

Pasture and Forage Crops *for* Irrigated Areas in Colorado

D. W. Robertson, R. M. Weihing, and T. G. Stewart



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Pasture and Forage Crops for Irrigated Areas in Colorado

D. W. ROBERTSON, R. M. WEIHING, AND T. G. STEWART¹

In territorial days stockmen came to Colorado to obtain free range for their livestock. As the rangeland was homesteaded, the open range disappeared. In the areas where irrigation farming developed, the production of cash crops was profitable and fitted into the type of farming which demanded a minimum of range livestock. As irrigated cropland agriculture developed, the need of dairy and feedlot livestock as an economical means of marketing a surplus of low-priced, bulky crops was demonstrated, and the place of this type of livestock in irrigated agriculture was established.

Continuous cropping of Colorado's irrigated soils soon caused a reduction in yield and indicated that some means of maintaining fertility was necessary if profitable crops were to be grown. One of the cheapest means of securing a portion of this fertility is the use of barnyard manure. Thus the use of livestock is necessary for a balanced agriculture. In developing this type of agriculture summer pasture, hay, fodder, and silage are desirable as feed for the various types of livestock that may be kept on the farm.

While no attempt is made to determine the place of the various types of forage in an agricultural economy, it is the purpose of this bulletin to present the information available concerning the production of crops which can be used for pasture, hay, fodder, and silage in the irrigated areas of Colorado.

Experiments with cultivated grasses under irrigation were started in the early days of the Experiment Station. In Bulletin 2 of the Experiment Station A. E. Blount² reported the following results: "Since the college was opened in 1879, the tame grasses have received considerable attention. Much difficulty has been experienced in getting the seed to germinate. After repeated trials, however, good stands have been secured with all except 5 of the 34 species that have been tried. The leading and most valuable varieties that succeeded best are timothy, orchard, Kentucky bluegrass, redtop, the fescues, English and Italian rye, Hungarian brome, and some others of no great value for feeding purposes. The best for pasture is a mixture of several kinds with clover."

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²Blount, A. E. Report of Experiments with Grains, Grasses and Vegetables. State Agr. College Bul. 2, 1887.

In two other early bulletins, No. 61 in 1900³ and No. 68 in 1902⁴, tests of grasses under irrigation are discussed. In Bulletin 68 the following information is presented: "The first trial of 3 years' duration was done in 1891. Mr. Huntley, the superintendent at Rocky Ford, reports of these in the annual report of the Experiment Station for 1894 as follows: 'Based upon trials of 3 years' duration, but two grasses out of eight tried have given promise of enduring field culture for pasture. They are brome and orchard grasses. The unsuccessful ones were hard fescue, meadow fescue, perennial ryegrass, Italian ryegrass, redtop, and bluegrass. It is quite probable some of these would succeed in moist soils of other localities in the state.' "



Livestock worth keeping is worth providing with good pasture.

No further reports on irrigated pasture grasses were available until a report of a selection in brome grass was given by Alvin Kezer⁵ in Bulletin 190. Hanson⁶ made some studies on the survival of various grasses in the different mixtures sown on farms in the vicinity of Fort Collins. These studies were made between 1926 and 1930.

³Watrous, F. L., Griffin, H. H., and Payne, J. E. *Bromus inermis*. Colo. Exp. Sta. Bul. 61, 1900.

⁴Griffin, H. H. *Pasture Grasses—Leguminous Crops*. Colo. Exp. Sta. Bul. 68, 1902.

⁵Kezer, A. *Variation Studies in Brome Grass, A Preliminary Report*. Colo. Exp. Sta. Bul. 190, 1913.

⁶Hanson, H. C. *Factors Influencing the Establishment of Irrigated Pastures in Northern Colorado*. Colo. Exp. Sta. Bul. 378, 1931.

PERMANENT PASTURE

The term "pasture" is used to designate areas that have been seeded to perennial and biennial plants for grazing by livestock. From a pasture the animals should obtain about two-thirds as much forage as from a similar area cut for hay, but since immature plants are more digestible than mature plants, the pasture should produce about three-fourths as much digestible nutrients.⁷ On fertile irrigated land alfalfa will produce about 5 tons of hay an acre in a growing season. To be profitable a pasture on similar land must produce nearly as much as alfalfa would when cut for hay. Pastures on fertile land which produce materially less than alfalfa are not profitable and should be replaced by forage crops grown for hay, fodder, silage, or higher yielding mixtures of pasture plants.

