Profitable Pasture Production in Central Oregon

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PROFITABLE PASTURE PRODUCTION IN CENTRAL OREGON

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SUMMARY

Irrigated pastures provide less profit per acre than any other crop grown in Central Oregon. This is due mainly to poor management practices , use of low-yielding grasses, and low soil fertility levels. Correcting these problems would greatly increase the profitability of pasture use. This report discusses aspects of pasture mixtures, soil conditions, legume inoculation, seeding, irrigation, weed control, and grazing management needed to increase production and profits from pastures.

INTRODUCTION

Irrigated pastures return less on investment per acre than any other crop grown in Central Oregon. The small profit is due mainly to poor management of livestock, pasture, and irrigation, use of low-yielding grasses, and low soil fertility levels.

Properly managed pastures can be among the most profitable areas on a farm, but when managed in the usual manner, they can actually cost the farmer money. Usually the quantity and quality of feed provided by unproductive, run-down pastures do not maintain livestock in healthy condition let alone return a profit (5).

PERMANENT PASTURES

Permanent pastures are maintained indefinitely for grazing; once established, they are seldom plowed under for use in crop rotation. Almost every farm has some area better suited to permanent pasture than

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to any other use. Shallow or rocky soils or erodable steep slopes should be left in permanent pastures.

Quackgrass and thin sods of bluegrass cover many permanent pastures. Usually only native legumes are present and both grasses and legumes produce very little. Many permanent pastures are unproductive because of low soil fertility levels. If a good stand of desirable plants exists in the pasture, top-dressing with fertilizers, manure, and lime can improve the botanical composition, feeding value, and productivity of the pasture. Pasture plants, like any other crop plants, need high levels of soil fertility to produce high yields.

ROTATION PASTURES

Rotation pastures are grown with other crops in a rotation schedule. Since they must be replanted every 3 to 5 years, they cost more than permanent pastures, but the extra establishment expenses are quickly repaid. Almost all cropland should be occupied by grasses and legumes at regular intervals; this maintains soil structure, prevents excessive leaching and erosion, and increases soil nitrogen levels. These effects combine to increase yields of crops grown in rotation with pastures. Because of these advantages, pastures should not be permanent where plowing is possible. Research studies comparing rotation and permanent pastures show that on productive, non-erodible cropland, maintaining land in pasture for long periods does not give maximum returns on investment. Occasional plowing and growing of one or more intervening crops or directly re-establishing with high-yielding grasses and legumes result in optimum forage production.

A study in Wisconsin compared two cycles of two 6-year rotations, with unimproved and renovated permanent bluegrass pastures (Table 1). Eight years of bromegrass-alfalfa pasture, in two cycles of pasture, corn, and oats rotation, produced more total digestable nutrients (TDN) than the entire 12 years of permanent grass, and more than twice as much TDN for the 12-year period. Not only were rotation pastures more productive than permanent pastures but they were also important in producing high yields of crops that followed in the rotation.

Table 1. Comparison of total digestible nutrients (TDN) from fields under four systems of management during two cycles of rotation (1944-49; 1950-53) in Wisconsin.

System	Yields of TDN		
	12-year crops & pasture total	8-year pasture total	Increase over continuous bluegrass
	-----------	tons/acre	-----------
Permanent bluegrass	6.89	4.33	----
Renovated bluegrass	10.19	6.45	2.12
Corn, oats, grass-clover (4 Years)	12.66	5.55	1.22
Corn, oats, bromegrass-alfalfa (4 Years)	14.67	7.19	2.86

Adapted from: Sund, J. M., et al. (19).

PASTURE MIXTURES

Simple mixtures of one grass and one legume usually perform best in both rotation and permanent pastures. Although mixtures complicate fertilization and management practices, their advantages outweigh their disadvantages.

Grass-legume mixtures are higher yielding, more persistent, and easier to harvest and cure for hay than legumes grown alone. Feeding grass-legume mixtures instead of pure legumes helps minimize bloat. Milk fever and reproduction problems also may decrease with mixtures because of a more favorable calcium-phosphorus balance in the forage, as compared to pure legumes.

