# Management of Irrigated Forages in Nevada

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## Summary

Information and recommendations regarding management of irrigated forages is presented in the following bulletin. Consideration is given to management of both pasture and haylands. Recommendations are made for the production of high quality forage in each of the three major climatic areas in Nevada with specific consideration given to the problems of primary importance in each climatic area.

This bulletin is part of a series of publications about adapted plant materials for various uses and soils in the different climatic regions of Nevada. These publications have been developed by Nevada Cooperative Extension and the Soil Conservation Service, United States Department of Agriculture, with assistance from other agencies. This series includes four other publications: Irrigated Forages for Northern Nevada-Type Climate, Irrigated Forages for Western Nevada-Type Climate, Irrigated Forages for Southern Nevada-Type Climate, and Conservation Plantings for Rangeland, Windbreaks, Wildlife, and Conservation Cover.

The recommendations were developed to serve as a common source of information regarding plant materials and their management. Their use is encouraged by agricultural workers in the state to aid individuals or agencies to arrive at proper decisions for use of plant materials for agricultural and non-agricultural use.

## Acknowledgements

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# Management of Irrigated Forages in Nevada

## Introduction

Forages are the most important irrigated crop grown in Nevada. During 1988-1989 an average of 510,000 acres of hay were harvested. This was 88 percent of the total harvest acres of all crops. Alfalfa hay was produced on 250,000 acres and other hay was grown on 260,000 acres. Production on this acreage was more than 1 million tons. Production of other hay was 286,000 tons. Other hay was primarily wild hay but some clover, timothy and annual hay were included in this total. The average yearly value of all hay produced during 1988-1989 was more than $126 million and was 60 percent of the total value of all crops harvested in the state (11). In addition, there were about 255,000 acres of irrigated pasture with a value of over $4.5 million.

## Establishment of Pastures and Haylands

### Seed and Seeding

**Species and varieties.** An important method of increasing crop yields is through the use of improved adapted varieties. In spite of a good seedbed with optimum amounts of fertilizer and water, yields will be reduced if the proper species and variety are not used. Adaptation of a forage species and variety are dependent upon climatic and soil conditions, availability of water, and resistance or tolerance to prevalent diseases and insects. Alfalfa is a universally adapted species to Nevada. There are relatively few areas in the state in which one or more of the many alfalfa varieties available cannot be grown. See your Nevada Cooperative Extension agent or district conservationist for current recommendations and variety characteristics. Characteristics and adaptation to climate and soils of other forage species are given in Nevada Cooperative Extension publications BE-91-01, BE-91-02 and BE-91-03.

**Use High Quality Seed.** The use of pure, high quality certified seed is essential for maximum forage production. Growers should buy only from reliable dealers. Seeds harvested when ripe and maintained under favorable storage conditions will retain their viability for many years. In general, seeds remain viable for long periods if stored at low temperatures and low relative humidity.

Certified seed is grown under isolated conditions so that genetic purity is maintained. Fields are inspected before planting and one or more times prior to harvest. Off-types are removed. If fields meet the certification standards, the harvested seed receives a lot number and each bag is sealed with a certification tag. Germination of the seed is updated annually by a seed test.

The ability of a forage seedling to maintain itself through photosynthetic activity does not begin until 10 days after emergence. Up to this time, seedling development depends largely upon the food reserve stored in the seed. Particular attention should be paid to seeding depth in relation to seed size. Heavy seeds usually produce more vigorous seedlings than light seeds, therefore, stands from large seed would have a better chance of survival under adverse growing conditions. Large, plump, well developed seeds contain an abundant supply of food reserves for the rapid development of the young seedlings. Small or poorly developed seeds may not contain enough stored food to give the plant a vigorous start.

Legumes differ from other forages in that rhizobia bacteria living in association with legumes are able to fix atmospheric nitrogen. The primary advantage of inoculation is to insure presence of effective symbiotic bacteria for nodulation. When this is done, it is unnecessary to add nitrogen fertilizer to the mature plants since the symbiotic bacteria will fix between 40 and 500 pounds of nitrogen annually. Inoculation should always be practiced even though legumes have previously been grown on the land.

Commercial inoculants are readily available and are specific for the legume to be grown. When inoculating alfalfa seed one should be aware that strains of rhizobia specific to alfalfa should be chosen. The viability of the bacteria that makes up the inoculant is drastically reduced by exposure to direct sunlight, high temperature or desiccation. Seed can be inoculated by mixing the inoculant with the seed as it is put in the planter box. Seed can be slightly moistened and mixed with inoculant prior to putting the seed in the planter, or pre-inoculated seed can be purchased. In the latter instance, the buyer should check with the seller relative to the date of inoculation. In general, seed inoculated more than six months prior to purchase will, in all probability, have lost many of the viable bacteria.

Many legume seeds and a few grass seeds are referred to on the seed tag as a percent hard seed that do not germinate readily. Hard seed can be overcome by scarification or fall planting. Hard seed, when planted, will generally germinate the following season.

**Seedbed Preparation. Tillage:** All necessary land leveling, grading, shaping and subsoiling operations should be completed prior to seedbed preparation. When deep cuts and fills are required in land leveling, a year in an annual crop will allow final smoothing operations after the soil has settled. This will also improve soil condition in areas where much topsoil is removed. Allow a year in cultivated or other annual crops before reestablishing a perennial forage crop.

A preparatory crop, such as sudangrass, corn or a small grain, leaves an excellent seed bed for drilling seed of forage plants and reduces wind or water erosion to a minimum.

Seed may be drilled directly into stubble in early fall.

A firm seedbed is essential for the successful establishment of forage plants. A firm seedbed is one that allows a person's foot to sink no deeper than one-half inch. This provides for more uniform depth of planting, and insures close contact between the seed and soil particles. A firm seedbed will help retain soil moisture near the surface and near the seed. If the seedbed is too soft, the producer should go over the area with a cultipacker or ring roller. Soils subject to compaction should not be tilled when wet.

Competition from weeds can be reduced by good seedbed preparation. Tillage should provide for germination of weed seeds and destruction of the seedlings when they are small. The use of preplant, pre-emergence or post-emergence herbicides should be considered and label recommendations followed.

**Soil Moisture.** A preplant irrigation should be applied as necessary to bring soil moisture to field capacity. Seeding should be done as soon as possible after soils have dried sufficiently to allow use of planting equipment. Planting seed in dry soil and "watering up" often results in soil crusting, salt accumulation and may delay or reduce germination. If "watering up" is a practice to be followed, light and frequent water applications will be necessary. This will be easier with sprinkler-applied water than with any other method of watering. The key to success is to keep the soil surface moist until the cotyledons and first true leaf have emerged.

**Companion Crops.** Pasture and hayland seedings establish rapidly with more vigorous stands when seeded alone. Although companion crops can provide more forage the first year, the density and vigor of the permanent species is generally reduced due to competition for light, moisture and nutrients. Accordingly, forage yields in subsequent years may be reduced. However, a companion crop is beneficial in areas where sand may blow and cut off or cover the young forage seedlings. If a small grain companion crop is used, the seeding rate of the cereals should be one-half the normal rate, and may be broadcast planted or planted in rows spaced 12 inches or wider. Forage seeding could be in a separate operation and in a different direction from the grain.

**Insect and Rodent Control.** Pests such as cutworms may be present in the soil and should be controlled before new seedings are planted. Grasshoppers, weevils, thrips and mites may also be a problem. Check with local information sources for necessary treatments for insects and rodents.

**Disease Control.** Diseases are best controlled by use of adapted varieties obtained from a reputable source. Producers should also consider crop rotations, proper irritation and management. Seed-born diseases are not generally a major hazard to forages. Normally, forage seeds are not treated, but a certain degree of disease control can be achieved with fungicides when label recommendations are followed.

## Autotoxicity of Alfalfa

When alfalfa yields begin to decline because the stands are old, the grower has the options of: (1) plowing the old stand under and replanting alfalfa; (2) planting an alternate crop and then seeding to alfalfa; (3) attempting to increase the productivity of the existing stand by overseeding with alfalfa; or, (4) retaining the stand in its declining condition and suffering losses. The practice of seeding alfalfa into depleted stands or into alfalfa sod has usually been unsuccessful in Nevada. Nevada Cooperative Extension researchers have attempted to determine if autotoxicity (when a plant is toxic to itself) is important in alfalfa seedling germination and seedling growth.

Results of greenhouse and laboratory trials indicate alfalfa is toxic to itself during establishment. In a greenhouse trial, alfalfa seedlings were smaller when grown in fallow soil, even though both soils were either steam pasteurized or fumigated. In laboratory trials, rate and percent germination, seedling vigor and seedling growth were reduced by the addition of alfalfa foliage extracts, alfalfa residue extracts or extracts from alfalfa soil. The reduction in performance in both trials is attributed to autotoxicity.

Field trials were conducted at the Animal Research and Extension Center in Reno, at Newlands Agricultural Research Center in Fallon, and at the Central Nevada Agricultural Research Center near Austin. Overseeding depleted alfalfa stands with alfalfa at the Reno and Fallon sites proved unsuccessful. This failure is attributed to competition from existing vegetation rather than autotoxicity. At Reno, when alfalfa or red clover was seeded into soils where grasses or alfalfa were the previous crop, no reduction in stand or alfalfa yields was observed. However, yields of red clover were significantly higher when it was grown in soils where alfalfa was the previous crop as compared to where grass was a previous crop (Table 1). At Austin, red clover yields were also higher where alfalfa was the previous crop. However, alfalfa yields and stand density were significantly lower if alfalfa had been the previous crop than when grass was the previous crop. Reductions in yield may be due to disease as well as autotoxicity.

**TABLE 1.**
**Effect of Previous Crop on Yield and Stand Density of Two Alfalfa Varieties and Red Clover at Austin, Nevada**

| Variety | Previous Crop: Cereals Percent Density | Cereals T/A | Alfalfa Percent Density | Alfalfa T/A | Percent Reduction Percent Density | Percent Reduction T/A |
|---|---|---|---|---|---|---|
| Narragansett | 48 | 1.75 | 41 | 1.10 | 15 | 37 |
| Agate | 47 | 1.62 | 39 | 1.52 | 17 | 6 |
| Red Clover | 68 | 1.49 | 70 | 1.82 | +3 | +22 |

These laboratory and field demonstrations showed that continuous alfalfa or overseeding declining stands is a questionable practice. Planting a cereal crop between alfalfa seedings is recommended. If a legume is needed in a rotation following alfalfa, red clover offers a short-term alternative.

## Fertilization

Forage seedlings require ample amounts of essential plant nutrients soon after germination. Young plants utilize seed-stored nutrients for germination and initial growth. When these reserves are depleted, the plant is dependent upon the soil for nutrition. Seedlings first develop roots that grow rapidly and supply moisture and nutrients even before emergence from the soil. This developing root system is not extensive and, consequently does not occupy much of the total soil volume. Root elongation and growth period is critical to the young plant. It is during this period of time that proper management can ensure a healthy, successful stand. Precautions must be made to be certain that growth factors such as nutrients and moisture are not limiting. If the soil is unable to provide the proper nutrients in the required amounts, supplemental fertilizer must be added. A soil test is a valuable tool to aid in the fertilizer management program. The test can determine the nutrients and amounts present and are the basis for supplemental fertilizer recommendations.

**Legumes.** Phosphorus ($P_2O_5$) will likely be the primary plant nutrient for legume establishment and production since it stimulates early root development and vigor. If the soil test suggests a phosphorus deficiency, this nutrient should be applied. Nevada trials indicate that phosphorus applied preplant and lightly incorporated is slightly more effective than the same amount of phosphorus broadcast at seeding. Incorporation mixes the phosphorus into the top few inches of the soil. This increases the opportunity for the roots to absorb this nutrient. Since phosphorus is not as damaging to seedlings as nitrogen fertilizers, it can also be applied in bands slightly below or beside the seed. Banding phosphorus 1-1/2 to 2 inches below the seed is more effective than a band application 3 to 4 inches to the side. Surface broadcast applications of phosphorus are generally not as effective because the young legume roots are not as active in the surface area and phosphorus does not move readily in the soil. Additionally, Nevada soil constituents react with soluble phosphorus to form less-soluble phosphorus compounds that are not available to the plant.

Proper inoculation can assure adequate nitrogen (N) status through nodulation. However, the nodulation-nitrogen fixation process does not occur immediately so a light, starter application of 30 to 40 pounds of actual nitrogen per acre should be broadcast at seeding. This supplemental nitrogen is good insurance that the young plant does not initially lack nitrogen or strong, healthy growth. One precaution—excessive nitrogen applications can cause a delay or lack of nodulation-nitrogen fixation.

A growth chamber study conducted with the University of Nevada, Reno, gave results that support the recommendation. Even though nodules were numerous on plants that received no nitrogen during the latter part of the trial, indications are they did not fix enough nitrogen to promote good growth compared to plants that received urea, nitrogen fertilizer at the rate of 30 pounds nitrogen per acre. The difference due to nitrogen was more apparent as the plants became older and when grown in a warm environment. Results of this experiment show there are benefits to applying nitrogen at a low rate when establishing alfalfa under both cool and warm environments where the soil is deficient in nitrogen. It may be more important to apply nitrogen when making a late summer seeding under warm conditions. In summary, the key management ingredient for the establishment of a legume stand is to assure that moisture and nutrients are not limiting and are in the proper placement for use by the young plant.

**Grasses.** As phosphorus is critical to legume establishment and production, nitrogen (N) provides the same functions for grasses. Economic grass response to nitrogen fertilization in Nevada has been varied because of extremes in elevations and growing seasons, availability and duration of soil moisture, grass varieties, seed mixture, and phosphorus content of the soil. Nitrogen responses can be expected if soil phosphorus levels are adequate. A soil test is suggested in order to determine nutrient levels prior to the development of a grass fertilization program.