On irrigated farms the problem is to produce a pasture with high yielding or carrying capacity for 5 to 6 months in the year. Unless the pasture has a high yielding or carrying capacity the farmer cannot afford to use good cash cropland for pasture. On every irrigated farm there should be some livestock to help maintain fertility.

On the livestock ranch, meadows supply hay for winter feeding and grazing during the fall and early spring months. A major problem in ranching in Colorado is to supply spring pasture from the time the livestock must be moved from the meadows or farms until they are allowed on the national forest range. Since some tame grasses show a vigorous growth a month earlier than native grasses, a pasture or meadow might profitably be seeded with a grass mixture which included some of these early grasses plus a perennial or biennial legume. The tame grass pasture may be grazed until livestock goes to the range, then one or two cuttings of hay may be possible, depending upon the length of the growing season and the moisture supply.

Improved pastures are useful in controlled breeding programs on the livestock ranch. Creep feeding of calves or lambs certainly can be carried on best in an improved pasture. Livestock losses from poison weeds can be reduced by providing improved early grazing.

The important plants for permanent pastures belong to either the grass or legume family of plants. Because the legumes are higher in protein and minerals than the grasses, a mixture provides a better ration for animals than either type of plants alone. Many legumes remain productive during the hot summer weather, whereas many grasses make little growth at this time, so that a mix-

⁷Sample, A. T., et al. A Pasture Handbook, U.S.D.A. Misc. Pub. 194, 1934, revised slightly 1937.

ture of grasses and legumes provides the desired season-long pasture.

Results from experiments with irrigated grasses and grass mixtures at Fort Collins show that several grasses and legumes are adapted to irrigated conditions in Colorado.

GRASSES

The most important permanent pasture grasses for Colorado are: Bromegrass, orchard grass, meadow fescue, perennial ryegrass, slender wheatgrass, tall oatgrass, crested wheatgrass, timothy, Ken-



Bromegrass is adapted to most sections of Colorado.

tucky bluegrass, redtop, and Reed canary grass. Table 1 shows (1) climatic adaptation, (2) soil adaptation, (3) degrees of palatability, (4) season of grazing, (5) acre-yield of hay at Fort Collins, and (6) remarks of special interest.

Bromegrass

Bromegrass (*Bromus inermis*) is a long-lived perennial which is ideally adapted to pasture in most sections of the State. It produces an even, dense sod after 2 years and is highly nutritious and palatable to all classes of livestock. Brome starts growing early in the spring. Its chief fault is that it may become "sod-bound" after 4 or 5 years. Experiments on the so-called "sod-binding" show it is caused by insufficient available nitrogen. Yields of sod-bound grass may be greatly improved or restored by proper fertilization with farm manures or commercial nitrogen fertilizers. Renovation or disking often will help. Bromegrass is grown successfully at

TABLE 1—*Information regarding grasses and legumes for permanent pasture under irrigation.*

Name	Adaptation in Colorado	Soil adaptation	Degree of palatability	Season of grazing	Acre yield of hay at Fort Collins (Tons per acre)	Remarks
Bromegrass (<i>Bromus inermis</i>)	All sections of the State	Practically any type	High	Very early spring to late fall	1.28	Becomes sod-bound
Crested wheat-grass (<i>Agropyron cristatum</i>)	Where summer is cool, or from 5,000 to 8,500 feet	Almost any type	Medium	Very early spring to late fall	0.76	Drought resistant; where adapted, easy to get stand
Kentucky blue-grass (<i>Poa pratensis</i>)	All sections of the State	Sandy loams to clays of high productivity	High	Spring to late fall		Occurs spontaneously in permanent pasture; omit from mixture
Meadow fescue (<i>Festuca elatior</i>)	All sections of the State	Loams to heavy clays	High	Early spring to late fall	1.08	A good grass in mixture
Orchard grass (<i>Dactylis glomerata</i>)	All sections of the State	Any soil type except sand, if not too wet	Medium	Early spring to fall	1.11	Inclined to grow in bunches unless seeded thickly
Perennial rye-grass (<i>Lolium perenne</i>)	Where summers are hot and winters mild; the Arkansas Valley	Sandy loams to clays of medium to good fertility	High	Early spring to late fall		Comes quickly and furnishes much pasturage at first, but is not permanent
Redtop (<i>Agrostis alba</i>)	All sections of the State	Grows on majority soil types; prefers moist soils	Medium	Early spring to late fall		Of most value on poorly drained soils too wet for other grasses