Advantages of grass-legume mixtures over pure grass stands are even more obvious. Yields increase and forage production is distributed more evenly over the season by mixtures than by grasses grown alone.

Introducing legumes into a pasture improves beef production. In an Indiana pasture study, application of nitrogen, phosphorus, potassium, and lime to bluegrass increased beef production by 100 percent per acre (Table 2). With no nitrogen fertilizer, but with a legume introduced (in this case birdsfoot trefoil) into the grass sod, beef production increased 127 percent over the control of bluegrass continuously grazed and receiving no lime or fertilizer (13).

Table 2. Effects of fertilizer treatments and birdsfoot trefoil on bluegrass pasture production and animal gains (7-year average) in Indiana.

Treatment	Avg no. Steers per acre	Days in grazing period	Total steer days	Beef pounds per acre
Control: no lime or fertilizer; continuously grazed	0.8	152	121	131
Lime, phosphorus, potassium; rotationally grazed	1.2	152	190	182
Lime, nitrogen, phosphorus, potassium; rotationally grazed	1.8	152	278	262
Lime, phosphorus, potassium, legume; rotationally grazed	2.0	152	306	297

Adapted from Scholl, J. M., and O. G. Bentley (13).

Managing mixtures is more difficult than managing pure grass or legume stands. Many management practices, including fertilization, height and frequency of cutting and grazing, and irrigation influence botanical composition of the stand, and maintaining desired proportions of each component in the mixture is difficult. Practices favoring grasses must be balanced with those favoring legumes; if the balance shifts in either direction, the grass or legume may be lost from the stand (2).

The pasture mixture used depends on individual needs and soil conditions. Mixtures of alfalfa, Ladino or New Zealand white clovers, or red clover (for short-term use), with either orchardgrass, bromegrass, tall fescue, intermediate wheatgrass, meadow foxtail, or bluegrass (for horse pasture) generally work well under Central Oregon conditions. A 5-year study comparing yields of 33 varieties of seven different kinds of grasses was conducted at the Central Oregon Experiment Station between 1968 and 1972. Average annual hay yields were highest for orchardgrasses as a group (4.52 ton/acre) followed in order of productivity by timothies (4.34 ton/acre), bromegrasses (4.22 ton/acre), meadow foxtails (4.14 ton/acre), intermediate wheatgrasses (4.05 ton/acre), tall fescues (3.97 ton/acre), and Kentucky bluegrass (3.60 ton/acre) (8).

ESTABLISHING THE PASTURE

Profitable and successful use of pastures depends on how well the plants are established. Poor establishment practices result in poor stands but cost about the same as if the job had been done right. Long-lived, high-yielding pasture mixtures can be established successfully by considering several aspects of establishment and following proven procedures.

SOIL CONDITIONS

Soil Testing

Determine soil fertility levels and fertilizer and lime needs with soil tests. Have soils tested before planting and at regular intervals during the life of pastures. Follow soil test recommendations to maintain high soil fertility levels for maximum forage production.

Fertilizers

Pasture mixtures with high-yielding potential reach their full capacity only when growing in soils with high fertility levels; applying fertilizer to pastures can give investment returns as large as those from cultivated crops (6). Forage plants differ widely in the amounts of nutrients they remove from soils (Table 3). Few soils can supply large amounts of required nutrients for very long without fertilizer applications. If fertilizers are not applied, sooner or later yields decrease, and run-down, worn-out pastures having low productivity and carrying capacity result.

Table 3. Plant nutrients removed from soils by different forages in 1 ton of hay.

	Nutrient				
Forage	N	P	K	S	Ca
	pounds				
Alfalfa	50	5	50	5	35
Ladino clover	71	7	43	5	26
Kentucky bluegrass	40	8	34	3	9

Adapted from Nat. Res. Council (10).