Some forms of nitrogen are very active and mobile in the soil; therefore, the producer must deal with a different set of problems when establishing a stand of grass. Depending upon the soil temperature, placement and moisture condition, nitrogen fertilizer can be readily transformed to the nitrate ($NO_3$) form and be leached, or the nitrate can be denitrified with the resultant loss of nitrogen gases, or the ammonia ($NH_3$) form can volatilize. Urea and ammonium fertilizers can lose large amounts of nitrogen through volatilization, especially during warm weather and when surface broadcast.

Nevada trials have shown little difference in seedling response to forms of nitrogen fertilizer if certain safeguards are recognized and observed. Nitrogen fertilizer should not be banded under or with the seed. Urea, anhydrous ammonia, and ammonium fertilizers should not be applied without immediate mechanical incorporation into the soil or irrigated to move the fertilizer into the soil.

Some converted forms of nitrogen fertilizer such as ammonia are extremely toxic or damaging to seedlings and young plants. Nitrogen fertilization of a new stand, either preplant or at seeding, should be just enough to assure an adequate supply of nutrients and yet not damage the young plants. A rate of 20 to 40 pounds of actual nitrogen per acre is a standard application rate for establishment. The material should be incorporated lightly or irrigated to move it into the soil as soon as possible.

The form of nitrogen fertilizer to use and the method of application are dependent upon the price per pound of nitrogen; and the producer's equipment, irrigation system, and operating schedule. The major management input is to provide the necessary plant nutrients and moisture to result in a healthy productive stand.

**Grass-Legume Mixtures.** For various reasons, grass-legume mixtures are sometimes preferred to pure stands of grasses or legumes. Fertilizer management practices, including nutrients present in the soil, have a direct influence upon the long-term composition of the stand thus causing difficulty in maintaining the desired proportion of grass-legumes. The producer must, therefore, strive to balance the nutrients favoring legumes with the nutrients favoring grasses. The first step in the development of a fertilizer management program for establishing a grass-legume stand is a soil test to determine nutrient status.

As mentioned previously, nitrogen is the critical nutrient for grasses; phosphorus is critical for legume production. An imbalance of nitrogen fertilizer applied to a new seeding mixture would favor the grasses, while an imbalance of phosphorus would favor legumes. A one-to-one proportion of nitrogen to phosphorus in relatively small amounts, would favor neither the grasses nor the legumes. Based upon soil test results and the nutrient status of the soil, an application rate of 20 to 40 pounds of actual N and 30 to 40 pounds actual $P_2O_5$ per acre would be an appropriate fertilizer application for establishing a grass-legume mixture. For best results the fertilizer should be lightly incorporated into the soil prior to planting.

## Special Soil and Water Problems

**Soil Amendments.** Research in Nevada has shown that soil amendments are not generally required, provided proper irrigation can be practiced. That is, plants can be established on sodic soils, if very frequent, light applications of water can be made during the establishment period. The soil surface must be maintained in a moist condition until seedling emergence to eliminate failure due to crusting.

**Saline Soils.** On highly saline soils where drainage is adequate, some leaching of excess salts prior to seeding pasture or hayland may be beneficial. Planting in furrows or on the lower slopes of furrows provides more favorable conditions for establishment than flat plantings. Maintenance of adequate soil moisture during and after establishment will usually limit soil salinity to tolerable concentrations. Soils that are either too wet for optimum forage production or that are excessively high in accumulated salts can benefit by a good drainage system. The drainage system design should reflect an adequate analysis of the soil characteristics.

Tall wheatgrass, basin wildrye and creeping wildrye may be used on saline-sodic sites. These species and creeping meadow foxtail may be used in areas with a high water table. Strawberry clover or narrow leaf birdsfoot trefoil are legumes to consider on these sites.

**Water Quality.** The quality of irrigation water must be considered when planning, establishing and managing land for forage production. The use of poor quality water requires the application of additional water for leaching. This not only means that a greater total quantity of water is needed but also that drainage must be provided for removal of the excess water and salts.

## Seeding

**Equipment.** Seedings made with a drill have been consistently superior to those broadcast and covered by other means. Drills give even distribution of seed and should be equipped with depth bands on the furrow openers to control seeding depth. Broadcasting usually requires about 50 percent more seed because of unevenness in both distribution and depth of cover. Packer seeders are a refinement of broadcast seeding. They should not be used on soils subject to wind erosion or crusting.

**Depth.** Seeds must be planted at the proper depth if uniform stands are to be obtained. Seeding depths on most soils should be made slightly deeper than on fine textured soils.

**Date and Rate of Seeding.** Except in those areas that have less than a 100-day growing season, fall seedings are generally more successful than spring seedings. In those areas that have 100 days or less growing season, spring seedings are more appropriate.

Alfalfa seeded alone should be seeded at 10 to 12 pounds per acre. Seeding rates for grass-legume mixtures will vary depending upon the species in the mixtures. Seed size and weight varies greatly among legume and grass species. Alfalfa seed with chaffy grass seeds such as smooth bromegrass or orchardgrass may be seeded through separate boxes or the drill. Most drills are equipped with a large box for chaffy seed and a smaller box for distributing slick legume or grass seeds.

**Seeding Methods.** Grasses and legumes may be seeded together in the same row or seeded in alternate rows. When a grass and legume are seeded at the same time, there are some advantages to seeding them in separate rows. The main advantages to separate row seedings are: (1) the establishment of a slow starting legume such as birdsfoot trefoil grown with a vigorous grass such as tall fescue; (2) to decrease seasonal competition from the more aggressive plants; and, (3) to maintain desired forage composition in absence of disease and selective grazing. At the former Knoll Creek Laboratory, and in Reno, seeding alfalfa and orchardgrass or smooth bromegrass as a mixture, alternate rows of grass and alfalfa, or two rows of grass and one of alfalfa did not affect the average dry matter yields.

Rice hulls, or rice hulls plus seed, will flow through drills at about the same volume rate as barley and at a little slower rate than wheat. Use of rice hulls will aid in seeding light or chaffy grass seeds or seeding grasses and legumes simultaneously. For mixed grass and legume seedings, calibrate the drill to seed one bushel of barley per acre (15 to 16 barley seeds per square foot). Mix the quantity of grass seed and legume seed for one acre with enough rice hulls to make one bushel in volume and the legume seed for one acre with rice hulls to make one bushel. Partition the seed box between each outlet. Place grass seed and rice hulls in alternate compartments and legume seed and rice hulls in remaining ones. Calibrate drill to seed barley at two bushels per acre.

**Solid Stands and Simple Mixtures.** Alfalfa where adapted and planted in a solid stand will produce more TDN (total digestible nutrients) per acre than a legume-grass mixture or grass alone as long as the stand remains clean and healthy. However, at high elevations, in shallow soils or on land with a high water table or in other environmental conditions that reduce the potential of alfalfa, a grass-legume mixture or grass alone would be advantageous. A grass-legume mixture is often preferred over a solid stand of alfalfa when the forage is to be harvested by grazing animals. Mixtures containing grass reduce the likelihood of bloat and reduce weed invasion.

A solid grass stand requires heavy fertilization, especially with nitrogen to obtain maximum yields. Although properly fertilized grasses will yield as much or more than a grass-legume mixture or legume alone, the addition of a properly inoculated legume makes considerable nitrogen available to the grass thereby reducing the need to apply nitrogen fertilizer. The legume also adds to forage quality.

Care must be taken to select species and varieties to insure that they can successfully compete for water, nutrients and light. The best mixture should include species that mature together and are of similar palatability. This is especially important if animals harvest the forage.

Nevada soils are quite variable. Where extreme variation exists in a field, a carefully chosen mixture is more likely to furnish species adapted to each soil characteristic. A grass-legume mixture also reduces erosion more effectively than pure legume stands and a mixture is likely to provide more complete ground cover and deter the encroachment of weeds.

Mixtures require more total seed per acre than single species. Where extremely hazardous environmental conditions exist, such as the presence of a high water table, high salt content, or both, there is a tendency to include a large number of species in the mixture. Avoid shotgun mixtures that increase plant competition, especially in the seedling stage, and favor the species with the greatest seedling vigor. One grass and one legume is best for ease in management, uniform use and maximum production of quality forage.

### Irrigation

Under most soil conditions, the seed bed should be pre-irrigated to a depth of several feet to provide available moisture in the lower profile, thereby promoting the development of deep rooted seedlings. Subsequent to planting, and during germination and emergence, frequent and light irrigations are required to insure moisture availability at or near the surface for the shallow rooted seedlings. Drought or desiccation of the germinating seed is a primary factor for planting failure.

In Nevada, if late water is available in areas that have more than a 100-day frost-free season, early fall plantings are favored over spring planting. Generally, early fall weather conditions (wind, soil and air temperatures) are milder, thereby reducing desiccation and low temperature shock effects upon the emerging seedlings.

Under coarse textured soil conditions, where low water holding capacity characteristics are common, the irrigation frequency may be as high as one application per 12 to 24 hours. For medium and heavy textured soils, the irrigation interval may be increased to once per three to seven days unless soil crusting is a problem on the heavier soils.

Ideally, for coarse textured soils, a solid-set sprinkler system provides a method that can efficiently apply water frequently and in small amounts to meet the moisture requirements of the shallow rooted seedling. If 1/4-mile wheel line sprinkler systems are used for establishment, four to five of these units are needed per 80 acres to meet the frequency requirements of the new planting.

Center pivot sprinkler systems, if soil moisture intake rates are matched to sprinkler application rates, offer a convenient method for applying water frequently and in small amounts.

In areas where surface irrigation methods (border or furrow) are physically and economically adapted and soil textures are coarse, the sprinkler method is often used temporarily during the first few weeks of establishments where frequent and light irrigations are required. The sprinkler method allows the application of as little as 1/3 to 1/2 inch per irrigation, whereas most surface methods are constrained to minimum applications exceeding 4 to 5 inches per irrigation.

In those areas where spring planting is recommended, the same irrigation frequencies and quantities are appropriate.

## Management of Established Stands

### Irrigation

**Frequency and Amount per Application.** Factors that determine the frequency and amount of irrigation water applied are: (1) the available water holding capacity of the soil in the root zone; and, (2) the rate and extent of removal of this water from the soil by the plants. Fine textured soils such as clay loams and silt loams usually hold in excess of 2 inches of available water per foot of soil. Coarse textured soils such as sands and loamy sands may hold as little as one-half inch of available water per foot of soil.

The rate of water use by plants varies according to temperature, humidity, solar radiation and wind. Water use is less in the fall, winter and spring and greatest during summer months. Generally, peak use periods occur between mid-June through mid-August. Peak daily use (averaged over a seven-day period) will vary from 0.33 inch per day in the northern portion of the state to 0.45 inch per day in the southern portion of the state (8). Expressed on a gallons per minute per acre basis (gpm per acre) where a 75 percent irrigation efficiency is assumed, the design irrigation water supply requirement to meet peak seven day periods of consumptive use for an unstressed forage crop will vary from 8.3 gpm per acre to 11.3 gpm per acre for the northern and southern portions of the state, respectively. For example, the pumping capacity of a groundwater well located in northern Nevada serving 160 acres should be 1,328 gpm (8.3 gpm per acre x 160 acre) to meet the peak consumptive use demand in July and August. Likewise, a 160-acre parcel of irrigated forage in southern Nevada should be served by a water supply of 1,808 gpm (11.3 gpm per acre x 160 acre).

Irrigation scheduling by using the U.S. Weather Bureau Class A pan is recommended to estimate consumptive use demand. A practical method for using the Class A evaporation pan (assuming an irrigation efficiency of 75 percent) is to replace by irrigation to the field the same amount (inches) that is observed to evaporate from the pan. e.g., if the observed two-week pan evaporation is measured at 4.2 inches, the irrigation at the end of this two-week period should apply 4.2 inches of water. When scheduling irrigation, ground control should be established by monitoring soil moisture and crop stress as a check against the consumptive use demand estimation, thereby avoiding either drought or water logging conditions.

Sub-irrigated areas require special irrigation water management in order to control water table levels and insure good production. Plant water supplied from the water table is directly related to the water level depth. Care must be taken to prevent water tables from remaining close to the surface for more than three days. Excessive mortality can occur due to lack of oxygen, disease organisms or both.

Soils should be irrigated before the moisture in the root zone has been depleted below 50 percent of the total available water holding capacity. Soil moisture may easily be evaluated by using a shovel or soil auger to obtain a handful of soil from the root zone, and using the feel method as described in Table 2 (10). Various types of instruments such as gypsum blocks or tensiometers may be used to indicate available moisture directly.

Pastures should not be grazed when the soil surface is wet. Irrigation water is best applied immediately after livestock are removed. Regrowth periods of 20 to 40 days, depending on climatic conditions, age, and species (type) of plants, must be provided to insure good forage production. Several irrigations may be required during regrowth periods.

**Irrigation Methods.** The irrigation system should be planned as part of the complete soil and water conservation plan. The irrigation method depends on topography; depth, texture and permeability of soil; quantity and quality of water available; delivery rate; and water cost. Border, sprinkler, corrugation, and contour ditch are all possible irrigation methods. Technical assistance on system design and layout, information on soil, and recommendations on system operation and management may be obtained from your local Soil Conservation Service.

Sprinkler irrigation has grown in popularity in recent years. This is one of the best methods for irrigating pastures. Properly designed sprinkler systems may be used to advantage on rolling or rough topography and on shallow or coarse soils. Steep slopes may be irrigated with less erosion hazard. A properly designed sprinkler system will give a more uniform water distribution than other methods. Windy conditions, however, may produce an uneven pattern. Initial costs for the system, which include pumping plants, may be high.