TABLE 1—Continued

Name	Adaptation in Colorado	Soil adaptation	Degree of palatability	Season of grazing	Acre yield of hay at Fort Collins (Tons per acre)	Remarks
Reed canary grass (<i>Phalaris arundinacea</i>)	All sections of the State	Loams to heavy clays	Medium	Spring to fall		Very good for wet lands, will endure submer- gence
Slender wheat- grass (<i>Agropyron pauciflorum</i>)	Cooler sections of the State	Practically any type except sand	High	Early spring to late fall	1.38	Better for hay than pasture; in- clined to be stemmy
Tall oat grass (<i>Arrhenatherum elatius</i>)	All sections of the State	Practically any type except sand	Medium	Early spring to late fall	1.63	Ditto. Very hard to plant seed of this grass with a drill
Timothy (<i>Phleum pratense</i>)	Where summers are cool	Practically any type except sand	Medium	Early spring to late fall		Comes quickly and furnishes much pasturage at first, but is not permanent
Alfalfa	All sections of the State	Practically any type	Very high	May to October	5.15	Danger of bloat. Use northern- grown seed
Sweet clover White Yellow	All sections of the State	Practically any type	Medium	Light, fall of first yr. Heavy, spring and sum- mer second yr.	2.44	Danger of bloat
White Dutch clover	All regions where moisture is sufficient	Practically any type	Very high	Early spring and fall		Requires frequent irrigation

TABLE 1—*Continued*

Name	Adaptation in Colorado	Soil adaptation	Degree of palatability	Season of grazing	Acre yield of hay at Fort Collins (Tons per acre)	Remarks
Alsike clover	Higher alti- tudes where weather is cool, up to 9,000 feet	Practically any soil type except sand. Will stand slight acidity, also will tolerate some inadequate drainage	Very high	Early spring to fall	2.40	Especially suited for wet land
Red clover	All sections of the State	Practically any type	Very high	Spring to fall	4.17	Danger of bloat
Ladino clover	All sections of the State	Practically any type	Very high	Spring to fall	2.74	Requires fre- quent irrigation
Strawberry clover	All sections of the State below medium alti- tudes	Wet alkali soils	High	Spring to fall		Requires wet soils

9,300 feet altitude in Teller county as well as at the lower altitudes of the State. A mixture of brome and alfalfa is being used as sheep pasture in some sections of the State with very good results. It survived in all the mixtures studied on the Agronomy Farm at Fort Collins.

Orchard Grass

Orchard grass (*Dactylis glomerata*) is a long-lived, deep-rooted perennial which will produce well for 10 years or longer under favorable conditions. It is a bunch grass and, for this reason, it should not be seeded alone for pasture. Orchard grass is less drought resistant than is brome grass and may die if heavily grazed in a fall followed by a dry winter. It starts growth early in the spring and should be grazed sufficiently close to keep new growth appearing since old growth of this grass is unpalatable. This grass survived well in pasture mixtures studied at Fort Collins.

Meadow Fescue

Meadow fescue (*Festuca elatior*) is a long-lived grass adapted to most regions of Colorado under irrigation or regions of moderate rainfall. It grows rapidly after seeding and is desirable in mixtures with some of the slower-growing species. This grass is slower to start growth in the spring than brome or orchard grass, but furnishes a fine, palatable growth during the summer and late fall. It might be classed as a semi-sod-forming grass, being less aggressive in its sod-forming habit than brome.

Slender Wheatgrass

Slender wheatgrass (*Agropyron pauciflorum*) is a native of Colorado. It is a drought-resistant bunch grass. It did not stand competition in irrigated grass mixtures at Fort Collins.

Crested Wheatgrass

Crested wheatgrass (*Agropyron cristatum*) is an erect bunch grass. It produces growth early in the spring and late in the fall. At Fort Collins under irrigation it yields less than brome grass. Its place in irrigated mixtures has not been determined.