Nitrogen is extremely important for both forage quality and yield; it forms a major part of proteins and chlorophyll and is essential for photosynthesis, growth, and reproduction. Legumes normally obtain almost all of their nitrogen supply from air through the symbiotic relationship with rhizobia (nitrogen-fixing bacteria) that live in nodules on the plant roots. Their ability to do this and provide nitrogen for associated grasses or other crops in rotation is one of the main advantages of growing legumes. Attempts to supplement legume nitrogen have been disappointing. Rhizobia stop fixing nitrogen in the presence of large amounts of available soil nitrogen; applied nitrogen replaces, rather than supplements, the nitrogen that normally would be fixed (23).

Response of grass-legume mixtures to nitrogen application depends on plant species (both legume and grass), botanical composition, availability of other plant nutrients, and grazing and irrigation management. Grasses in mixtures obtain their nitrogen from one or more of three sources: (1) soil organic nitrogen, (2) fertilizer nitrogen, and (3) underground transfer from associated legumes. Under ideal field conditions, legumes may transfer half of the fixed nitrogen to grasses.

The economics of applying nitrogen to grass-legume stands have been studied in detail. Considering all aspects (yields, legume content of the mixture, and seasonal distribution of production), nitrogen fertilizer should not be applied until the percentage of legume in the stand falls below 20 percent (2).

Plants require phosphorus in photosynthesis, energy transfer, and in production and breakdown of carbohydrates. It is a key element in growth and cell division and concentrates in young, actively growing tissues. Since these tissues are the most palatable and nutritious, highest quality forage only results when the phosphorus supply is adequate. Soil phosphorus is especially critical for normal root development and establishment of young seedlings (2,23).

Phosphorus is one of the nutrients most generally deficient in soils. Soils rapidly tie up large amounts of phosphorus in forms not readily available to plants; because of this, usually no more than 10 to 20 percent of applied phosphorus is recovered in the first crop after application. Phosphorus usually is not leached from the soil. It is more available to plants at soil pH levels between 6.0 and 7.0.

Potassium is not as universally deficient in soils as phosphorus, but potassium levels decrease and limit production after soils have been cropped for some time. Only a small part of the total potassium in soils becomes available in any one year; because of this, soils often support forages at low-yield levels, without potassium application, but yields increase greatly with potassium fertilization (Table 4).

Table 4. Effect of potassium (K) fertilizer on yield and botanical composition of four grass-legume mixtures in Maryland. 1954.

Mixture	K applied, lb/acre	Forage yield tons/acre	Forage yield % increase	Legume yield % legume	Legume yield tons/acre	Legume yield % increase
Bromegrass-alfalfa	0	1.99		73	1.45	
	250	4.08	105	90	3.67	153
Orchardgrass-alfalfa	0	2.50		27	0.55	
	250	2.79	36	46	1.28	132
Orchardgrass-Ladino clover	0	1.87		7	0.13	
	250	3.03	62	12	0.36	177
Tall fescue-Ladino clover	0	2.04		8	0.16	
	250	2.92	30	28	0.74	375

Adapted from Hunt and Wagner (8).

Soils lose potassium through leaching and by plants absorbing amounts in excess of their actual requirements (luxury consumption). Many grasses and legumes take up much more potassium than they need for maximum growth; this tendency makes it difficult to increase soil potassium levels. Consequently, small frequent applications of potassium are better than large infrequent ones.

Competition for potassium among plants grown in mixture affect the botanical composition of the mixture. Grasses remove potassium more efficiently from soil than legumes; this difference becomes more serious as potassium supply decreases. Therefore, higher levels of available soil potassium need to be maintained for mixtures than for pure stands (2,23).

Almost all soils in the area require annual applications of sulfur. Although only 5 pounds of sulfur are needed to produce 1 ton of hay, sulfur leaches from Central Oregon soils. Consequently, 50 to 100 pounds of sulfur per acre should be applied each year, depending on soil texture; sandy soils require larger amounts than loam soils. Apply sulfur in fall, spring, or early summer, preferably in two, 50-50 split applications to minimize loss due to leaching. Soils having pH levels of 7.5 or less should receive sulfur as gypsum or as contained in ordinary superphosphate so that soil pH is not lowered as would happen if elemental sulfur were applied. Apply sulfur as elemental sulfur on soils with pH levels higher than 7.5.

