.

For mixed grass/legume stands, you should minimize application of nitrogen fertilizers if you want to maintain the legume component. Nitrogen stimulates grasses to the point that they out compete the legumes. Applying as little as 30 to 40 lbs of nitrogen per acre can cause significant reductions in the legume component. Nitrogen rates in the 80 to 100 lb/ac range will almost totally eliminate the legumes. Conversely, if you want to stimulate the legumes, test your soil phosphorus levels and apply if needed. Legumes need adequate phosphorus to be productive and compete with the grasses.

Nitrogen fertilizers used for pastures and hayfields include granular urea (46-0-0), liquid urea ammonium nitrate (UAN, 28-0-0 or 32-0-0), and sometimes anhydrous ammonia (82-0-0). If used, anhydrous ammonia is generally applied by metering it in with irrigation water. When using sprinkler irrigation, liquid UAN can easily be injected with the water using a fertigation pump. Ammonium nitrate (34-0-0) was a common source of nitrogen at one time, but most

suppliers no longer carry it due to increased regulations associated with its explosive nature. Fertilizers like granular monoammonium phosphate (11-52-0) and diammonium phosphate (18-46-0) supply small amounts of nitrogen, but are typically only applied if phosphorus is limiting in the soil.

Phosphorus: Legumes such as alfalfa and the various clovers are big users of phosphorus (P), but grasses also need a certain amount of P and a soil test is needed to determine those needs. Phosphorus serves a number of functions in the plant, but is especially important for enhancing root development. As stated above, maintaining adequate phosphorus in the soil is important for maintaining the legume component in mixed grass/legume stands.

On established pastures and hayfields, phosphorus should be applied in the fall for maximum benefit the following growing season

Phosphorus is not very water soluble, so freezing and thawing in the winter can assist in moving granular phosphorus into the soil. This allows a plant's feeder roots to start utilizing the phosphorus the next spring.

Applying granular phosphorus sources in the spring can be done; however, the full benefit may not be realized in that growing season. Since phosphorus does not readily leach out of the soil, a portion of spring applied phosphorus should still be available the following season.

Phosphorus becomes less available as soil pH exceeds 7.5. Most area soils have pH's ranging from 7.8 to 8.3 or higher which may require more phosphorus to be applied compared to other areas with lower pH's. This is another reason to soil test. Soil test extracts measure only the portion of P which is available to plants.

Phosphorus fertilizer needs for irrigated pastures or hayfields can be as high as 80 lbs/ac with most requirements falling in the 30 to 40 lbs/ac range. Again, a soil test is the only way phosphorus deficiencies can be determined for particular pastures or hayfields.

Commonly used granular phosphorus fertilizers are monoammonium phosphate (11-52-0) and diammonium phosphate (18-46-0). Liquid ammonium polyphosphate (10-34-0) can be injected through sprinkler irrigation systems.

Potassium and Micronutrients: Colorado soils are generally adequate for potassium and micronutrients, however, a soil test should be done to know for sure.

Fertilizer Rates

The amount of nutrients recommended on a soil test report is expressed in lbs/ac of nitrogen, phosphorus, potassium, and other nutrients. Different fertilizers contain different percentages of nitrogen, phosphorus, etc. For example, if 80 lbs/ac of nitrogen is needed and urea (46-0-0) is the product being used, you would need to apply 174 lbs/ac of bulk urea to obtain the 80 lbs of nitrogen per acre. This is calculated by dividing 80 lbs/ac by 0.46, which is the percentage of nitrogen in urea.

Mountain Meadows

Low soil fertility is generally the major factor limiting forage production from mountain meadows. Nitrogen (N) is the number one limiting nutrient. Nitrogen is so universally limiting that a soil test is generally not required to obtain a positive yield response. However, soil testing determines the N needed to obtain the desired yield goal.