Tall Oatgrass

Tall oatgrass (*Arrhenatherum elatius*) is a succulent, high-yielding bunch grass. It is best adapted to irrigated conditions or areas having rather high rainfall. It did not survive under competition in mixtures with other grasses at Fort Collins. It is hard to sow with a drill and the seed is low in germination.

Timothy

Timothy (*Phleum pratense*) is a cooler-region, moisture-lov-

ing grass most widely grown for hay. It makes quick growth, is a sod-former, and is not a very long-lived grass when subjected to close grazing. Timothy produces a less heavy leaf growth than brome, orchard grass, or tall oatgrass. When it is mixed with alsike clover in high-altitude hay meadows, excellent yields of high-quality hay are obtained. This grass did not stand competition with other tall grasses and legumes in the mixtures studied at Fort Collins.

Kentucky Bluegrass

Kentucky bluegrass (*Poa pratensis*) is primarily a grazing grass adapted to areas with a plentiful moisture supply. It is a very aggressive, shallow-rooted, sod-forming grass. When planted in mixtures under moist conditions, it will usually crowd out all other species of grasses or crop plants except White Dutch clover. Unless continually supplied with moisture, bluegrass will fire or produce very little forage during July and August. Where moisture conditions are favorable it will gradually come into pasture without seeding.

Redtop

Redtop (*Agrostis alba*) is another moisture-loving grass with the sod-forming habit of growth. Redtop will survive even when kept under water for several days at a time. Shallow, vigorous rootstocks enable redtop to make a dense turf, crowding out other crop plants. It is one of the least palatable of the cultivated grasses. White Dutch clover, Ladino clover, or alsike clover may be grown in mixtures with redtop to increase the value and palatability of the pasture.

Perennial Ryegrass

Perennial ryegrass (*Lolium perenne*) provides good grazing and makes good hay but is not sufficiently winter hardy to be used in the northern part of Colorado. It does not survive in mixtures with other grasses at Fort Collins but thickens up the stand until other grasses become established.

Reed Canary Grass

Reed canary grass (*Phalaris arundinacea*) is adapted to wet lands, especially those subject to overflow. It is rather difficult to get a stand of Reed canary grass but after a few plants become established they spread rapidly by underground rootstalks. It does best under wet conditions and should be pastured heavily to keep it palatable.

LEGUMES

Alfalfa

Alfalfa (*Medicago sativa*) has been used exclusively for grazing in California, but it has not been used much in Colorado because of frequent losses of livestock from bloating and because of the injurious effect of grazing on the stand. The following recommendations by Semple^s and others are made for pasturing alfalfa: "If the crop is allowed to become quite mature before being grazed, both troubles are avoided to a large extent, but the full feed value of the crop is not realized by such a practice. The most profitable practice appears to be to cut the first crop for hay and to graze during the rest of the season. Apparently the stand of alfalfa may be maintained if not grazed too severely and if the animals are removed sufficiently early in the fall to allow the alfalfa to restore the exhausted food reserves in the root system."

Sweetclover

The sweetclovers (*Melilotus officinalis* and *M. alba*) are biennials which depend upon seed production the second year for continued appearance in pastures. Yellow-blossom sweetclover is more likely to reseed itself than the white-blossom variety because of the tendency to produce low branches which escape pasturing. Sheep are especially fond of the young growing tips of sweetclover and often prevent reseeding by too close grazing. Additional sweet clover seed can be drilled in a pasture if necessary to maintain this crop in the mixture. Sweetclover has some tolerance to alkali. In grazing sweetclover there is danger of bloat.

White Dutch Clover

White Dutch clover (*Trifolium repens*) is the white-flowered clover commonly grown with bluegrass in lawns. It is a long-lived, low-growing clover with creeping stems which grow along the surface of the ground and take root, thus forming new plants. This clover is a moisture-loving crop suitable for pastures where plenty of water is available for irrigation. It has the ability to withstand close grazing and will maintain itself in a pasture mixture by its rooting habit and ability to produce seed.