**TABLE 2.**
**Practical Interpretation Chart of Soil Moisture for Various Soil Textures and Conditions**

| | Feel or Appearance of Soil | | | |
|---|---|---|---|---|
| Available moisture in soil | Course textured soils | Moderately coarse-textured soils | Medium textured soils | Fine- and very fine- textured soils |
| | Sand to loamy sand | Loamy fine sand to fine sandy loam | Very fine sandy loam to silt | Sandy clay loam to clay |
| 0 percent | Dry, loose, and single-grained; flows through fingers | Dry and loose; flows through fingers | Powdery dry; in some places slightly crusted but breaks down easily into powder | Hard baked and cracked; has loose crumbs on surface in some places |
| 50 percent or less | Appears to be dry; does not form a ball under pressure[1] | Appears to be dry; does not form a ball under pressure[1] | Somewhat crumbly but holds together under pressure | Somewhat pliable; balls under pressure[1] |
| 50 to 75 percent | Appears to be dry; does not form a ball under pressure[1] | Balls under pressure but seldom holds together | Forms a ball under pressure; somewhat plastic; slicks slightly under pressure | Forms a ball; ribbons out between thumb and forefinger |
| 75 percent to field capacity | Sticks together slightly; may form a very weak ball under pressure | Forms weak ball that breaks easily; does not slick | Forms ball; very pliable; slicks readily if relatively high in clay | Ribbons out between fingers easily; has a slick feeling |
| At field capacity (100 percent) | On squeezing, no free water appears on soil but wet outline of ball is left on hand | Same as for coarse-textured soils at field capacity | Same as for coarse-textured soils at field capacity | Same as for coarse-textured soils at field capacity |
| Above field capacity | Free water appears when soil is bounced in hand | Free water is released with kneading | Free water can be squeezed out | Puddles; free water forms on surface |

[1]Ball is formed by squeezing a handful of soil very firmly.

Side roll wheel line and center pivot sprinkler systems are commonly used to irrigate forages. In coarse textured soils three, 1/4 mile long side roll wheel lines are required per 80 acres. In heavier textured soils two, 1/4-mile long roll wheel lines will generally be adequate. The side roll wheel line sprinkling method allows flexibility in that lines can be added or taken away from a particular field in response to changing crop or consumptive use demand. Under center pivot irrigation, the design of the system is more critical, i.e., sprinkler application rates must be matched to the soil profile intake rate and crop water demand during peak use periods. In many circumstances (e.g. shallow profile and slow soil intake rates) the center pivot must be managed in such a way as to store water in the profile in the spring that later can be taken from storage during peak use period (June 15 to August 15) in the summer.

In border irrigation, water is applied between low parallel dikes on land that has been leveled to a planned grade. This can be an efficient method of applying irrigation water to forage crops. Border length and grade depends on the soil water intake rate and available water supply.

Contour ditches provide a practical way of distributing irrigation water on land that has physical limitations or cannot be economically leveled. Spacing between ditches depends on topography and soil. Siphon tubes or gated outlets provide easily controlled and efficient methods of discharging water from ditches.

Corrugations are small furrows that are spaced so that the area between them will wet across the surface by the time the water fills the root zone. In most instances corrugations of 24 to 36 inches apart are adequate. Corrugations may be used in combination with borders.

**Coordination of Irrigation and Forage Harvest.** Harvesting and irrigation are key factors in good forage management. Continuous grazing is the least productive method of harvesting forage. It results in lower yields and trampling damage to the forage. Rotation grazing is a much better harvest system, but it does require careful planning. The irrigation frequency appropriate to the soil and regrowth requirements of the plants involved determine the number of pastures needed in the rotational grazing system as well as stocking rates.

Plants do not use water at a uniform rate throughout the growing season. Either the amount of water applied at each irrigation, or the frequency of irrigation should be varied in order to obtain season long efficiency.

## Water Management for Alfalfa

The results of trials conducted by the University of Nevada, Reno, at the S - S Ranch at Wadsworth, Nevada, showed alfalfa forage was of higher quality when applied water was based on about 50 percent of Food and Agriculture Organization Pan Evaporation (FAOPE). However, the yields and Total Digestible Nutrients (TDN) produced were so low that irrigation at this level did not represent an efficient use of water in terms of amount of dry matter produced per unit of applied water. The highest applied water use efficiency (AWUE) was obtained when applied water was based on about 75 percent FAOPE. The highest yields and TDN production were obtained with the 100 and 125 percent FAOPE based irrigation treatment. Depending on whether AWUE, or yield and TDN are of greatest importance, applied water requirements determine from 75 or 100 percent FAOPE, respectively, were considered to represent the most judicious use of water for alfalfa production when evaluating the indicators studied. Higher water application was not considered a wise use of water since AWUE decreased and neither yield, quality, nor TDN production were increased. Although actual amounts of applied water would vary from region to region because of meteorological conditions, some supporting evidence was found to suggest that applied water irrigation requirements based on these respective percentages of FAOPE would produce results consistent with the findings of this investigation.

## Cutting and Grazing

**Hay.** Hay should be cut in the early stages of maturity. The percentage of leaves and protein decreases as the plant matures and, in contrast, the percentage of stems and the crude fiber increases. A typical change in composition of alfalfa as it matures is shown in Figure 1. The percentage of leaves decreases from about 60 percent when in the bud stage to slightly over 40 percent when in full bloom; conversely, the percentage of stems and crude fiber content increases as the plant matures. Dry matter digestibility decreases about .3 percent per day after the early bloom until full bloom and consumption of the hay is reduced .14 percent per day per 1,000-pound liveweight of growing beef cattle during this period (Figure 2).

The average percent crude fiber as related to maturity stage and anticipated daily gains from a 500-pound calf are shown in Figure 3. These illustrations clearly show the advantage of feeding high quality hay compared to feeding fully mature, lower quality hay.

The Nevada alfalfa hay evaluation uses acid detergent fiber and crude protein to estimate TDN. Digestible protein is estimated from a crude analysis. In addition to maturity, many other factors (weeds, foreign matter, soil fertility, rain damage, mechanical damage and season of growth) may also affect forage quality. Mechanical losses and respiration are estimated to be from 20 to 24 percent. Losses are higher when hay is rained on. Baling should occur when the hay has dried to 20 to 22 percent moisture and when standard bale size is chosen. When larger bales are used, baling should occur when the hay reaches 15 percent moisture. To decrease field losses, hay should be baled and removed as soon as possible after cutting.

When considering yield, quality and persistence of stand, alfalfa usually should be harvested in the 1/10 bloom-stage of maturity or when the crown buds are 1-1/2 inches long, whichever occurs first. This is when the highest yield of digestible nutrients per acre is usually obtained. Cutting at a more immature stage will result in a higher percentage of digestible nutrients at the expense of yield and stand persistence.

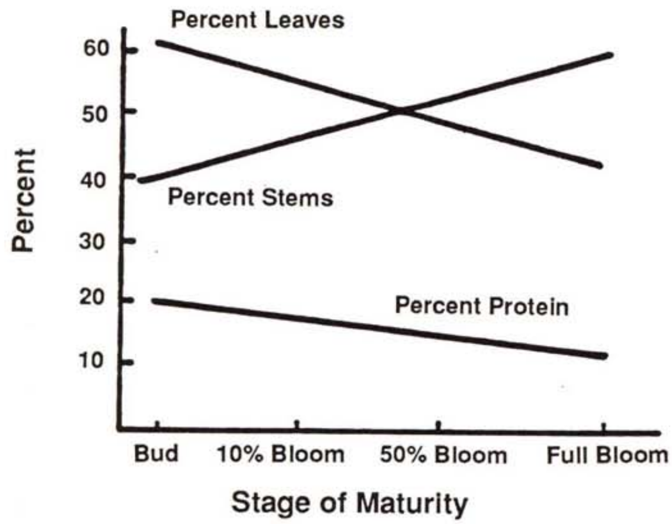



Figure 1.
Effect of Stage of Maturity on Average Leaves, Stems and Alfalfa Protein on a Dry Weight Basis

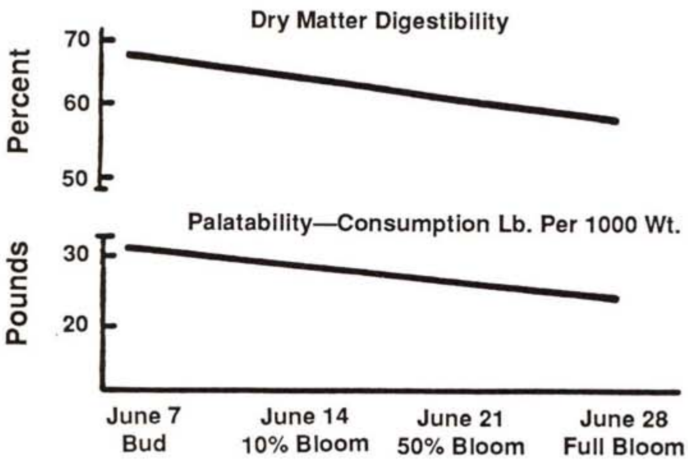



Figure 2.
Effect on Stage of Maturity of Alfalfa on Average Dry Matter Digestibility and Palatability When Consumed as Hay

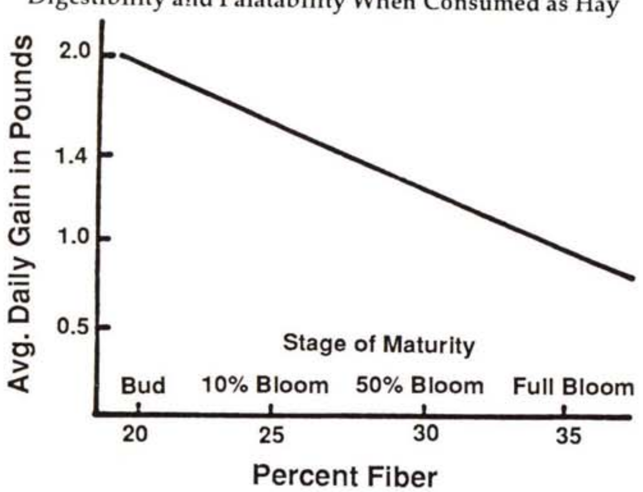



Figure 3.
Effect of Stage of Maturity of Alfalfa on Average Percent Crude Fiber and Estimated Daily Gains of a 500-pound Calf on Full Feed

The number of cuttings vary from one or two in northern Nevada to six to eight in the southern part of the state. Cutting before the bud stage will shorten the life of the stand because the amount of stored food in the roots is very low before that stage of maturity. Food reserves increase as the plant matures. Smith (9) clearly illustrates the trend of readily available carbohydrates in the alfalfa roots from initiation of growth in the spring until maturity (Figure 4).

Adequate food reserves are necessary to keep the plant vigorous and growing. When alfalfa was cut at less than three-week intervals in Nevada, stands did not persist and the loss of stands was undoubtedly related to depletion of food reserves. Feltner and Massengale (2) at Arizona also reported a relationship between frequent cuttings of alfalfa and stand decline. They found the adverse affects of frequent cuttings were much too severe on food reserves during warm temperature periods.

In addition to chemical composition and palatability, the form in which hay is fed also affects feeding value. The relative feeding value of average alfalfa hay when fed baled, cubed, or pelleted, is approximately 100, 120, and 130 percent, respectively. There are many factors, however, that influence the form in which hay is fed.

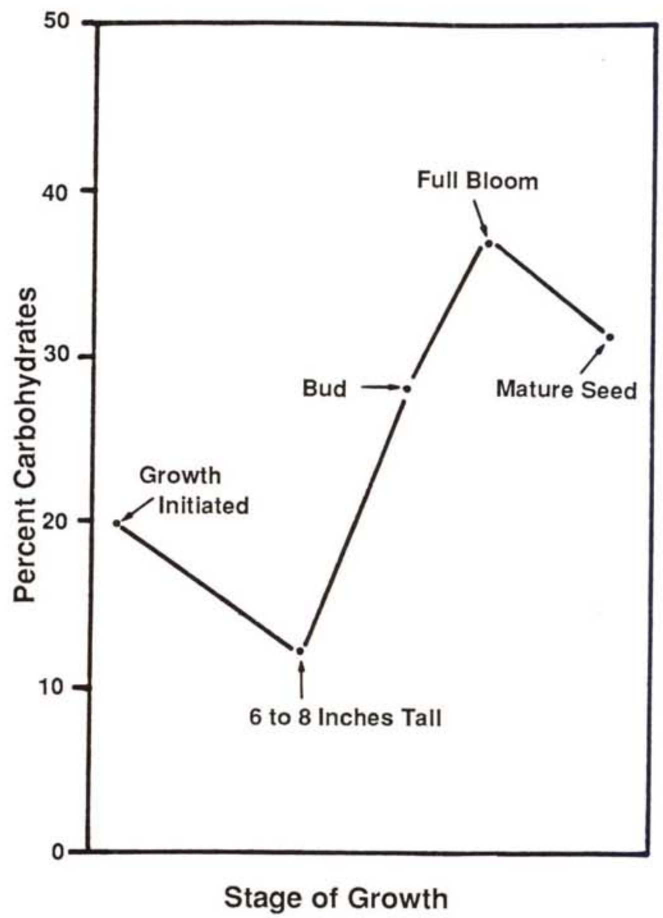



Figure 4.
Percent Readily Available Carbohydrates in Alfalfa Roots as Related to Growth Stage According to Smith (9)

Trials conducted by the University of Nevada, Reno, show that when a windrow was left on alfalfa for four or eight days, the reduction in yield from the area under the windrow was 7 and 18 percent, respectively. Wheel traffic also reduced yield by approximately 7 and 27 percent in areas that had wheel traffic one and seven days after the cutting. Therefore, alfalfa hay should be cured as rapidly as possible to reduce respiration loss, and to lessen the chance of damage from rain. The crop should be baled and bales removed from the field as soon as possible to reduce yield losses from windrows and wheel traffic.