Lime

Lime corrects soil acidity and supplies calcium and magnesium. It also affects availability of almost all essential nutrients, promotes growth of microorganisms, decreases solubility of toxic elements (aluminum and manganese) and increases efficiency of any other fertilizers used. It is easy to understand why old-timers say that lime sweetens the soil.

Legumes are more sensitive to soil pH levels and supply of calcium than grasses. Part of legume sensitivity to soil pH and nutrient level is due to requirements of rhizobia in plant root nodules. A soil pH range of 6.5 to 7.5 is ideal for plant growth and is also the range in which nitrogen fixation occurs at highest rates. Legumes show larger and more direct responses to liming than grasses but grasses also respond to liming. In addition, grasses usually benefit indirectly from liming through the better growth of legumes and resulting increase in nitrogen supply.

Correct soil acidity by applying the rate of lime recommended by soil test. Since lime reacts slowly in soils, apply it six months before seeding if possible. Lime also can be top-dressed on a pasture at any time, but usually it is best to mix lime thoroughly with acid soils in the rooting zone. Studies have shown that finely branched feeder roots and nodules remain in limed soil layers (23).

Seedbed Preparation

Seedbeds should be moist and firm, with some looseness at the surface to cover seeds. Seedbeds should be compacted before and after seeding; a firm seedbed maintains soil moisture for seedling roots. Sandy soils especially should be firm because they lose moisture rapidly if they are loose. If a soil crust forms over seeds, seedlings have firm soil to push against, and can break through the crust; seedlings emerging from loose soil under a crust may actually push themselves deeper into the soil. Irrigation before seeding helps to firm seedbeds and makes inoculation more effective (21).

INOCULATION

A major problem in establishing and maintaining productive grass-legume pastures in Central Oregon is the failure to achieve effective nodulation of legumes. Effectively nodulated legumes increase yields of both grass and legume, improve forage quality, and survive better. Without nodulation, plants suffer from nitrogen deficiency, yields decrease, and pastures rapidly degenerate into low-yielding, pure grass stands. Therefore, it is absolutely essential to inoculate legume seed with a vigorous and effective strain of rhizobia to nodulate the plants so that nitrogen fixation occurs at high rates.

If a few simple steps of the inoculation procedure are followed, legumes usually become well nodulated:

1. Use only fresh inoculants specifically for the legume being sown. Store inoculants under refrigeration until planting; if the inoculant has not been stored under refrigeration where it is sold, do not buy it. Do not use inoculants after the expiration date of the package. Sufficient numbers of live rhizobia are present in the package for about 4 months from time of packaging if kept under refrigeration, and for only 3 to 4 weeks without refrigeration. It is best to reinoculate preinoculated seed, because if the seed was not stored under cool conditions, rhizobia on the seed may be dead. Use two or three times the amount of inoculant specified on the package; it is not possible to over-inoculate.
2. In spite of directions usually found on inoculant containers, dry application of inoculant does not work, because only about 20 percent of the dry material sticks to seeds. Also, survival of rhizobia on seeds is less if applied dry. A special slurry method of inoculation should be used to insure maximum survival of rhizobia on seeds. Suspend the inoculant in about a quart of 25 percent sugar solution (one cup of sugar per quart of water) for each 100 pounds of seed. Just before planting, mix the slurry and seed together thoroughly, before placing in the seeder box. Add the slurry to the seed slowly so it does not get too wet. If the seed-slurry mixture becomes too moist for planting, add small amounts of finely ground limestone to soak up the excess moisture. With this method of inoculation, it is best to recalibrate the seeder to be certain the desired amount of seed is being sown.