Alsike Clover

Alsike clover (*Trifolium hybridum*) is best adapted to a cool, moist climate. Its greatest value is in the mountain irrigated hay meadows. It grows well on seepy areas or fields that receive excessive amounts of irrigation water. Alsike is longer-lived than is red

^sSemple, A. T., and others. Establishment, Maintenance, and Improvement of Pasture—A Pasture Handbook. U.S.D.A. Misc. Pub. 194, 1937.

clover, reseeds itself readily in pastures or hay meadows, and will withstand fairly close grazing.

Red Clover

Red clover (*Trifolium pratense*) is grown principally as a seed crop in the Arkansas Valley and western Colorado. Good seed yields have also been obtained in northern Colorado and, experimentally, on the Agronomy Farm at Fort Collins. Its value as a hay and pasture crop has not been proved throughout the State because of the ease of producing alfalfa in all sections. Red clover is classified as a biennial, but in Colorado single plants have been known to live for as long as 7 years. Good hay yields for 3 consecutive years have been produced from a single planting of red clover. Red clover has a wide range of adaptation under irrigation throughout Colorado at all altitudes. A simple mixture of red clover, brome, and orchard grass is adapted to most irrigated conditions in Colorado. Red clover in the pasture mixture is believed to cause more bloating in cattle or sheep than sweetclover in the same mixture.

Ladino Clover

Ladino clover (*Trifolium repens latum*) when seeded alone is satisfactory as a pasture crop on areas where water is plentiful and alkali is not excessive. Ladino is a crop for a cool, moist climate and is useful for pasture only. Ladino will probably find its greatest usefulness along rivers or creek bottoms, in shady places, or in heavily irrigated or seeped areas. It will not survive competition of other plants; therefore it must be planted only on well-prepared land. The seeds are very small. Four pounds per acre is considered to be a liberal seeding. Success in establishing a Ladino clover pasture depends largely upon the preparation of a firm seed-bed, shallow covering of the seed, and liberal moisture at the surface of the ground for several weeks.

Strawberry Clover

Strawberry clover (*Trifolium fragiferum*) is somewhat similar to White Dutch clover. It is primarily a pasture crop, capable of spreading and establishing itself by its stout, creeping runners and through the scattering of seed by cattle grazing on a field of the clover which has matured seed. The flowers are pink. The flower-heads when beginning to mature closely resemble a strawberry in appearance. This clover is apparently tolerant to alkali. It thrives in wet soils which are moderately saline or non-saline. However, it will withstand for extended periods of time very high concentrations of salts and limited amounts of moisture. Strawberry clover

thrives under wet conditions and will compete with sedges when heavily grazed.

Production of Several Pasture Mixtures at Fort Collins

In 1923 an experiment was started to determine the value of various grasses both singly and in mixtures. A similar set of experiments was run in 1924, 1925, and 1926.

The experimental plantings were made at Fort Collins, Cheyenne Wells, and Fort Lewis. The results of the Fort Lewis experiments have been published by Koonce.⁹ At Cheyenne Wells, only 1 year's seeding came through the winter successfully and no yields were obtained. The following discussion presents the data obtained from the Fort Collins experiments.

Thirteen pasture mixtures were grown on the Agronomy Farm near Fort Collins from 1923 to 1930 to determine their productivity. Six of the mixtures were composed of two to four grasses and yellow sweetclover, three were composed of two to four grasses and red clover, three had two to four grasses, red clover, alsike clover, or White Dutch clover, and one had five grasses. In addition five grasses were grown singly 5 to 6 years. These mixtures were cut three times each year for hay at the normal dates for cutting alfalfa and also on other plots were clipped four times each year to simulate grazing conditions. Data on the yields obtained from these mixtures when cut for hay make it possible to compare their productivity with other hay plants, while data on the yield when clipped frequently is indicative of the amounts of forage which would be eaten by livestock grazing the mixtures. Some difference would result from trampling or selective grazing. However, the results of clipping give some indication of the yields of various mixtures.

Each mixture was seeded with a nurse crop in duplicate plots in 1923, 1925, and 1926. One plot was cut for hay and one was cut frequently to simulate grazing. The harvesting was started the first year after seeding and continued through the season of 1930. The plots seeded in 1923 were harvested 7 years, those in 1925, 5 years, and those in 1926, 4 years. The average hay and pasture yields of first, second, third, fourth, fifth, sixth, and seventh harvests, the mixtures grown, and the rates of seeding are shown in table 2. The pastures were irrigated about once each month from May to September.