## Dormant Season Grazing

Grazing the aftermath of alfalfa in the fall and early winter is a common practice in Nevada. Some ranchers also graze in early spring after growth has begun because they believe frost frequently kills early spring growth not utilized by the livestock. The effect of these grazing or defoliation practices on summer yields and total yields is of some concern.

Results of a trial conducted by the University of Nevada, Reno, are presented in Table 3. Grazing aftermath in the fall or winter did not adversely effect yield. Total production was enhanced by grazing in November and November plus April in the trial conducted at Reno. Grazing or defoliation as late as April and May reduced total yield in most years. Since forage yields and severity of crown rot damage were not decreased by hoof traffic and defoliation by grazing, it was concluded that dormant season grazing is a practical management practice in western Nevada. Ranchers can obtain one-half or more tons of forage per acre from this practice.

However, in southern Nevada where semi-dormant and non-dormant varieties are used, grazing the aftermath when the alfalfa has not gone dormant can result in lower summer yields, a more rapid decline in longevity and bloat.

**Pasture.** Rotational, strip grazing, and "pasture-a-day" are alternate ways of pasturing that are suited to irrigated areas. The most widely adapted system in Nevada is rotational grazing as it permits regrowth and a buildup of food reserves after grazing. The system also permits irrigation at a period when the animals are not in the field. The number of paddocks is dependent upon soil, water supply, species and the rancher's needs. Strip grazing or a "pasture-a-day" are modifications of the rotational grazing system where individual pastures are further subdivided to provide enough new forage for each grazing period. This type of management requires extra fencing and labor, but will permit alfalfa grazing with a diminished bloat danger and optimum regrowth periods. This system is most suited for dairy cattle but can also be used for beef herds.

**Green Chop.** Green chop is also suited for the dairy farmer. Its use is dependent upon herd size. Whatever system is used, forage should not be allowed to over mature. Excess forage during the growing season should be clipped. Droppings should be spread by dragging. Regardless of the system of pasture management, close grazing or mowing should not be practiced because it shortens stand life and reduces yields. The concept of leaf area index (L.A.I.) is important in grazing management. The leaf area in square feet per square foot of sod is called the L.A.I. Thus, an L.A.I. of 1 would have 1 square foot of leaf area per square foot of soil surface. Brougham (1) in Australia, showed that regrowth or production was related to the amount of light intercepted by the plants. Thus, if a plant was cut or grazed close to the ground, less light was intercepted than if a higher stubble and more leaf area remained. Forage production was closely related to the amount of light intercepted and Brougham's results are shown in Figures 5 and 6. He found dry matter production was at a maximum rate when 95 percent or more of the light was intercepted. A L.A.I. of approximately 5 is required to intercept 95 percent or more of the light.

Other effects of close grazing such as depletion of food reserves must be considered when developing a grazing system. In general, plants are most susceptible to overgrazing in the spring when the stored carbohydrates in the plant

**Table 3.**
**Total Dry Matter Yield of Alfalfa During Dormant Season and Summer**

| | Time of Defoliation | | | | | |
|---|---|---|---|---|---|---|
| Year | None T/A | November T/A | November and April T/A | January or February T/A | April T/A | Early May T/A |
| First | 4.98c* | 5.70ab | 5.47b | 5.73a | 5.10c | 4.56d |
| Second | 4.59b | 5.26a | 5.22a | 5.13a | 4.72b | 4.18c |
| Third | 4.39c | 5.18b | 5.84a | 4.96b | 4.96b | 4.43c |
| Fourth | 4.49cd | 5.22a | 5.31a | 4.60b | 4.70bc | 4.40d |
| Fifth | 5.50c | 6.32a | 6.66a | 5.99b | 5.77bc | 4.29d |
| Average | 4.79 | 5.54 | 5.70 | 5.28 | 5.05 | 4.37 |

*Means within years followed by the same letter are not significantly different at the 5 percent level of probability.

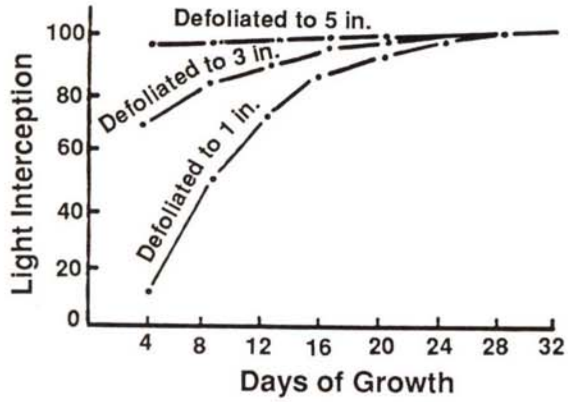



**Figure 5.**
**Percent Light Interception by Ryegrass as Related to Stubble Height and Time After Cutting**

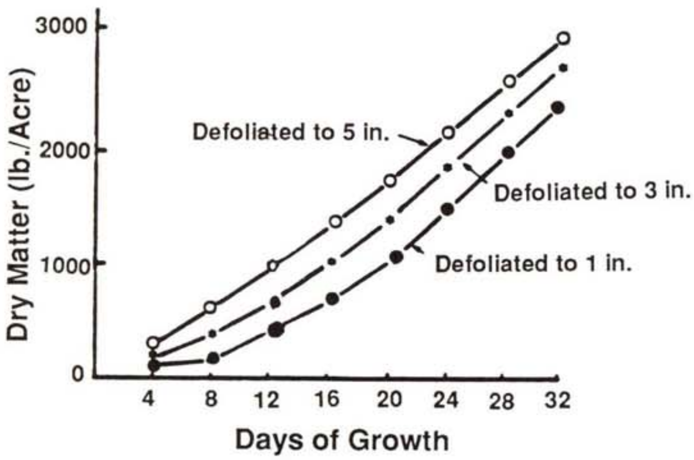



**Figure 6.**
**Relationship of Ryegrass Stubble Height and Dry Matter Yields at Different Days After Cutting**

roots are low and the animals are permitted to graze before food supplies are replenished.

## Fertilization

**Grasses.** Nitrogen and phosphorus fertilizer responses in Nevada vary because of differences in elevations, growing season, temperature, and soils. Grasses usually respond to nitrogen fertilization if other nutrients are in adequate supply. Nitrogen fertilizer rates on grasses may vary from 75 to 160 actual pounds per acre in the south.

Grass dry matter yields can be expected to increase with each additional increment of nitrogen fertilizer applied—provided other nutrients and moisture are not limiting. However, beyond a certain input of nitrogen fertilizer, the increase is not economically feasible for the producer. Grass fertility research was established in western and central Nevada to determine economical nitrogen rates and to compare split versus single applications of nitrogen fertilizer. Preliminary results indicate that rates of 150 to 200 pounds of actual nitrogen per acre are economical rate for these areas. Also, there was little difference between the same amounts of nitrogen applied as either a single application in the spring, or split between spring and early summer applications. However, the split applications resulted in better seasonal forage distribution through the growing season into late summer-early fall. In general, single applications would be recommended for one harvest areas (short growing season). Split applications in the spring and the remainder of the application early in summer after the first harvest or grazing is recommended for two harvest areas (longer growing season).

**Legumes.** Response to phosphorus fertilization has been erratic, especially with broadcast applications. Nevada trials indicate no timing effect with phosphorus applications, so spring would be a good time to add the nutrient. A soil test should be the basis for decisions concerning fertilization of an established stand.

**Grass - Legume Mixtures.** Northern Nevada yields from alfalfa-grass mixture fertility research were similar to those of grasses grown alone with nitrogen fertilization. Six forage grasses were grown alone with fertilization of 75 and 100 pounds of actual nitrogen per acre. These same grasses were grown with alternate rows seeded to inoculated alfalfa (approximately 25 percent alfalfa mixture). Average yields for the six grasses fertilized with 75 and 150 pounds of nitrogen were 4.3 and 4.7 tons per acre, respectively. The average grass-alfalfa mixture yields were 4.3 tons per acre. (Pure alfalfa stands grown in the same experiment yielded 4.3 tons per acre).

The same experiment was repeated in central Nevada with dissimilar results. Average dry matter yields for the six grasses fertilized with 75 and 150 pounds of nitrogen were 2.0 and 2.5 tons per acre, respectively. The average grass-alfalfa mixture yields were 4.1 tons per acre. (Pure alfalfa stands yielded 4.3 tons per acre).

These experiments show the ability of legumes to supply nitrogen to grasses in a mixture and the possible fertilizer dollar savings when grass-legume mixtures are utilized.

## Winter Annual Weed Control in Alfalfa

Spring grazing of alfalfa by sheep is often used to control winter annual weeds in alfalfa.

A study was initiated at the Newlands Agricultural Research Center in Fallon, Nevada, in the fall of 1986. The purpose of the study was to compare the effectiveness of spring grazing by sheep with dormant applications of herbicides as a means of controlling winter annual weeds and perennial grasses in alfalfa. A deteriorating stand of Lahontan alfalfa was selected for this trial. Herbicides used were Karmex, Sinbar, Sencor, Simazine and Velpar.

Early spring grazing by sheep can give partial control of winter annual weeds and perennial grasses. However, if sheep grazed when the growth of alfalfa was 4 to 6 inches tall, both the first and second harvests were reduced. Velpar gave the best control of winter annual weeds and grasses. Other herbicide treatments were relatively ineffective in controlling the winter annual weeds and especially perennial grasses.

## Toxic Properties

**Bloat.** Cattle frequently bloat when they graze pastures that are primarily alfalfa or clover. Bloat may generally be avoided if the forage mixture contains at least 40 percent grass and a good grazing system is used. When the pasture is primarily legumes, the bloat problem can be reduced by using one or more of the following precautions: (1) feed hay before pasturing or have hay available at all times, mow and leave strips two or three days before grazing; (2) strip graze so the animals will not have an opportunity to select the more succulent portion of the plants; (3) spray pastures with anti-foaming agents such as peanut oil or animal fats; (4) green chop the forage (in some cases, bloat may occur even when alfalfa is fed in this manner); (5) change pastures at noon; (6) use non-bloat legumes such as birdsfoot trefoil, cicer milkvetch, and sainfoin; and, (7) use poloxalene daily. A number of products are produced that may have bloat preventing properties, however, the practical way to reduce bloat is to include a grass in the pasture mixture and follow the best management practices known. Many factors affect the success of bloat preventative materials and practices.

**Nitrate Poisoning.** Oat hay that contains high levels of nitrates has been a problem in many areas of Nevada. Levels of nitrate in hay should be ascertained before feeding. Nitrate in plants is converted into nitrite in the gastrointestinal tract of the animal. When an excessive level of nitrate is absorbed into the blood it converts normal blood hemoglobin into methemoglobin which is incapable of transporting oxygen to the body tissues. Factors that affect the amount of nitrate accumulated by the plant are species, nitrogen fertilizer, light intensity and drought. There are many reports that vary regarding the level of nitrates in the plant that may be toxic to the animal. A conservative estimate was made by Garner (3) at Missouri who reported that sublethal levels can cause milk production loss and abortion in cattle. He predicts the following animal response to various levels of nitrate (Table 4). In general, production decreases when nitrate levels in the plant exceed 0.5 percent or when nitrate nitrogen levels exceed .06 percent.

Levels of nitrate in the plant may be expressed as potassium nitrate ($KNO_3$), nitrate ($NO_3$) or nitrogen ($NO_3$-N). High nitrate levels in oats are associated with heavy nitrogen fertilization where oats are grown on soils immediately following alfalfa, and when plants are drought stressed.

**Molybdenosis.** Molybdenum toxicity to cattle is a problem of economic importance in parts of Nevada and California. In Nevada, toxic molybdenum levels in forages range from 5 to 30 ppm. Molybdenum toxicity in ruminants is not simply associated with high molybdenum forage. Many other complex mineral interrelationships are involved. The toxicity degree to cattle may vary with the sulfate and copper content of the diet. Nevertheless, toxicity to the animal is positively related to the molybdenum concentration in the forage. Studies at Nevada have shown molybdenum accumulation by forages was affected by plant species, water table and by its concentration in a neutral pH soil. Application of soluble molybdenum to the soil increased the molybdenum content of both alfalfa and tall fescue. The accumulation by plants was proportional to the amount added to the soil with an increase of 4.6 and 3.1 ppm in alfalfa and tall fescue, respectively, for each pound per acre molybdenum added to the soil.

Molybdenum accumulation varied significantly among plant species. The wide variation in accumulation among plants permits selection of an adapted species that accumulates low levels of molybdenum. Because birdfoot trefoil and true clovers accumulated more molybdenum than the other species tested they should not be planted where high levels of available molybdenum occur. Selection of species in these cases should be from adapted grasses that accumu-

TABLE 4.
**Expected Animal Response to Various Levels of Nitrate in Plants**

| Levels of Nitrates on Air-Dry Matter Basis | | | |
|---|---|---|---|
| $KNO_3$ (Potassium Nitrate) | -Percent- $NO_3$ (Nitrate) | $NO_3$-N (Nitrate Nitrogen) | Animal Response |
| 0 to 0.5 | 0 to 0.3 | 0 to .07 | Normal if on an adequate ration. |
| 0.5 to 1.0 | 0.5 to 0.6 | .07 to .14 | Milk production drop. Slow at first, increasing after the 6th to 8th week. Typical Vitamin A deficiency symptoms in the 6th to 8th week. |
| 1.0 to 1.5 | 0.6 to 0.9 | .14 to .21 | Milk production loss within 4 to 5 days. Reproduction difficulty over the period fed and may extend over several weeks after change to adequate diet. |
| 1.5 plus | 0.9 plus | .21 plus | Death, usually suddenly. |

late low levels of molybdenum. For example, bermudagrass would be a good species to plant under irrigated conditions in a hot climate. Smooth bromegrass would be a good cool climate species where molybdenum toxicity may occur.