3. Inoculate in the shade--never in direct sunlight--because ultraviolet rays in sunlight kill rhizobia.
4. Plant the seed as soon as possible after inoculation (3,4,9).

SEEDING RATE

Use 1 pound of clover seed or 2 pounds of alfalfa seed and 15 pounds of grass seed per acre for mixtures, and 20 pounds of grass seed per acre for pure grasses. Use only good clean seed which has high percentages of purity and germination; clean seed helps decrease the amount of weeds planted (4,16,20,24).

SEEDING DEPTH

Small seeded forage plants are best sown ¼ to ½ inch deep or less. Sowing deeper than 1 inch is fatal to seed the size of clover or timothy unless covered by loose soil; even when seedlings emerge from deeper planting, they are so weakened that survival decreases. Sometimes certain conditions, such as in sandy soils, require that small seed be sown deeper than ¼ to ½ inch, but the hazard is always greater. More forage seed is wasted by sowing too deeply than in any other way (21).

IRRIGATION

Dry soil conditions kill more pasture seedlings than any other cause. Almost all forage seeds are small and must be sown near the soil surface; soil moisture may be sufficient to germinate seeds, but seedlings may die before they root enough to become established. Irrigations should be applied to keep the soil moist during establishment (11,18).

SEEDING TIME AND METHOD

The best times for seeding pastures in Central Oregon are in spring and late summer. Spring seedings made during the first week of June usually are not damaged by late-spring frosts and become established well enough to survive the high temperatures of July and August. Late summer seedings made before August 15 usually become established well enough to resist heaving by frost in the following fall and winter.

Rotation Pastures

To control weeds, spring seedings of grass-legume mixtures either must be sown with a companion crop, such as oats, or must be clipped periodically during the season. Preplant herbicides cannot be used unless a pure grass or pure legume pasture is being seeded (1). If an oat companion crop is used, plant no more than 50 pounds of oats per acre, and remove the oats as soon as possible as oat hay. If companion crops are planted too thickly, fertilized heavily with nitrogen, or allowed to remain on the field too long, they may compete so severely with forage seedlings for water, nutrients, light, and space that the pasture stand would be reduced (22).

Late summer seedings usually are not bothered by annual weeds, because weather and light conditions at this time discourage their growth. Seedings may be made in stubble of oat-hay crops, thereby permitting some production to be realized from fields in the pasture-seeding year.

Table 5 presents first-year results of a study on the effects of seeding time and method on alfalfa yield at the Central Oregon Experiment Station. Alfalfa sown in spring with an oat companion crop established poorly and produced little alfalfa forage. Although total yield of alfalfa-oat hay was similar to the yield of pure alfalfa hay from alfalfa sown in spring with Eptam preplant herbicide, the alfalfa sown with herbicide formed a well-established, vigorous stand by the end of the season.

Alfalfa sown in late summer in stubble of an oat-hay crop also became well-established by the end of the season. The amount of forage produced by this method, however, was about twice that produced using a companion crop or herbicide. Consequently, net income during the establishment year from the sale of hay produced by this method, would be almost double that from the spring-planting methods.

When establishing grass-legume pasture mixtures by these methods, yield and income results probably would be similar to those obtained with alfalfa, except that mixtures would not be seeded with herbicide. Consequently, the most profitable method of establishing rotation pastures in Central Oregon probably would be to seed them in late summer in oat-hay stubble.

Table 5. Effects of companion crop and herbicide on yield of spring-sown alfalfa, as compared to yield of oat hay, followed by alfalfa sown in late summer in oat-hay stubble at Redmond (1976).

Variety	Oat companion crop alfalfa	Oat companion crop oats	Oat companion crop total	Eptam herbicide alfalfa	Oat hay
	-----------dry forage yield, tons/acre-----------				
Vernal alfalfa	0.54*	1.81	2.35	1.83	
Anchor alfalfa	0.58	1.73	2.31	2.40	
Park oats					4.30**

*Totals of two harvests made August 10 and September 21, 1976 (no nitrogen applied).
**Harvested July 10, 1976 (100 pounds per acre of nitrogen applied; treated with 2,4-D herbicide to control broadleaf weeds).