In addition, soil testing is necessary in meadows that have received excessive additions of manure through either actual application or concentration of animals during

winter feeding. Manure is a low analysis source of N, but can supply adequate amounts for plant growth if applied or deposited in large enough quantities. A drawback to applying manure as a source of N is that it is even a larger source of carbon which contributes to the already overabundant pool of organic matter common to many mountain meadows. Manure additions contribute to the formation of a peat layer which is resistant to decomposition and acts as a nutrient sink. Over 5,000 lbs of N/ac has been measured in a four inch layer of peat, but the N was tied up in forms unavailable for plant growth. Essentially, the meadow was N deficient and needed additional inputs of N for optimum plant growth.

Phosphorus (P) is the second most common nutrient that limits plant growth in mountain meadows. Unlike N, relatively few (25%) Colorado meadow soils are P deficient. A soil test is required to determine P deficiencies. Adequate soil P is essential to promote vigorous growth of legumes such as clover, alfalfa, and birdsfoot trefoil. Although legumes have greater requirements for P compared to grasses, P fertility should not be overlooked when trying to promote grass growth with N. Grass response to added N can be reduced or totally nullified if soil P levels are low.

Potassium (K) and sulfur (S) are the other elements that may occasionally be deficient in mountain meadows. Most Colorado soils contain adequate amounts of these two elements, but soil levels should be routinely determined by testing because of the importance these nutrients have in plant function.

Benefits and Drawbacks Associated with Added Fertility

Increased yield is the primary benefit associated with added fertility. Nitrogen fertilization is generally the quickest, most reliable method to increase meadow production.

Even with today's high N prices, it is usually also the most economical way for operations that are short on hay to obtain more (versus buying). However, there are other positive and negative effects associated with N fertilization that must be considered before starting a fertility program.

Grasses and many grasslike plants (i.e. sedges and rushes) respond extremely well to N fertilization. Grass plants have a fine, fibrous root system concentrated in the upper 12" of soil which acts like a sponge for N. The ability of grass plants to quickly uptake applied N gives them a competitive advantage over other plants.

Loss of the legume component generally lowers forage quality, especially crude protein content. This can be a major economic factor if additional protein supplement must be purchased to make up for the lower protein content in the hay.

Crude protein content of the grass component can increase, decrease, or be unaffected by N fertilization. Rate of N application in conjunction with time of cutting determines the response in crude protein content. Only at application rates above 150 lbs N/ac can crude protein content of grass be consistently increased. These rates are not economically feasible for mountain meadows. At normal application rates between 60 and 100 lbs N/ac, crude protein content of grass will be equal to or generally lower than unfertilized grass. Only by harvesting before grass plants reach peak production (at least two to three weeks earlier than normal) can the crude protein content of N fertilized hay be increased one to two percentage points over unfertilized hay.

Nitrogen fertilization will almost always increase the amount of crude protein produced per acre. However, if hay is not harvested in a timely manner, the concentration of crude protein may be lowered (i.e. diluted by all the extra growth) to the point where animals cannot physically consume enough

to meet their requirements. As a general rule, N fertilization should not be counted upon to increase crude protein content of hay.

Although N fertilization negatively affects clover composition, it can have positive effects on grass composition. Many meadows have been overseeded with improved grass species over the years. These grasses often remain as part of the composition, but only in minor amounts. Improved varieties of grass species have been selected for high yield, but only with adequate fertility. Additions of N can stimulate these introduced species to compete with the lower producing native plants. Major shifts in species composition and productivity of a meadow can occur in as little as two to three years following implementation of an N fertility program. The drawback to shifting species composition to higher producing, introduced grasses is that yearly applications of N are required for those plants to remain productive. Yields may drop below pre-fertilization levels if N fertilization is discontinued after several years.

The positive effects of N on grass composition can occur even under less than optimum water conditions. Vigorous stands of grass can be maintained under higher than optimum soil water conditions with added N fertility. Without added N, native sedges and rushes tend to quickly reestablish themselves.