Depth to water table was associated with molybdenum accumulation in plants during two of three years. Forage grown where the water table was near the soil surface contained more molybdenum than where depth to water table was greater.

On the basis of experiments conducted at Nevada and other states, the molybdenosis problem in cattle can be reduced by use of forages that are low molybdenum accumulators and by drainage and leaching of the soil. The addition of copper in plants or dietary copper to the animal is also effective.

**Prussic Acid or HCN Poisoning.** Sudangrass, sorghums and sundangrass-sorghum hybrids contain a cyanogenetic glucoside known as dhurrin. Glucosides that yield hydrocyanic acid (prussic acid—HCN) upon hydrolysis (breakdown in presence of water) are termed cyanogenetic. When the compound dhurrin is intact it is not toxic and there is little free HCN found in healthy, actively growing plants. Hydrolysis is brought about by enzymatic action in the plant or animal. Ruminant animals are more susceptible to HCN poisoning from plants because there is a greater enzymatic breakdown in the rumen by microflora than in non-ruminants.

Death can occur as quickly as 15 minutes or as long as a few hours after a lethal dose of forage is consumed. The HCN inhibits the action of the enzyme cytochrome oxidase. The function of this enzyme is to pass oxygen into the metabolic respiratory pathway. Therefore, death from HCN poisoning occurs because of asphyxiation at the cellular level. Symptoms of poisoning are: rapid respiration, depression, stupor, convulsions and paralysis. The mucous membranes may also turn blue.

The absorption of HCN from plants in the digestive tract is influenced not only by the total cyanogenetic glucoside and free HCN in the plant, but also by the rate of ingestion and amount of food already in the stomach.

Some researchers believe that more than 20 milligrams (mg) per 100 grams (gm) of dry matter may be toxic while others state that 50 to 75 mg per 100 gm dry matter are doubtful toxicity. Forages containing about 75 mg per 100 dry matter are dangerous to graze.

The minimum lethal dose of HCN is 1 mg per pound of animal; that is, a 1,000-pound animal may be killed with 1.000 mg of HCN. If a 1,000-pound animal ate 11 pounds of dry forage containing 20 mg per 100 gm dry matter it would have ingested a lethal dose.

**The danger from HCN poisoning can be reduced by:**

1. Choosing an adapted variety with low HCN potential.
2. Deferring grazing of sudangrass until it is at least 18 inches tall or sudan-sorghum hybrids until they are 30 inches tall.
3. Providing adequate soil moisture and balanced soil fertility. Any factor that reduces growth rate may increase the potential danger from HCN.

The cyanogenetic glucoside content of sorghums is not increased through freezing. The immediate danger is from the increased free HCN brought about by hydrolysis of the cyanogenetic glucosides already present. Recommendation as to length of time to wait before grazing vary from no deferment to 72 hours or until the plants are dead and cured.

If the plants are only partially killed and new growth or tillers develop these may contain toxic levels. Plants that did not contain toxic levels of HCN prior to freezing may be made into silage or hay.

Many reports show that cyanogenetic plants lose their toxic properties by drying or when made into hay. However, not all researchers agree. Some researchers obtained only a little reduction in HCN content upon air drying. Results of an extensive study in South Dakota showed that the average loss of HCN over a six-week period of curing was 79 percent.

Injuries to livestock from HCN when sorghum is preserved as silage are rare. Again there is conflict in the literature regarding loss of HCN upon ensiling of sorghums. Some workers obtained as much as an 88 percent loss while others obtained only slight reduction. However, if a farmer has a field of sudangrass or sorghum that does not contain toxic amounts of HCN prior to frost it can be made into either hay or silage with no danger or injury to livestock if harvested before regrowth appears.

**Other Dangers.** Spoiled sweet clover that contains a high coumarin content may cause "bleeding disease" in livestock. Heating during storage may result in the formation of dicoumarol. When hay containing dicoumarol is fed, the clotting properties of the blood are reduced and the animals may bleed to death from slight wounds. Therefore, spoiled sweetclover forage should not be fed to livestock.

Poisonous or mechanically injurious weeds may occasionally be a problem in irrigated forages grown in Nevada.

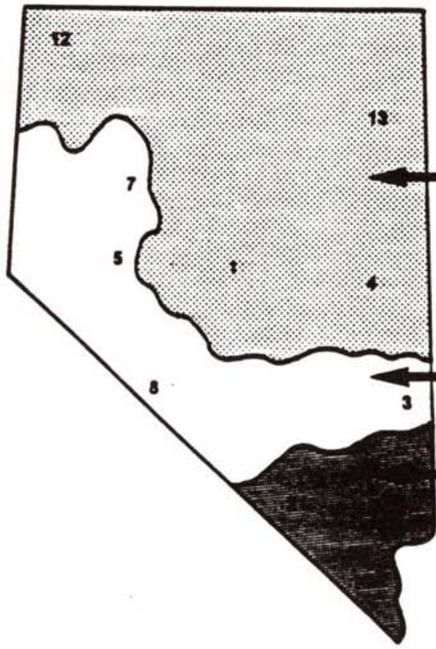
## Specific Recommendations for Climatic Areas

The previous recommendations are for general practices needed in sound forage management. However, because of the great diversity of climate and soils in our state, specific recommendations are made for three climatic areas (Figure 7). Detailed descriptions of the climatic areas are given in references 4, 5, and 6.

### Northern Nevada-Type Climate

### Improved Meadows

**Adapted Plants—Full Season Water.** It is important to select plants that will withstand climatic extremes and still produce high yields during the relatively short season. Forage adaptation trials have been conducted at the Knoll




| Location | Elevation feet | Annual Precipitation inches | Mean Temperature Annual | Mean Temperature July | Mean Freeze-Free Period 32 F days | Mean Freeze-Free Period 24 F days |
|---|---|---|---|---|---|---|
| 1. Austin | 6600 | 12 | 48 | 70 | 109 | 168 |
| 2. Beatty | 3300 | 4 | 59 | 80 | 198 | 254 |
| 3. Caliente | 4400 | 9 | 53 | 76 | 150 | 211 |
| 4. Ely | 6300 | 8 | 44 | 68 | 80 | 141 |
| 5. Fallon | 4000 | 5 | 51 | 73 | 132 | 192 |
| 6. Las Vegas | 2200 | 4 | 66 | 90 | 248 | 302 |
| 7. Lovelock | 4000 | 6 | 52 | 75 | 129 | 178 |
| 8. Mina | 4600 | 4 | 54 | 78 | 155 | 213 |
| 9. Overton | 1200 | 4 | 68 | 91 | 231 | 291 |
| 10. Pahrump | 2800 | 5 | 61 | 84 | 201 | 257 |
| 11. Reno | 4400 | 7 | 49 | 68 | 103 | 171 |
| 12. Sheldon Hq. | 6500 | 12 | 42 | 61 | 51 | 115 |
| 13. Wells | 5600 | 10 | 45 | 69 | 61 | 122 |
| 14. Winnemucca | 4300 | 9 | 47 | 71 | 94 | 143 |

Figure 7.
Approximate Freeze-Free Period at Locations in Three Climate Areas of Nevada

Creek Field Laboratory (KCFL), Jackpot, and at the Central Nevada Agricultural Research Center (CNARC), Austin, for many years. The elevation of both locations is nearly 6,000 feet. There is a frost-free season (28 degrees Farenheit) of under 100 days. The soils at the KCFL are deep and fertile and have a good infiltration rate. The soils at CNARC are shallow and have moderately slow infiltration rates. Results of recent trials where grasses were fertilized with urea at the rate of 150 to 200 pounds actual nitrogen per acre are presented in Table 5.

In these, and previous trials at KCFL, intermediate wheatgrass was the top yielding grass. Lincoln smooth bromegrass, redtop and Garrison creeping meadow foxtail also yielded well at this location. At the less favorable site at CNARC the yields were approximately half of those obtained at KCFL. At CNARC, Oahe intermediate wheatgrass, Alta tall Fescue and Drummond timothy were the top producers.

Alfalfa is important for hay and in mixtures for hay and/or pasture. Two harvests are normally taken in these areas. At KCFL, alfalfa yielded about the same as the top yielding grass, but at CNARC top yielding alfalfa varieties yielded from 1 to 2 tons more than the top yielding grasses. Consideration should be given to planting alsike, red or strawberry clover in soils where alfalfa is not adapted.

TABLE 5.
Average Dry Matter Yields of Grasses When Irrigated Throughout the Entire Season at Knoll Creek and Central Nevada

| Species and Variety | Knoll Creek, Jackpot T/A | Central Nevada, Austin T/A |
|---|---|---|
| Intermediate Wheatgrass-Greenar | 5.2 | 2.6 |
| Intermediate Wheatgrass-Oahe | 5.1 | 2.9 |
| Pubescent Wheatgrass-Luna | 4.6 | 2.0 |
| Smooth Bromegrass-Lincoln | 4.8 | 2.2 |
| Smooth Bromegrass-Manchar | 3.9 | 2.4 |
| Turkish Bromegrass-Regar | 4.4 | 2.4 |
| Tall Fescue-Alta | 4.4 | 2.8 |
| Tall Fescue-Fawn | 4.2 | 2.3 |
| Tall Fescue-Kenmont | 5.1 | 2.3 |
| Orchardgrass-Latar | 3.9 | 2.4 |
| Orchardgrass-Potomac | 4.0 | 2.2 |
| Creeping Meadow Foxtail-Garrison | 4.6 | 2.6 |
| Timothy-Drummond | 4.5 | 2.9 |
| Redtop | 4.9 | 2.6 |

**Adapted Plants--Short Season Water.** In some areas it is not possible to irrigate throughout the entire season because of lack of runoff, storage facilities or wells.

Results of KCFL trials and trials conducted at CNARC and the Gund Ranch show "Nordan" desert, "Greenar" intermediate, "Lunar" pubescent and "P-27" Siberian wheatgrass can be successfully grown for forage production with limited irrigation. Yields of 2 to 4 tons dry matter per acre can be obtained (Table 6). Annual nitrogen applications of 75 to 100 pounds of actual nitrogen are necessary to obtain these yields. Alfalfa or cicer milkvetch, when grown in alternate rows with grasses, did not increase yields over unfertilized pure grass stands. "Paiute" orchardgrass, "Manchar" smooth bromegrass and "Sawki" Russian wildrye were less productive than the better yielding wheatgrasses. "Alkar" wheatgrass and "Whitmar" beardless wheatgrass are not recommended for forage production with limited irrigation water.

TABLE 6.
Average Dry Matter Yields of Grasses Irrigated Until July at Knoll Creek and Central Nevada

| Species and Variety | Knoll Creek, Jackpot T/A | Central Nevada, Austin T/A |
|---|---|---|
| Desert Wheatgrass-Nordan | 3.9 | 1.9 |
| Intermediate Wheatgrass-Greenar | 4.4 | 2.2 |
| Pubescent Wheatgrass-Luna | 4.2 | 2.3 |
| Siberian Wheatgrass-P27 | 4.3 | 2.0 |
| Russian Wildrye-Sawki | 3.3 | 1.6 |
| Smooth Bromegrass-Manchar | 3.6 | 1.7 |

The results of these trials show that the producer has a viable opportunity for forage production by irrigating only until early summer.

For specific recommendations of irrigated forages for northern Nevada-type climate, see Nevada Cooperative Extension Bulletin BE-91-01.

**Establishment.** As in other areas, a well prepared seedbed is necessary to obtain a good stand. When converting an old, sod-bound meadow to an improved meadow it will be necessary to crop the area with small grain for at least two years after breaking the old sod. This will aid in decomposing the organic matter and killing undesirable species.

Grasses can be seeded as early as April 15 and legumes a month or more later after the danger of a killing frost is past. Plantings can be made anytime after these dates as long as water is available. However, summer planting should not be made after July 15 at high elevations (4,500 to 7,500 feet) and August 15 at low elevations since the danger of killing frost is increased with later plantings.

**Cutting and Grazing Management.** It is common practice in northern Nevada to delay cutting of hay until maximum dry matter yields have been obtained. This is an undesirable practice as the percent crude protein and digestibility decreases with maturity of the forage.

Experiments conducted on high mountain meadows with improved species in Colorado have shown the dry matter yields from early cuttings (June) and regrowth were not significantly different than when one late cutting was made (7). Cutting the forages when in early bloom is recommended because the hay quality will be superior to that cut late in the season. Fields may be planted with species having different maturity dates to insure that the entire forage crop on a ranch or farm does not mature at the same time.