Yield Studies

The forage yields of the six mixtures composed of various

⁹Koonce, Dwight. High Altitude Studies on Dry Land Grasses and Clovers. Colo. Exp. Sta. Bul. 439, 1937. (Out of print.)

TABLE 2--*Summary of data on irrigated pastures grown at Fort Collins for varying periods of years from 1923 to 1930, inclusive.*

Forage mixture	Seeding rate in pounds	Total pounds seeded	Treatment	Average yield in pounds per acre of dry forage							Weighted average
				1	2	3	Years 4	5	6	7	
			Number of crops grown	3	3	3	3	2	1	1	16
Slender wheatgrass	8										
Bromegrass	8		Clipped	3,815	2,256	2,479	2,121	1,764	2,009	1,464	2,438
Yellow sweetclover	4	20	Hay	4,452	3,325	4,013	3,362	2,954	4,340	2,000	3,607
Slender wheatgrass	8										
Meadow fescue	4		Clipped	4,199	2,241	2,704	2,257	2,085	1,976	1,639	2,624
Yellow sweetclover	4	16	Hay	4,209	3,079	3,768	3,564	3,202	4,413	2,190	3,554
Bromegrass	12										
Meadow fescue	8		Clipped	4,373	2,145	2,448	2,169	1,890	1,966	1,448	2,537
Yellow sweetclover	4	24	Hay	4,440	2,819	3,718	3,181	2,833	3,672	1,928	3,359
Bromegrass	15										
Orchard grass	15										
Meadow fescue	10										
Timothy	6		Clipped	4,709	1,674	1,865	1,875	1,357	2,393	1,020	2,281
Yellow sweetclover	4	50	Hay	4,853	2,544	2,988	2,523	2,986	2,482	1,378	3,035
Bromegrass	10										
Orchard grass	6										
Meadow fescue	5										
Perennial ryegrass	5		Clipped	5,710	4,787	5,301	4,016	2,599	2,527	1,242	4,275
Red clover	4	30	Hay	4,122	5,707	4,696	4,944	3,789	1,995	1,478	4,341
Bromegrass	10										
Orchard grass	6										
Meadow fescue	5										
Redtop	5		Clipped	5,368	4,641	4,895	3,446	1,610	1,999	1,183	3,941
Red clover	4	30	Hay	6,378	6,736	7,782	6,398	4,664	3,353	2,465	6,071

TABLE 2—Continued

Forage mixture	Seeding rate in pounds	Total pounds seeded	Treatment	Average yield in pounds per acre of dry forage							Weighted average
				Years							
				1	2	3	4	5	6	7	
			Number of crops grown	3	3	3	3	2	1	1	16
Bromegrass	10										
Orchard grass	6										
Tall oatgrass	6										
Alsike clover	2		Clipped	7,161	5,321	5,471	3,993	2,811	2,549	1,268	4,704
Red clover	4	28	Hay	8,194	7,677	8,327	7,065	4,962	3,891	2,663	6,891
Kentucky bluegrass	5										
Orchard grass	6										
Tall oatgrass	6										
Redtop	5										
Red clover	4		Clipped	6,670	5,436	5,614	3,927	2,601	2,202	1,122	4,591
White Dutch clover	1	27	Hay	7,206	6,792	8,010	6,514	4,407	3,204	1,992	6,223
Bromegrass*	8										
Orchard grass	8										
Meadow fescue	6										
Timothy	4		Clipped	4,957	5,715	1,394	1,521	1,346			3,169
Yellow sweetclover	4	30	Hay	5,665	2,605	3,032	1,947	3,480			3,331
Bromegrass	10										
Orchard grass	5										
Tall oatgrass	5										
Redtop	5										
Red clover	3		Clipped	5,736	4,854	5,333	3,943	2,636	2,292	1,352	4,282
White Dutch clover	1	29	Hay	4,465	5,750	5,539	4,468	3,271	1,956	1,382	4,409
Bromegrass	10										
Orchard grass	5										
Tall oatgrass	5										
Redtop	5		Clipped	1,795	1,447	2,032	1,612	1,113	1,590	1,027	1,594
Perennial rye	5	30	Hay	1,387	2,033	2,016	2,535	2,796	3,389	2,541	2,215