Added fertility, both N and P, can also improve success of other management practices. Interseeding of improved forage species is a good example of how two management practices can complement one another. As indicated earlier, improved forage species have been selected for high yields, but only with added fertility. Introduction of these species without consideration of fertility requirements will often lead to disappointing results. Grasses need adequate amounts of both N and P for vigorous

growth while legumes need only adequate amounts of P.

The rate at which N should be applied depends primarily on the producers individual yield goal and yield potential of the given meadow

Nitrogen Recommendations

Time and rate of application, source of N, and type of soil to be fertilized are the main factors that must be considered when designing a nitrogen fertility program for mountain meadows. Currently, the granular form of urea (45% N) is the most common source of N used to fertilize mountain meadows. Until recently, ammonium nitrate was the preferred source of N for use in mountain meadows, but as stated above, most suppliers no longer carry it due to the regulations associated with its explosive nature. Urea-based fertilizers have a tendency to volatilize ammonia into the atmosphere. To reduce potential for ammonia volatilization, urea should not be applied to warm, saturated soils, to soils with a pH much higher than 7.0, nor be allowed to lie on a dry soil surface for long periods of time. To optimize yield response, urea should be applied to moist soil or as close as possible to an anticipated rainfall or irrigation event so that the granules quickly dissolve, allowing the N to move into the soil.

Urea-ammonium nitrate (32%) is a liquid blend of the two N sources that is also commonly used. Ammonia volatilization can also occur with this N source because of the urea component. With liquid fertilizers, the potential for increased N losses exists when applied to meadows with heavy plant residues. Spraying or dribble banding liquid fertilizer leads to interception of some of the

solution by plant residues. The intercepted N can then volatilize or be tied up by organic residues in forms that are unavailable for plant growth. For the N to be effective, it must reach the soil surface. Generally, dribble banding is superior to broadcast spraying when applying liquid fertilizers to mountain meadows.

Spring is generally preferred to fall as the time to apply N to meadows for several reasons. First, potential losses are minimized. Applying N in the spring just as plants begin to grow allows roots to quickly absorb N as it moves into the soil. The most effective time to apply N in the fall is after all plant growth has ceased. This means that the N is in a highly mobile form for up to six months before plants begin to uptake it in the spring. During this time, N can be carried off meadows in runoff or percolate below the rooting zone, potentially contaminating groundwater. Most mountain meadow soils also contain large amounts of organic matter which can immobilize free N making it unavailable for plant growth in the spring.

Most meadows are also grazed in the spring. If N is applied in the fall, plants will quickly uptake any available N early in the spring which will subsequently be removed by livestock, thus lowering subsequent hay yields. This same scenario applies if N is applied too early in the spring. Nitrogen should not be applied in the spring until after all livestock have been removed from a meadow to achieve maximum hay yield response to added N.

Fall applications of N are practical, given proper timing, when the meadow will not be grazed in the spring. Application should be timed to occur after all plant growth has ceased, but before the ground freezes. This allows time for N to move into the soil. Fall application of N can stimulate reproductive growth of some grass species the following year, thereby increasing yields above what

would be achieved with spring application. On some meadows that are excessively wet in the spring, fall application may be the only practical alternative.

Although virtually all meadows will respond to N fertilization, it is almost impossible to accurately predict the exact response for a given meadow in a given year. Elevation, topography, soil type, water regime, species composition, and grazing practices are all factors that can cause meadow-to-meadow and year-to-year variation in yield responses. Meadows with the following characteristics have the greatest potential for response to added N: (1) improved grass species present such as smooth brome, meadow brome, orchardgrass, timothy, and creeping or common meadow foxtail, (2) mineral soil, (3) good drainage, and (4) good water control and coverage. Meadows dominated by sedges and rushes growing on heavy organic soils with poor drainage have the least potential to respond to N fertilization. Meadows or parts of meadows with the largest number of desired characteristics should be chosen for N fertilization so that the highest return on investment can be realized. Blanket applications of fertilizer across whole meadows may not be economically justifiable.