Alfalfa and improved crops in northern Nevada are frequently grazed in the spring and fall in addition to one cutting of hay. Alfalfa trials at KCFL where plants were cut as hay, hay plus late fall pasture, spring pasture plus hay, spring and early summer pasture plus hay showed that total yields were greatly reduced by spring defoliation (Figure 8). Removal of aftermath after a killing frost did not reduce yields. These and other trials show that spring grazing of hay fields greatly reduces total yield and shortens stand life. It is advisable to delay fall grazing until after a killing frost of the legume. Grazing before frost reduces storage of food reserves in the plants and also reduces yield potential and stand longevity. Grazing where the soil is wet can cause

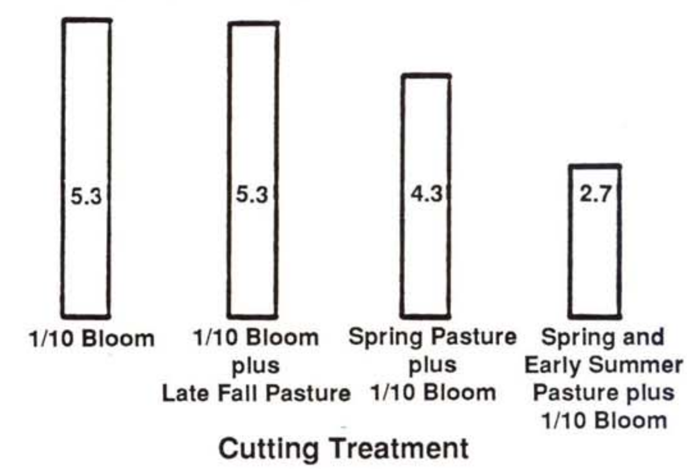



Figure 8.
Tons of Air-Dry Alfalfa at Knoll Creek When Cut at Different Times

mechanical injury to the plants and may compact soil. Damage to legumes, however, may be more severe than to other species.

## Native Meadows

In northern Nevada there are many more acres of unimproved native meadows than there are acres of improved native meadows. The major reasons for low forage production are one or more of the following: (a) poor grazing management; (b) uncontrolled water—excess in the spring and a shortage during the summer; (c) poor soil conditions—often shallow and infertile; (d) a short, cool growing season; and, (e) the species present have a low yield potential. Experiments in Nevada and elsewhere show that the amount of forage produced can be increased markedly through management practices discussed below.

**Improvement.** Willhite, et al, (12), at Colorado estimated that at 6,000 feet elevation, where irrigation is not controlled on sedge-rush type meadows, dry matter yields would be approximately 1.25 tons per acre. Where irrigation is controlled and not excessive, a grass-legume type meadow would develop and yield about 3.5 tons per acre. Yields of up to 6 tons per acre can be expected with a good stand of grass and legume, and where adequate nitrogen is applied and irrigation is controlled. Trials with improved species at KCFL have shown this to be true in Nevada also. There have been many test plots on Nevada ranchers' fields and at the Knoll Creek Field Laboratory. In general we can expect an average yield increase from 1 to 1.6 tons per acre from the addition of 80 to 160 pounds of actual nitrogen per acre.

Trials conducted at the Vineyard Ranch near Contact, Nevada, show a typical response of a native meadow to nitrogen fertilization (Table 7). Nitrogen and phosphorus were applied in the spring before irrigation and the forage was harvested only once in mid-July. Aftermath yield was not determined.

**TABLE 7.**
**Response of Native Meadow Vegetation to Fertilizer in Elko County at the Vineyard Ranch Near Contact, Nevada**

| Fertilizer Applied Lb/A | Forage T/A | Crude Protein % | Phosphorous % |
|---|---|---|---|
| 0 | 1.8 | 7.9 | .18 |
| 50 N | 2.5 | 6.2 | .16 |
| 100 N | 2.5 | 6.5 | .16 |
| 200 N | 3.1 | 7.3 | .17 |
| 200 N+100 $P_2O_5$ | 3.5 | 6.8 | .19 |
| 400 N | 3.6 | 8.4 | .16 |

Forage yields increased significantly up to the 200 pound actual nitrogen application, but the 50-pound actual rate gave the highest increment per pound of nitrogen. No yield increase from phosphorus was obtained in this trial, but none was expected as soil test values were not low. Protein and percent phosphorus were not appreciably altered by nitrogen and phosphorus fertilization. Similar results were obtained in other trials.

The time of fertilizer application is an important consideration. A fall application is preferred on some soils that are shallow (3 to 12 inches deep). Where soils are deep and kept wet during the winter by flooding or a high water table, spring fertilization is recommended. However, since such soils are found in canyon bottoms and around spring areas, they would be difficult to fertilize after the spring thaw. Time of fertilizer application to deep soils is not an important consideration when winter moisture is normal or below normal.

Application of nitrogen fertilizer on grasses usually results in increased yield and percent crude protein and higher animal gains. The benefits of nitrogen fertilizer on forage quality from mountain meadows has been questioned. Therefore, researchers fertilized portions of a meadow at 0, 64, 128, 192, 256 actual pounds per acre of nitrogen and then fed this forage to Hereford heifers. Animals weighed four hundred pounds at the beginning of the trial. The feeding trials were conducted for 45 days. Two digestion trials were conducted with the non-fertilized forages and those that received up to 256 lbs. of actual nitrogen per acre. Results are given in Table 8.

**TABLE 8.**
**Animal Response to Native Hay Fertilized at Four Rates of Nitrogen**

| | Nitrogen Applied lb/A | | | | |
|---|---|---|---|---|---|
| | 0 | 64 | 128 | 192 | 256 |
| Animal gain lb/day | .74 | .73 | .70 | 1.03 | .97 |
| Lb hay fed/day | 11 | 10 | 10 | 11 | 12 |
| Lb hay eaten/lb gain | 15 | 13 | 13 | 10 | 11 |
| Digestible dry matter % | 54.4 | — | — | — | 56.0 |
| Crude protein % | 6.4 | 6.2 | 6.8 | 6.7 | 6.3 |
| Forage yields T/A | 1.8 | 2.7 | 2.7 | 3.1 | 3.3 |
| Carrying capacity | | | | | |
| Days/A-400# animals | 240 | 415 | 415 | 620 | 600 |
| Beef production lb/A | 178 | 303 | 290 | 638 | 619 |

These trials indicate that fertilization increased yields and did not reduce quality as measured by intake or gains. Waste of feed was only slightly more from the heavily fertilized forage, but the amount was not significant. When both increased forage yields and animal performance is considered, the benefit from nitrogen is apparent.

Another important consideration in mountain meadows management is the maturity stage of forage when harvested. Early harvest is preferred because of increased quality. Experiments from the KCFL and the Newlands Agricultural Research Center in Fallon, Nevada, have shown the benefits from early harvest. Hay harvested in early July was far superior in quality to that harvested in early September (Table 9). Little additional forage was produced after July 15. Willhite (13) at Colorado also shows the benefits of early harvesting as well as anticipated yields from nitrogen fertilization over a broad range of conditions (Table 10).

In general, researchers recommend application of at least 75 pounds of nitrogen per acre and up to 150 pounds where there are improved plant species and good water management.

**TABLE 9.**
**Effect of Timing Harvest on Quality of Native Meadow Hay**

| | Time of Harvest | |
|---|---|---|
| | Early Cut | Late Cut |
| Crude protein % | 11.0 | 6.1 |
| Crude Fiber % | 27.1 | 29.6 |
| TDN % | 54.2 | 38.3 |
| Daily consumption lb/day | 15.7 | 11.9 |
| Daily gain lb/day | 1.5 | .02 |

**TABLE 10.**
**Computed Values Showing the Influence of Harvest Management and Nitrogen Fertilized Forage Fed to Short Yearling Beef in Colorado (13)**

| Nitrogen Applied Per Year lb/A | Estimated Forage Yield lb/A | Beef Production on | | |
|---|---|---|---|---|
| | | Early Cut Hay lb/A | Medium Cut Hay lb/A | Late Cut Hay lb/A |
| 0 | 3000 | 323 | 121 | 106 |
| 100 | 5400 | 581 | 218 | 191 |
| 200 | 6700 | 720 | 270 | 237 |
| 300 | 7800 | 839 | 315 | 276 |
| 400 | 8800 | 946 | 355 | 311 |

## Economic Considerations in Mountain Meadow Improvement

Within the operation of a ranch there is always some resource that limits the number of cattle that can be carried. This may be the amount of summer range or available spring grazing. On some ranches the availability of hay is limiting. On other ranches there may be shortage of fall grazing. Meadows are a source of hay for winter feeding as well as a source of fall grazing. For those ranches where mountain meadows are an intricate part of the operation the productivity of the meadows is very important.

Research and ranch experience has indicated that meadow hay quantity and quality can be increased. The question is whether the cost of the improvements is justified by the expected returns. This is not a simple question to answer because expected results from improvements are affected by the particular location of the meadow in terms of soils, weather and water. Additionally, the results are affected by management practices that are, in turn, influenced by available resources on the rest of the ranch. Meadow improvement can play an important role in the overall management scheme of increasing pounds of beef produced in terms of increased weaning weights and calving percentages.

An individual considering meadow improvements should identify the specific results desired. For example, is the goal to increase hay production or aftermath production, or is the purpose to extend the green forage grazing season? The specific reason for the improvement will determine the magnitude of the improvement. This is important in answering the question of whether or not the improvement will pay for itself.

In many meadows, hay and aftermath yields can be increased by adding fertilizer. Assume that a meadow yields 1 ton per acre of hay and provides .25 tons per acre of aftermath. Field trials indicate that applying 100 pounds of nitrogen may increase hay yields to 2.5 tons per acre and aftermath to .40 tons per acre. Every meadow will not do this well; some may do better. The fertilizer cost will be about $30 per acre. Thus, if native hay is selling for more than $20 per ton it would pay to apply the fertilizer. Looking at it another way, if native hay was selling for $60 per ton it would only require .50 tons per acre increase in hay yield to cover the cost of the fertilizer.

In addition to increased hay production, aftermath production also increases about .15 tons per acre. It was assumed that prior to fertilizing the aftermath yield was .25 tons per acre. This would provide a stocking rate of about 6 acres for one cow/calf for the months of September, October and November. Further, it is assumed that the calf will gain about .40 pound per day while on the meadow. If the price of calves is $.68 per pound, the benefit from fertilizing is $24.48 or $6.53 per acre. This does not pay for the fertilizer. Caution must be used with this analysis because of assumptions that may not be true. First, it is assumed that the number of cattle on the meadow aftermath is doubled. This is not realistic for a ranch. Further, it is assumed that quality of aftermath is the same following fertilization, and that the length of the grazing period, three months, is constant. Nevertheless, it indicates that additional hay production will pay for the fertilizer in addition to increased beef production from the aftermath.

If this same pasture receives late water, into August, forage yields will be greater. Additionally, the period of green forage will be extended. The result is not only greater hay yields and increased carrying capacity, but also increased calf gains. If calves gain .66 pounds per day instead of .40 pounds per day this results in 59 pounds of additional beef as a result of fertilizing and later water. At a market price of $.68 per pound, the additional revenue is $20.06 per acre. Because aftermath yields increased to .75 tons per acre only two acres are required to graze a cow/calf for three months.

Finally, consider a total pasture improvement program. The program assumes that there is available late water with an adequate water distribution system. Additionally, late maturing improved grass species are planted. Fertilizer is applied at the rate of 100 pounds of nitrogen early in the year and an additional 60 pounds of nitrogen after haying. A field of 3.5 tons per acre of hay and 1 ton per aftermath might be expected. Calves are expected to gain .66 pounds per day on the aftermath as a result of increased hay production as well as an increase in the length of the grazing season. Thus, if the market price of calves is $.68 per pound the 59 pounds of additional beef is worth $26.75 per acre. The fertilizer cost alone will be about $48 per acre. The cost of renovating the pasture can vary considerably.

The analysis on these various scenarios is reported in Table 11. The additional hay, valued at market price, will probably more than cover the costs of getting the additional hay. The additional pounds of calf sold as a result of additional aftermath production will probably not cover costs. This is, of course, dependent on individual situations as well as market price of calves. Valuing the hay at market price is certainly reasonable. A producer may argue that the analysis should be based on the expected returns to the total ranching operation. This is true but beyond the scope of this analysis, and in the long run will provide the same results.

Pasture improvement may result in the producer's ability to improve management practices that could result in improvements such as calving percentage and weaning weights. Improvements may be economical from the standpoint of potential returns, but may not be feasible from the standpoint of cash flow.

Table 11 provides a summary of the analysis. Note that $.68 per pound is used for calf price and $60 per ton for native hay price. Irrigation labor is added where appropriate. The last row of values is an estimate of how much could be spent, break even value, on improvements given a 10-year payback period and an expected rate of return on the investment of 3 percent. The most profitable alternative is a complete renovation, but again, it depends on how much soil has to be moved in developing the irrigation system.

TABLE 11.
Economics of Alternative Meadow Improvements

| | Unimproved | Unimproved and Fertilizer | Unimproved With Fertilizer and Late Water | Renovated |
|---|---|---|---|---|
| Hay Yield/Acre | 1 ton | 2.5 tons | 3 tons | 3.5 tons |
| Aftermath Yield/Acre | .25 tons | .40 tons | .75 tons | 1 ton |
| Total Lb. of Beef | 36 lb. | 36 lb. | 59 lb. | 59 lb. |
| Acres/Cow | 6 | 3.75 | 2 | 1.5 |
| Returns from Hay/Acre | 60.00 | $150.00 | $180.00 | $210.00 |
| Returns from Aftermath/Acre | 4.08 | 6.53 | 20.06 | 26.75 |
| Total Returns/Acre | 64.08 | 156.53 | 200.06 | 236.75 |
| Cost/Acre | — | 30.00 | 32.60 | 50.60* |
| Returns Over Costs | 64.08 | 126.53 | 167.46 | 186.15 |
| Spendable** | $— | $438.38 | $725.69 | $856.90 |

*Includes only fertilizer cost and irrigation labor.
**Calculated as additional returns above the returns from unimproved pasture. Assumes an 8-year payback period at three percent return on investment. This is not to be confused with comparing this investment with an investment that would have a return greater than three percent.

## Western Nevada-Type Climate

### Adapted Plants

**Perennial Forages.** Alfalfa is the most important forage crop in western Nevada. Production of this crop, however, is not without problems. Irrigated land in this region has been cropped for many years with a subsequent buildup of diseases and insects. Phytophthora root rot, bacterial wilt organisms and stem nematodes occur in most soils. The spotted alfalfa aphid, pea aphid and blue alfalfa aphid also present problems in certain years. However, there are adapted alfalfa varieties that have resistance to one or most of these pests and should be planted where these problems exist.