Permanent Pastures

Renovation is the best method to improve rundown permanent pastures. It is an intensive improvement program that includes cultivation with or without the use of herbicide, fertilization, liming, and seeding to high-yielding grasses and legumes. No attempt is made to plant any crop but forages.

In renovation, there is little danger of soil losses through erosion since old sod pieces remain on the soil surface. The sod is thoroughly torn up by disking, spring-tooth harrowing, or roto-tilling. Herbicides can be used to kill the old sod before cultivation. Fertilizer, lime, and manure should be applied before cultivation (5).

Roundup* is a relatively new contact herbicide that may be useful in killing quackgrass and other weedy sods when renovating permanent pastures. A study was begun in 1976 at the Central Oregon Experiment Station to determine the effect of Roundup in renovating an old alfalfa hay field that was infested with quackgrass. Although the alfalfa was not as run-down and weak as many pastures in the area, excellent results were obtained with the use of Roundup.

When the quackgrass-alfalfa had produced about 6 inches of topgrowth in the spring (May 20), it was sprayed with 2 pounds of Roundup active ingredient per acre. During the first week of June, the sprayed area was roto-tilled twice, compacted with a corrugated roller, sown with seven

*Roundup has not been cleared for public use on forages.

grass-legume mixtures, and compacted again. Two pounds of legume seed and 15 pounds of grass seed per acre were sown for each mixture. Pacer alfalfa and New Zealand white clover were each combined in simple mixtures with orchardgrass, Fawn fescue, and meadow foxtail. Anchor alfalfa was combined with orchardgrass.

All mixtures formed well-established stands, free of quackgrass, by the end of the season. All mixtures could have been grazed once during August. The mixtures were harvested on August 23. Highest average yields were produced by mixtures containing orchardgrass (1.27 tons DM/acre), followed by mixtures with fescue (1.06 tons DM/acre), and meadow foxtail (0.54 tons DM/acre) (Table 6). The results show that, with Roundup herbicide, permanent pastures in Central Oregon can be renovated in spring and restored to profitable production during one growing season.

Table 6. Dry forage yields of seven pastures mixtures established following application of Roundup herbicide in pasture renovation at Redmond. 1976.

Mixture	Dry forage yield
	tons/acre
Orchardgrass-Anchor alfalfa	1.48*
Orchardgrass-Pacer alfalfa	0.97
Orchardgrass-New Zealand white clover	1.35
Fawn fescue-Pacer alfalfa	0.93
Fawn fescue-New Zealand white clover	1.19
Meadow foxtail-Pacer alfalfa	0.58
Meadow foxtail-New Zealand white clover	0.50

*Harvested August 23, 1976.

MANAGING THE PASTURE

Managing pastures for maximum production and persistence in Central Oregon is even more difficult and more critical than in other northern areas of the United States. Dry, hot summer conditions require careful and correct irrigation practices. Cold winters, without continual snow cover and with freezing and thawing conditions, make fall management especially critical. Soils vary widely in depth, drainage, texture, water-holding capacity, and fertility; this makes it very difficult to achieve and maintain correct soil conditions for pasture plants.

IRRIGATION

A major problem of pasture management in Central Oregon is achieving proper irrigation. If haphazard irrigation practices are used, pastures are either too wet or too dry, with very little time in between when moisture conditions are just right. plants require adequate soil moisture for normal growth; water deficiencies for any length of time reduce growth and promote early maturity (14).

Central Oregon soils generally are shallow and have low water holding capacities; moisture conditions in such soils change rapidly. Consequently, irrigations should be made when available soil moisture reaches 50 percent of the soil's water-holding capacity (13). Almost all Central Oregon soils have water-holding capacities of 1.5 to 2.4 inches per foot of soil (Table 7). Irrigation needs can be predicted if the soil's water-holding capacity is known.