Based on years of research on numerous meadows throughout Colorado, the average yield response is 20 pounds of extra forage per pound of added N up to the 100 lb N/ac application rate. Although yields continue to increase above the 100 lb N/ac rate, the efficiency of use of the applied N steadily decreases. As a general rule, the lower the application rate, the higher the efficiency. For most producers that take only one cutting, application rates between 40 and 80 lbs N/ac are sufficient to stimulate economical yield responses. At rates above 80 lbs N/ac, many common meadow grasses tend to lodge (i.e. fall over on the ground) which creates difficulties in cutting and drying hay. Rates be-

low 40 lbs N/ac tend to stimulate the undergrowth that many producers like while not totally driving out clovers and other legumes. However, the yield response may not be sufficient to meet the total hay needs of an individual operation. Even low rates of N are generally economical given the higher efficiency of yield response.

Producers at lower elevations that harvest meadows more than once should consider split applications of N. The total amount of N applied for the year will usually be higher than for a single application. For example, a meadow harvested only once may receive 80 lbs N/ac in the spring, but a meadow harvested twice may receive 60 lbs N/ac in the spring and 40 lbs N/ac after the first cutting for a total of 100 lbs N/ac for the year. Generally, a slightly higher rate is applied in the spring to stimulate early growth and earlier harvesting so the second crop has time to mature.

The final consideration is soil type. Many mountain meadow soils have developed a dense surface mat of organic matter that ranges from one to four inches thick. This mat, often referred to as a peat layer, has developed as the result of many years of flood irrigation with cold water from snowmelt. Nitrogen fertilizer applications usually increase forage production on meadow soils with organic mats. However, recovery in the forage and use efficiency of the applied N generally are much lower on organic soils than on mineral soils. Recovery of applied N generally averages less than 30% on organic soils compared to 30 to 50% (may be as high as 80%) on mineral soils. Although organic soils respond favorably to N fertilization, the lower N efficiency must be considered when determining optimum N rates based on economic returns. Nitrogen fertilization of organic meadow soils generally is economically feasible, but break-even values will be lower as compared with those for mineral soils.

Phosphorus Recommendations

Only about 25% of mountain meadow soils in Colorado are P deficient. Therefore, P deficiencies and application rates should be based on soil test results. Suggested P rates based on broadcast applications related to soil test levels are shown in Table 1. The main soil tests for extractable P in Colorado use either AB-DTPA or sodium bicarbonate (NaHCO₃) extracts, and values for both tests are included.

Phosphorus moves very slowly into the soil. For that reason, soils should be tested, and P should be applied in the fall if needed. This gives the P time to move into the soil so plants can uptake it during the following growing season. Freezing and thawing also helps incorporate P fertilizers that have been applied during the fall. The yield response to applied P may be at least partially delayed until the following year if application occurs during the spring.

Unlike N, P is not susceptible to leaching losses which means it can be applied once every two to three years at higher rates to avoid yearly application costs. However, producers using this practice should be aware that the potential exists for some of the added P to become unavailable on meadows with large amounts of organic matter (i.e. peat layer). Also higher rates at a single application increases potential of P runoff. Although the forage will continue to respond to the added P beyond the first year, the total response may be lower than if smaller amounts were applied on a yearly basis.

Table 1. Suggested broadcast phosphorous rates for irrigated mountain meadows.

Extractable P (ppm)			Fertilizer rate, lb P ₂ O ₅ /ac	
AB-DTPA	NaHCO ₃	Relative Level	New Seedings	Established Stands
0-3	0-6	very low	80	40
4-7	7-14	low	40	20
8-11	15-22	medium	20	10
>11	>22	high	0	0

NOTE: Apply P fertilizers for established stands on the basis of current soil test results.