Red, alsike, ladino and strawberry clover, as well as birdsfoot trefoil, are adapted to western Nevada and are recommended for special uses, but do not yield as much as alfalfa where the latter is adapted.

Other forage plants have been widely tested in western Nevada. Tall fescue has been superior in yield and persistence to other grasses, but produces lower animal gains.

**Annual Forages.** Sudangrass and sudangrass-sorghum hybrids and Japanese millet will grow well in this area. Two cuttings of sudangrass and one of sudangrass-sorghum hybrids and millet can be obtained. Yields of about 5 tons dry matter can be harvested when properly managed. The danger of HCN poisoning from the sudangrass and sudangrass-sorghum can be reduced by a low HCN variety such as Piper sudangrass. Sudangrass grows best in the warm season and should be planted in late May or early June.

At 1989 market conditions, farmers in Nevada can gross $200 more per acre from growing oats for hay rather than growing cereals for grain. Both the domestic and foreign markets for oat hay are strong at this time. The cereals are grown in a rotation for one or two years following alfalfa. Yield trials conducted at three locations in western and central Nevada show yields of 4 tons per acre can be consistently obtained. Forage yields of 6 tons per acre were obtained in some trials. Monida is the recommended cultivar. In 1988, the nitrate content of Monida oats grown at three locations was in the toxic range. The average nitrate content, expressed as percent $KNO_3$, was 1.19, 1.57 and 1.91 in oats grown at Eureka, Fallon and Reno, respectively. In 1989, application of urea, ammonium sulfate and ammonium nitrate increased yields more consistently than calcium or potassium nitrate when applied at 50 or 10 lb/A of actual nitrogen. Rate or form of nitrogen did not affect protein or nitrate content. However, at Eureka, both the protein and nitrate content of the oat forage was significantly higher etc., when following alfalfa than when grown after fallow. At Reno, the protein content of the forage was significantly higher when grown after corn than when grown after alfalfa. The nitrate content of the oat hay was significantly higher when grown following alfalfa than when planted after corn.

Protein content of the forage was significantly increased by planting Austrian winter peas or common vetch in eight of the 10 trials. However, the increase in protein was small (1 to 4 percent). Seeding oats at 60 lb/A is recommended if a higher protein content is desired. Oats for forage is a viable alternative for cereals grown for grain in Nevada.

Results of trials conducted at Reno and Eureka in 1989 show winter annual cereals can be successfully grown in Nevada. Jenkins triticale yielded 5 to 6 and 6.9 tons per acre at Eureka and Reno, respectively. Aroostock, Hancock, Musketeer, Rymin and Palouse rye all yielded over 6 tons per acre at Reno. At Eureka, Aroostock, Rymin rye all yielded more than 5 tons per acre. These forage cereals should be fall seeded and planted at the same time winter cereals for grain are planted. At Reno, the winter cereals were harvested in mid-June and Piper sudangrass was seeded into the stubble. Four tons of forage was harvested the first week of September, giving a combined yield of nearly 11 tons of forage from the winter annual cereals and summer grown sudangrass.

## Pastures

Results of a grazing trial at Reno show that tall fescue had a greater grazing capacity than orchardgrass, smooth bromegrass or Kentucky bluegrass, but average daily gain of yearling steers was lowest from tall fescue pastures (Table 12). Total beef production per acre was greatest from orchardgrass and least from Kentucky bluegrass, but tall fescue had the greatest carrying capacity.

Beef yields of a thousand pounds per acre have been obtained where the following management practices have been used: (a) high yielding and palatable mixtures or species; (b) adequate fertilization; (c) proper irrigation; (d) rotational grazing; (e) clipping one or two times during the summer; (f) harrowing to spread droppings; (g) use of young animals with potential for high rate of gain; and, (h) adding or removing animals according to available feed.

TABLE 12.
Effect of Pasture Species on Grazing Capacity, Average Daily Gains and Live Weight Gains Per Acre by Yearling Steers at Reno

| Species | Grazing Capacity AUM/A | Average Daily Gain lb. | Live Weight Gain Per Acre lb. |
|---|---|---|---|
| Tall fescue | 18.0 | 1.76 | 952 |
| Orchardgrass | 16.2 | 2.30 | 1114 |
| Smooth bromegrass | 12.7 | 2.51 | 955 |
| Kentucky bluegrass | 12.9 | 2.32 | 896 |

## Cutting and Grazing Management

Alfalfa can be cut three or four times each year depending on variety and length of frost-free season. Spring grazing of alfalfa should be avoided, but grazing in the fall or winter after a killing frost results in more forage utilized without reducing summer yields. This is also true for grasses where maximum forage yield is desired. Even though early spring pasture is frequently needed in western Nevada, pasturing hayland during the spring and then taking a hay crop will reduce total dry matter yield. Experiments conducted on grass-legume meadows at Reno showed that when forage plots were cut as pasture on May 15, and then as hay, yields of hay were more than half a ton less than those forages cut as hay only. Those that were cut twice in the spring with the last pasture cutting on May 27, and then cut as hay, produced a ton less hay forage than when cut in the hay stage only.

However, Table 13 shows that pounds protein produced per acre may not be reduced by frequency of cutting. In fact, protein yields from a wet meadow were higher from plots cut four times than from those cut twice. The decision to graze and then cut the meadows as hay, or harvest as hay only, would be dependent upon the rancher's needs regarding total forage or total crude protein in this operation.

TABLE 13.
Average Forage Yields, Percent Protein and Pounds Protein per Acre from Meadows Harvested at Different Frequencies.

| Number of Harvests | Forage T/A | Protein Percent | Protein lb/A |
|---|---|---|---|
| **Improved Meadow** | | | |
| 7 (grazing) | 2.44 | 16.2 | 791 |
| 4 (grazing) | 3.14 | 13.2 | 829 |
| 2 (hay) | 3.76 | 10.2 | 767 |
| **Indigenous Meadow** | | | |
| 7 (grazing) | 1.87 | 17.0 | 626 |
| 4 (grazing) | 2.12 | 13.8 | 585 |
| 2 (hay) | 3.04 | 10.3 | 626 |
| **Wet Meadow** | | | |
| 7 (grazing) | 1.88 | 14.5 | 545 |
| 4 (grazing) | 2.31 | 12.8 | 591 |
| 2 (hay) | 2.83 | 8.8 | 498 |

## Forage Production on Salt Affected Soils

Estimates indicate there are more than 100,000 acres of saline, sodic, or saline-sodic soils in Nevada located near sources of water that could be used for forage production. Much of this acreage is in western Nevada. Most of these soils are not suited to intensive row cropping or alfalfa production for forage because of fine texture and/or high water table and their saline-sodic condition. Much of the area is presently devoted to production of native grasses such as saltgrass which, while well adapted to both saline-sodic conditions and the natural low fertility, do not yield much forage, even with fertilization and adequate irrigation. If these native grasses were replaced by higher yielding species, forage production could be increased.

Results of experiments conducted at Reno demonstrated the feasibility of establishment of adapted desirable forage species such as tall fescue and tall wheatgrass on saline-sodic soils where saltgrass is the native vegetation. The most critical phase is during emergence and establishment. This problem can be effectively met by maintaining a moist soil surface during the first weeks of establishment (Figure 9). This reduces the salt concentration around the germinating seed and seedling and avoids problems associated with hard surface crusts. A moist surface may be accomplished by frequent water applications by sprinkler or application of water through a furrow.

With careful management, one-half to two-thirds as much beef can be produced per acre with tall wheatgrass and tall fescue on saline-sodic soils as can be produced on the better soils.

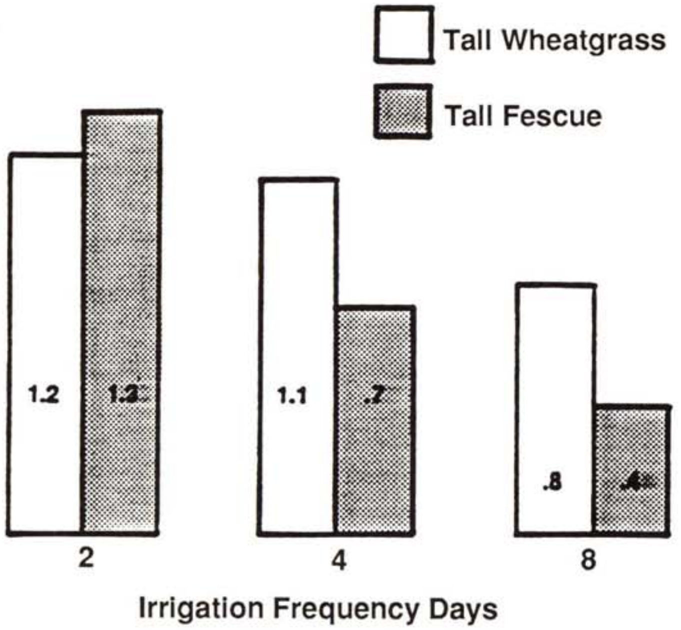



Figure 9.
Tons of Air-Dry Forage Per Acre from Plots on Salt Affected Soils Irrigated at Different Frequencies During Establishment.

## Southern Nevada-Type Climate

### Adapted Plants

The utilization of adapted species of cool and warm season forages allows year-round forage production in southern Nevada. To produce year-round forage on the same land requires use of summer and winter annuals or two compatible perennials that do not crowd one or the other out during their dormancy period. Recommended forages for southern Nevada-type climate are given in reference (5).

Alfalfa plays an important role in forage agriculture and is the largest single crop grown solely for forage. The higher elevation valleys of southern Nevada produce four to five cuttings of alfalfa per year; the lower valleys six to seven cuttings. Varietal selection is based on forage yields, seasonal distribution, longevity of stands and resistance to insects and disease. The hardy alfalfa varieties become dormant in the fall when the weather cools and the day length shortens. Non-hardy varieties will continue to grow during the mild winter in southern Nevada. The amount of forage produced depends upon the severity of the winter, therefore, seasonal distribution of alfalfa forage can extend over a longer period of the year with non-hardy varieties. If alfalfa is utilized as hay, seasonal distribution is not as important as if the forage is used for green chop, pasture, or as a hay and green chop combination. Non-hardy varieties decline slightly during the second year and quite rapidly thereafter. Varieties with a slight dormancy period persist four to six years.

Sudangrass and sorghum-sudangrass hybrids are well adapted to southern Nevada as warm season grasses. Past trials at the Southern Nevada Field Laboratory (SNFL) have shown yields of 12 to 16 tons dry forage per acre with four to five harvests per year for sudangrass and three to four harvests of the hybrid varieties.

Several perennial grasses have been tested for adaptation in southern Nevada. Fawn and Alta tall fescue appear to be more adapted than other cool season grasses tested and yield well in the spring and late fall.

Bermudagrass is commonly considered a weed, but by using improved forage varieties and high rates of nitrogen fertilizer, high yields of bermudagrass hay, green chop or pasture are possible. The giant form yielded significantly more than other varieties tested and has the advantage that it can be established from seed rather than from sprigs. Therefore, NK-37 is normally recommended. Another acceptable variety to use is Coastal.

Bermudagrass produces forage during May through October in southern Nevada and is dormant the remainder of the year. Establishment of cool season forages in bermudagrass pastures provides forage during periods of low productivity or dormancy. Overseeding with annual grasses such as oats, wheat, barley or ryegrass resulted in a better forage distribution because they provide forage in late fall, winter or early spring. By planting in September, however, some bermudagrass forage will be sacrificed in the fall. Competition in the spring resulted in a lower yield of bermudagrass in the May harvest.

Legumes such as black medic, bur clover or ladino clover increase the forage yields of the mixture. In addition, forage quality may be increased and nitrogen fixed by the symbiotic bacteria associated with the legume. The fixed nitrogen would be available to aid growth of the bermudagrass later in the season. Black medic and bur clover persisted into the summer better than the other legumes tested.

Cereals as forage produce feed in late fall and early spring. Northern varieties yield higher than the southern types as green chop forage. Oats can be utilized for ensilage as well as green chop, pasture and hay.

Vetch and winter peas have been previously grown at the Southern Nevada Field Laboratory for green manure. They are well adapted as a winter crop. Utilizing them as a mixture with oats should increase the quality of the forage for hay.

### Establishment

Alfalfa can be planted in any month in southern Nevada, but fall planted alfalfa generally performs better than spring or summer plantings. Weed infestation is greatly reduced with fall planting and yields are higher the first year. Planting with a companion crop is recommended only if there is danger of wind abrasion to the alfalfa seedlings. Stands will be thinner and first year yields lower if a companion crop is used.

Sudangrass and sorghum-grass hybrids can be planted from late March to August. Yields are greater from early plantings (Table 14), however, some chloritic conditions may result if the temperature becomes cool after planting.

TABLE 14.
Forage Yields of Piper Sundangrass Planted at Six Dates at Logandale, Nevada

| Date of Planting | Month of Harvest and Yield June T/A | July T/A | August T/A | Sept. T/A | Oct. T/A | Total T/A |
|---|---|---|---|---|---|---|
| March 14 | 2.1 | 4.0 | 3.1 | 2.0 | — | 11.2 |
| March 23 | 1.9 | 2.4 | 2.6 | 2.6 | — | 9.5 |
| April 4 | 1.9 | 2.2 | 4.6 | 1.6 | — | 10.3 |
| April 13 | 2.5 | 3.2 | 2.4 | 2.7 | — | 10.8 |
| April 25 | — | 1.3 | 3.9 | 2.5 | — | 8.2 |
| May 4 | 2.2 | 2.6 | 1.7 | 2.0 | — | 8.5 |
| May 16 | — | 1.6 | 3.9 | 2.2 | — | 6.9 |
| May 25 | — | 1.8 | 2.0 | 2.8 | — | 6.6 |
| June 5 | — | — | 2.7 | 3.7 | 1.0 | 7.4 |
| June 15 | — | — | 1.0 | 1.9 | — | 2.7 |
| June 19 | — | — | 2.1 | 1.2 | — | 3.3 |
| July 6 | — | — | — | — | — | — |

Tall fescue can be established at any time other than during the hot summer months. Fall establishment results in a better stand with less weed infestation and forage can be harvested the following spring.