For example, a soil such as Deschutes loamy sand stores 1.5 inches of water per foot of soil. If the soil is 2 feet deep, it can only hold 3 inches of water. A shallow, light-textured soil such as this should be irrigated when soil moisture reaches 50 percent of water-holding capacity, or 1.5 inches of available water. On hot summer days, water loss (evapotranspiration) from a vigorously growing pasture mixture is about 0.3 inches per day. At this rate, 50 percent of the water would be lost from the soil in 5 days; ideally, it should be irrigated that often during hot, drying weather. With longer times between irrigations, plants would be under moisture stress after 5 days, and forage yields would be reduced.

Table 7. Available water-holding capacities of major soils in Central Oregon.

Soil type	Avg available water-holding capacity	Location, county
	in/ft	
Agency sandy loam	2.2	Crook, Deschutes, Jefferson
Agency loam	2.2	Crook, Deschutes, Jefferson
Deschutes loamy sand	1.5	Crook, Deschutes
Deschutes sandy loam	1.7	Crook, Deschutes
Lamonta loam	1.7	Crook, Deschutes, Jefferson
Madras sandy loam	2.2	Deschutes, Jefferson
Madras loam	2.3	Deschutes, Jefferson
Metolius sandy loam	2.4	Crook, Deschutes, Jefferson
Ochoco sandy loam	2.4	Crook
Prineville, sandy loam	1.6	Crook
Willowdale loam	2.9	Jefferson, Wasco

Adapted from Simonson, G. H. and M. N. Shearer (13).

Each irrigation should apply only enough water to fill the soil up to its water-holding capacity. Not only is it inefficient to apply more water than can be stored in a soil, but over-irrigation is harmful to plant growth and leaches nutrients from soils.

WEED CONTROL

Pastures, like all other crops, must compete with weeds; successful production depends on weed control. Low fertility, lack of moisture, and poor grazing management result in more weeds in pastures.

Cultural Control Methods

Do not plant weeds; use good, clean seed when planting the pasture.

In forage crops, the basic principle of weed control is competition: (1) producing a growth so vigorous that weeds do not have a chance to establish themselves, and (2) using grazing or cutting schedules that remove or control weeds that do get established.

Pasture mixtures often are more efficient competitors with weeds than single crops. An important example is a grass-alfalfa mixture, which competes with winter annual weeds far better than alfalfa alone. Alfalfa makes a short fall growth, which does not produce enough shade to prevent growth of weed seedlings. If spaces between alfalfa plants are already occupied by perennial grasses, weeds do not have a chance to start.

Fertilizer and lime are important in weed control because they increase competition of forages with weeds. A large group of "poverty" weeds grows on low-fertility soils. These weeds exist only because they can survive poor soils and conditions. They cannot compete with good stands of vigorous forage growing on fertile soil; they disappear when fertilizers and lime are added to the soil.

Pasture plants must survive grazing and mowing; they often can endure more or different cutting than weeds. To control annual weeds by mowing, almost all of the leaf surface and living buds from which new growth arises must be removed. This means that:

1. Broad-leaved weeds are more easily controlled by mowing than grasses; foxtails and similar weedy annual grasses cannot be controlled by mowing.

2. Weeds should be allowed a reasonable amount of growth before mowing. If cut when they are too young, even weeds such as lambsquarters and redroot pigweed sprout from stubs and are then much more difficult to kill.

3. Thick stands of weeds or weeds growing in thick stands of forage are more easily controlled by mowing than thin stands, because leaves and buds on lower stems are killed by shading; when the tops are removed, nothing remains to begin regrowth.

The same principles apply in controlling perennial weeds by mowing. Quackgrass is hardly affected and cannot be killed by cutting. Perennial weeds should be cut just before flowering because food reserves are low at this growth stage.

Pastures should be clipped as needed to remove weeds and uneaten forage after livestock finish grazing. Drag pastures periodically after clipping to spread the dung.