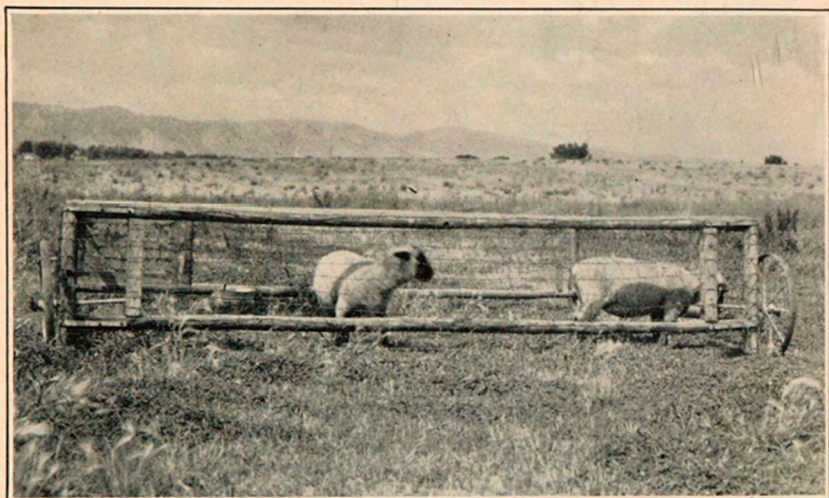
*This mixture was not seeded in 1923, but it was seeded in 1925 and 1926.

TABLE 2—Continued

Forage mixture	Seeding rate in pounds	Total pounds seeded	Treatment	Average yield in pounds per acre of dry forage							Weighted average
				1	2	3	Years 4	5	6	7	
			Number of crops grown	3	3	3	3	2	1	1	16
Timothy	8										
Redtop	8										
Red clover	4										
Alsike clover	4		Clipped	6,062	4,898	5,195	3,030	2,612	2,337	1,285	4,150
White Dutch clover	3	27	Hay	7,889	8,171	6,784	6,187	5,176	4,362	3,092	6,569
Slender wheatgrass	8										
Orchard grass	5										
Tall oatgrass	5										
Redtop	5		Clipped	5,478	1,758	2,073	2,297	1,186	1,809	1,050	2,503
Yellow sweetclover	3	26	Hay	4,564	2,675	3,543	2,926	2,382	2,985	1,616	3,155
			Number of crops grown	2	3	3	2	2			1
Bromegrass	15		Hay	2,437	2,774	2,218	3,257	2,172			2,553
Slender wheatgrass	15		Hay	3,217	3,067	2,416	2,808	1,762			2,751
			Number of crops grown	3	3	3	2	2			13
Orchard grass	15 to 30		Hay	2,163	2,077	1,706	3,392	2,149			2,225
			Number of crops grown	3	3	3	2	1	1		13
Tall oatgrass	40		Hay	3,484	3,274	2,749	4,237	3,635	1,790		3,263
			Number of crops grown	2	2	2	2	2			10
Meadow fescue	20		Hay	2,444	1,837	1,626	3,012	2,427			2,156

The clipped plots were cut when 6 inches high. The hay plots were cut for hay after the grasses and clover had bloomed.

grasses and yellow-blossom sweetclover were nearly equal. The forage yields of the mixtures containing red clover also were nearly equal but were higher than the mixtures containing yellow-blossom sweetclover. This suggests that there was not much difference in the productivity of the combinations of grasses used in the mixtures. However, the mixtures containing red clover were more productive than those with yellow-blossom sweetclover, while those containing sweetclover were more productive than the grass mixture.



Portable pen of sheep pasturing on an experimental area of strawberry clover on the Agronomy Farm at Fort Collins

The data in table 2 are summarized in table 3 to show the average yields by years for the six red clover-grass mixtures, for the six sweetclover-grass mixtures, and for grass mixtures when cut for hay and when clipped to simulate grazing. For hay and simulated grazing, red clover-grass mixtures are decidedly more productive than sweetclover-grass mixtures or the mixture of grasses. The red clover grass mixtures remained relatively productive 4 to 5 years for hay and from 3 to 4 years for simulated grazing, whereas sweetclover-grass mixtures were less productive after the first year. This is because the perennial red clover lived and produced for several years but the biennial sweetclover largely disappeared after the first year of harvesting (second year after seeding). The grasses alone produced low yields every year. They were equal to the red clover-grass mixtures the sixth and seventh years, by which time the red clover had disappeared, and were nearly equal to the sweetclover-grass mixtures the third year. The yield of the clipped plots was about 30 percent lower than that of the plots mowed for hay.