Trials at the SNFL indicate cereals can be planted from August through November, but seeding in mid-September will result in the highest forage yields. Data presented in Table 15 shows the effect of date of seeding on yield distribution of cereals planted for forage. Seeding after mid-October greatly reduces yield.

TABLE 15.
Forage Yields of Cereals Planted at Five Dates

| Planting Date | Species | Nov. 9 T/A | Nov. 23 T/A | Jan. 21 T/A | Feb. 12 T/A | Feb. 26 T/A | Mar. 21 T/A | Mar. 25 T/A | Total T/A |
|---|---|---|---|---|---|---|---|---|---|
| Aug. 20 | Wheat | 1.4 | — | — | 1.6 | — | 2.4 | — | 5.4 |
| | Barley | 1.8 | — | — | 1.8 | — | 1.4 | — | 5.0 |
| | Oats | 1.6 | — | — | 1.6 | — | 1.4 | — | 4.6 |
| | Rye | .6 | — | — | 1.7 | — | 2.2 | — | 4.5 |
| Sept. 10 | Wheat | — | 1.4 | — | — | 1.9 | — | 1.9 | 5.2 |
| | Barley | — | 3.0 | — | — | 2.1 | — | 1.3 | 6.4 |
| | Oats | — | 3.1 | — | — | 2.1 | — | 1.6 | 6.8 |
| | Rye | — | 1.8 | — | — | 2.2 | — | 1.6 | 5.6 |
| Oct. 1 | Wheat | — | — | 1.0 | — | 3.2 | — | 1.0 | 5.2 |
| | Barley | — | — | 1.5 | — | 2.7 | — | .8 | 5.0 |
| | Oats | — | — | 1.3 | — | 2.4 | — | .8 | 4.5 |
| | Rye | — | — | 1.4 | — | 2.2 | — | .7 | 4.3 |
| Oct. 20 | Wheat | — | — | — | — | — | 1.6 | — | 1.6 |
| | Barley | — | — | — | — | — | 2.5 | — | 2.5 |
| | Oats | — | — | — | — | — | 1.8 | — | 1.8 |
| | Rye | — | — | — | — | — | 2.4 | — | 2.4 |
| Nov. 10 | Wheat | — | — | — | — | — | — | .7 | .7 |
| | Barley | — | — | — | — | — | — | 1.5 | 1.5 |
| | Oats | — | — | — | — | — | — | 1.2 | 1.2 |
| | Rye | — | — | — | — | — | — | .6 | .6 |

**Management and Utilization**

Alfalfa is harvested several times each year in southern Nevada and phosphate fertilizer is normally needed for maximum production. Applications of 200 and 400 pounds per acre of treble superphosphate (0-45-0), depending upon soil conditions, are usually necessary for best results. Application rates should be based upon soil tests. Normally, annual phosphate applications may be more beneficial than a single application at planting.

Proper management is essential to produce high yields of quality hay and to maintain satisfactory stand life. In southern Nevada, alfalfa can be harvested every three to four weeks during the summer months. Sufficient regrowth of the plant is essential to replenish the carbohydrate reserves in the roots used in regrowth. Alfalfa stands are rapidly depleted if harvested too frequently. Harvesting about one-tenth bloom stage or when the crown buds are 1 1/2 inches in length, is usually a good harvest guide. However, non-hardy varieties will attain one-tenth bloom stage 14 to 16 days after the previous harvest during midsummer. The carbohydrate reserves have not been replenished adequately in the roots to maintain good stands. Therefore, it is especially important that harvesting should be determined by new crown bud development or delayed slightly after one-tenth bloom to allow replenishment of root reserves.

Alfalfa should be harvested and removed from the fields in three to five days. Severe retardation of growth of alfalfa covered by windrows or bales can be observed in subsequent crops.

Trials at the SNFL indicate that yields of more than 10 tons of alfalfa hay per acre can be anticipated most years; an average of about 8 tons per acre is not unusual.

Alfalfa is frequently utilized as a green chop forage or a combination of hay and green chop. Harvest management of alfalfa as green chop should be the same as when utilized as hay. Too frequent harvesting results in severe stand depletion and encroachment of weeds and grasses.

Sudangrass and sorghum-sudangrass hybrids utilize large amounts of nitrogen fertilizer. Applications of 60 actual pounds nitrogen per acre preplant and an additional 60 pounds after each harvest is recommended for most soils in southern Nevada. A preplant application of 100 to 150 actual pounds treble superphosphate is usually recommended.

Quality of sudangrass and sorghum-sudangrass harvested for hay is comparable to most grass hay, but is lower in feed value than alfalfa. Harvesting at pre-bloom or early bloom stage results in a higher quality hay than later stages of maturity. Yields of 12 to 16 tons dry forage per acre can be expected from late April or early May plantings. The hybrid varieties have larger leaves and stems than the sudangrass varieties; therefore, higher planting rates are recommended for quality forage. For faster recovery, a 4 to 6 inch stubble height should be left. Hybrids are slower maturing and will produce greater amounts of forage than the sudangrasses when harvested only three times each season. On the other hand, if the sudangrasses are harvested at the early bloom stage of maturity, (four to five times each season) their total annual yields will be comparable to the hybrids.

Sudangrass and sorghum harvested at pre-bloom stage produce a succulent green chop forage readily accepted by livestock. When harvested at the pre-bloom stage of growth, the protein content is higher than when harvested at a later stage of maturity. However, results of lower protein forage is evidenced in trials at Logandale where young grazing animals failed to gain weight when fed only silage, but gained 1 pound or more a day when fed at least 50 percent alfalfa with silage (Table 16).

TABLE 16.
Performance of Heifers Fed Sorghum Silage and Varying Portions of Moapa Alfalfa Hay

| | Percent Alfalfa in Ration | | | | |
|---|---|---|---|---|---|
| | 0 | 25 | 50 | 75 | 100 |
| Average Daily Gain (lb) | 0.08 | 0.79 | 1.06 | 1.11 | 1.56 |
| Dry Matter Intake (lb/day) | 8.00 | 11.0 | 11.1 | 11.6 | 15.7 |
| Feed Fed Per Lb Gain | 100.0 | 13.8 | 10.5 | 10.5 | 10.0 |

Sudangrass and sorghum-sudangrass pastures provide large amounts of forage during the summer. Rotation grazing starting at the pre-bloom stage is recommended for a three- to five-day grazing period each three to four weeks. Grazing during the early stages of growth or under drought or frost conditions may be injurious to livestock because of higher levels of prussic acid. The sorghum-sudangrass hybrids contain higher levels of prussic acid. The sorghum-sudangrass hybrids yield higher when a 4 to 6-inch stubble height is left at harvest. For best results, close grazing should be avoided.

Tall fescue requires ample nitrogen fertilizer for highest yields. Applications of 50 pounds actual nitrogen per acre in March, April, May, September and October will satisfy the nitrogen requirements on most soils in southern Nevada.

Forage production of tall fescue is mainly in the spring and fall with limited summer growth and slight growth during mid-winter. Seasonal distribution of forage yields at Logandale are given in Table 17. Two spring hay harvests and one or two harvests in the fall are possible each year. High yields are possible, but animal acceptance of the forage is better if harvested at root rather than after head stage.

Green chopping tall fescue will provide feed early in the spring and again in the fall when forage production of other species is low. Forage can be harvested each month from April through December, but summer yields are low.

Tall fescue is probably best suited for pasture in southern Nevada. The carrying capacity of tall fescue pastures fluctuates, but animals can graze year-round on well managed pastures. A legume mixture of either birdsfoot trefoil, strawberry clover or black medic will enhance forage production.

Bermudagrass hay quality is similar to other grass hay and is readily accepted by animals. Protein content is usually about 8 to 12 percent when fertilized with nitrogen. The grass can be green chopped six to eight times each year and is readily accepted by animals. Green chopping should not be more frequent than every three or four weeks because yields may be reduced and nitrate content increased by more frequent harvesting. Bermudagrass responds well to nitrogen fertilizer (Table 18). Care should be taken not to apply too much nitrogen fertilizer because of a danger from nitrate toxicity to animals.

Spring burning of the stubble or residue organic matter appreciably increased bermudagrass yields and gave additional benefits of reduced incidence of weeds and insects as well as slightly earlier spring growth.

Rotation grazing of three to seven days and three weeks regrowth is recommended when bermudagrass is utilized as pasture.

Trials with blue panicgrass have shown greater yields with increasing nitrogen rates up to 1,000 pounds per acre per year. Applications of 100 actual pounds per acre in the spring and 75 actual pounds after each harvest will produce satisfactory yields. Blue panicgrass is a warm season grass and should be harvested at early bloom as hay with a stubble height of 5 to 8 inches to maintain better stands. Yields of 6 to 8 tons of forage in five harvests can be anticipated, however, animal acceptance is low. When utilized as green chop forage, management should be similar to that of hay to maintain adequate stands.

Cereals are utilized primarily as green chop forage in southern Nevada, however, they provide good pasture

TABLE 17.
Harvest Management and Forage Yields of Alta Tall Fescue

| Simulated Harvest | No. of Cuttings | Mar. T/A | Apr. T/A | May T/A | June T/A | July T/A | Aug. T/A | Sept. T/A | Oct. T/A | Nov. T/A | Dec. T/A | Total T/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| First Harvest Year | | | | | | | | | | | | |
| Pasture | 10 | .6 | 1.2 | 1.8 | .3 | .3 | .4 | .6 | .5 | .4 | — | 6.1 |
| Green Chop | 7 | — | 1.7 | 1.9 | — | .7 | — | 1.6 | .6 | — | .5 | 7.0 |
| Hay | 5 | — | 2.8 | 1.6 | — | .8 | — | — | 1.6 | — | 1.0 | 7.8 |
| Second Harvest Year | | | | | | | | | | | | |
| Pasture | 9 | .8 | 1.1 | 1.0 | .6 | — | .9 | — | .7 | .8 | — | 5.9 |
| Green Chop | 6 | 1.0 | — | 1.1 | .8 | — | 1.0 | — | — | .9 | .5 | 5.3 |
| Hay | 4 | — | 1.2 | 1.3 | — | — | — | 1.3 | — | — | 1.5 | 5.3 |

TABLE 18.
Dry Matter Yields of Giant Bermudagrass Fertilized at Four Nitrogen Rates for Five Years

| N/A Applied at the Start of the Season and After Each Harvest lb | N/A Applied | Harvest Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | First T/A | Second T/A | Third T/A | Fourth T/A | Fifth T/A | Avg. T/A |
| 0 | 0 | 7.8 | 2.9 | 4.3 | 3.1 | 4.0 | 4.4 |
| 25 | 150 | 9.1 | 4.8 | 6.5 | 5.3 | 5.9 | 6.3 |
| 50 | 300 | 11.7 | 6.2 | 8.3 | 8.9 | 7.7 | 8.6 |
| 100 | 600 | 13.9 | 9.3 | 11.0 | 12.4 | 11.2 | 11.6 |
| 200 | 1200 | 15.7 | 10.4 | 12.1 | 15.8 | 13.5 | 13.5 |

during the winter months. Oat hay is an excellent feed for horses. Cereals respond well to nitrogen fertilizer and applications of 60 pounds of nitrogen per acre pre-plant plus an additional 60 pounds after the first harvest or in early March are recommended.

A rotation grazing system of cereals will allow grazing throughout the entire winter. Grazing should be in the pre-boot or early-boot growth stage to insure regrowth for subsequent grazing. As with forage harvested mechanically, a 4-inch stubble should remain after grazing.

If cereals are to be green chopped more than once, harvesting must be done before early-boot stage to insure adequate regrowth for subsequent harvests. Also, a stubble of at least 4 inches should be left. Cereals will provide forage from November to April when most grasses and legumes are not productive. Northern varieties will provide greater winter forage growth than southern varieties. Trials at the Southern Nevada Field Laboratory indicate that more than 5 tons per acre can be harvested depending upon planting date as shown in Table 15.

Oats for hay planted in late September or early October will provide winter pasture or green chop and then can be left for hay. Planting in late November or in February can be pastured, green chopped or harvested for hay, but not as a combination of harvests. Caution must be taken to pasture or green chop the crop before the early boot stage to insure subsequent growth.

## Forage Mixtures

Alfalfa, blue panicgrass and Alta tall fescue were seeded alone, and in all combinations, at the SNFL to evaluate the yield potential and forage composition of mixed stands. Dry matter yields indicated that alfalfa and blue panicgrass are not enhanced by mixed stands, but that tall fescue yields can be increased by addition of alfalfa. Alfalfa was the dominant species in mixed stands.

Alfalfa was the most competitive species during the establishment year and at the end of the growing season. It was also the principal component of the mixtures where it was included. Blue panicgrass was more competitive in the various mixtures than tall fescue during this trial period. Planting alfalfa, blue panicgrass and tall fescue in mixtures does not appear to be advisable for southern Nevada. See reference (5) for recommended forage mixtures for southern Nevada.

Forage mixtures do not yield significantly higher than the more productive species when planted alone. However, seasonal distribution of forage can be altered to fit the individual forage needs by overplanting or seeding mixed stands.

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