<u>Chemical Weed Control</u>

Herbicides affect some plants more than others; because of this, they can be used to kill susceptible plants growing with tolerant ones. This selectivity usually is based on physiological differences among the treated plants. Tolerance or susceptibility results from varying interactions between herbicides and enzyme systems within different plants; exact knowledge of herbicidal action is limited. No herbicide exists that does no harm to tolerant crops; selective herbicides simply injure crop plants less than weeds.

Herbicides have not been used on pastures as much as on other crops because forage mixtures make it difficult to use herbicides, which control either grasses or broad-leaved plants (legumes). No herbicides exist that remove weeds from grass-legume mixtures without injurying either the grass or legume. Also, livestock eat the sprayed material, and many chemical products are excreted in milk or accumulate in meat. Always obtain the most recent information on an herbicide and use it only on authorized crops (21).

GRAZING MANAGEMENT

Grazing involves the two biological systems of plants and animals; both must be considered in any successful grazing system. The main animal considerations are energy, nutritive value, and palatability of the forage. Grazing managment directly affects the botanical composition of any mixture. With more frequent grazing, tall-growing plants usually decrease in vigor and stand; short-growing species usually increase. Infrequent grazing favors tall plants when grown with short ones (2).

Differences in timing and degree of grazing greatly affect productivity and persistence of pasture plants. Grazing too early or too frequently may prevent adequate food manufacture for maximum growth and persistence of most pasture plants. When plant parts are removed, new growth must depend on stored food reserves. Stored reserves also are used to develop heat and cold resistance, to live on during the winter dormant periods, to begin growth in spring, to promote flower and seed formation, and for many other processes that occur within plants. Grazing when food reserves are low may leave very little energy available for regrowth. Most damage is done when grazing occurs during periods of minimum food reserves, such as in early spring; continued grazing at young stages of growth exhausts and kills plants. Plants weakened by early, heavy, or frequent grazing usually are more susceptible to drought, heat, winter injury, and diseases.

Tall-growing plants need more growth before grazing and cannot be as closely grazed as low-growing plants. Grazing removes almost all the leaves of tall-growing plants; low-growing plants keep many leaves even after being closely grazed. Alfalfa and timothy, for example, have few leaves near the ground; they must have 12 to 15 inches of top growth before enough green leaf surface is present to maintain satisfactory growth rates. Ladino clover and orchardgrass, however, have more leaf area exposed with only 6 inches of top growth. Almost all other legumes and grasses, such as red clover and tall fescue, need 8 to 10 inches of top growth. In general, the more erect the growth habit, the less tolerant plants are to close, coninuous grazing (6,15).

FALL MANAGEMENT

The most critical time in management of forage plants, especially legumes, is the period before the first killing frost in fall. During this time, plants need top growth to produce carbohydrates for storage before winter. Pastures should not be grazed or cut during late summer, beginning 4 to 6 weeks before the first killing frost that usually occurs about September 15. After frost has killed the top growth, grazing is less damaging to the plants.

MANAGEMENT OF WEAKENED STANDS

Stands that have been weakened or injured during a severe winter, drought, or by frequent grazing or cutting, usually need careful management to bring them back to a level of high productivity. The plants may appear weak and yellow, with only a few stems per plant. Weakened stands sometimes are plowed under too quickly; many would recover with proper management. Delaying grazing until plants reach full bloom or maturity allows them to heal injured tissues and to store high levels of food reserves; subsequent growth often returns to normal. Grazing weakened and injured stands at young growth stages may kill the plants or keep them in a weakened condition (15).

ALTERNATE GRAZING

In the alternate-grazing system, two or more pastures are grazed in regular order and pastures rest between grazings. A field growing the same mixture is divided into equal parts; as forage is eaten in one pasture, livestock are moved to the next, and so on, until all pastures have been grazed. Alternate grazing attempts to use the management best suited to particular growth habits of a pasture (6). Recovery periods of alternately grazed pastures favor good plant growth, which improves total production and stand survival. Animal gains per acre usually are greatest when pastures rest between grazings until the plants have made recovery growth of both tops and roots (12).

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