TABLE 3—*The yield of pasture mixtures of red clover and grasses, of sweetclover and grasses, of grasses, and grass cut for hay and clipped frequently to simulate grazing, 1923-30.*

Mixture	Number of Mixtures	Yield in tons per acre by years							
		1st	2nd	3rd	4th	5th	6th	7th	Average
Cut for hay									
Red clover and grasses	6	3.19	3.40	3.43	2.96	2.19	1.56	1.09	2.55
Sweetclover and grasses	6	2.35	1.42	1.76	1.46	1.48	1.79	0.91	1.60
Grasses*	1	0.69	1.02	1.01	1.27	1.40	1.69	1.27	1.19
Grasses**	5	1.37	1.30	1.07	1.67	1.21			1.32
Clipped frequently to simulate grazing									
Red clover and grasses	6	3.06	2.50	2.65	1.86	1.24	1.16	0.62	1.87
Sweetclover and grasses	6	2.29	1.32	1.08	1.02	0.80	1.02	0.66	1.17
Grasses*	1	0.90	0.72	1.02	0.81	0.56	0.80	0.51	0.76

*A mixture of brome grass, orchard grass, tall oatgrass, redtop, slender wheatgrass, and perennial ryegrass.

**The following grasses were grown singly: Brome grass, slender wheatgrass, orchard grass, tall oatgrass, and meadow fescue.

Survival Studies

Counts of the number of grasses and clovers in the various seedings were made in the fall and spring of 1923, 1924, and 1925, and in the spring of 1926. These counts showed that the number of grass and clover plants decreased. However, the area occupied by the remaining plants increased. From 1926 to 1930 these stand studies were made by the Botany and Plant Pathology Section and the method was somewhat changed. Each species was determined in the mixture, and the area occupied by each was measured. The same areas (quadrats) were used for both studies. The two 1926 seedings were so similar that data were recorded on only one of them. The area occupied by each kind of plant originally planted, the area occupied by weeds, and the total area of the plant cover are given in appendix tables 1 and 2.

A noticeable difference may be observed in the total plant cover of the lighter seeding mixtures between 1925 and 1930. The cover decreased from 21.4 to 9.1 percent in mixture No. 1 in the clipping series. The other mixtures maintained their cover fairly constantly throughout the experiment.

In some of the heavier seedings a noticeable increase in cover was obtained. In the bulk of the plots only a slight increase was noticed. When red clover was included in the mixture, an increase in total cover was obtained which in some cases, in the clipped plots, amounted to more than 100 percent between 1925 and 1930. The highest percentage cover was obtained in mixture No. 8 and was due to the presence of orchard grass and Kentucky bluegrass. This mixture, however, did not show any marked increase in total cover when cut for hay.



Mixture containing orchard grass, smooth brome grass, meadow fescue, timothy, and yellow sweetclover near close of second season, planted at rate of 50 pounds of seed to the acre. Mowed 4 to 5 times during the season. October 19, 1926. Courtesy of Botany and Plant Pathology Section.

These studies suggest that brome grass, orchard grass, meadow fescue, yellow-blossom sweetclover, and red clover should be used in irrigated pasture mixtures. Hanson¹⁰ shows that on grazed pastures the following grasses survived: Brome grass, orchard grass, meadow fescue, and Kentucky bluegrass. White Dutch clover survived when the pasture was closely grazed.

The weed cover stayed fairly uniform in most of the plots throughout the test. It decreased in some and increased slightly in others. In the clipping plots the grasses and clovers competed with the weed cover and held it fairly constant. In the hay plots the weed cover was fairly high in the light seedings, "24 pounds or less of seed per acre." The weeds did not increase in area occupied in the thicker stands.

¹⁰Hanson, H. C. Factors Influencing the Establishment of Irrigated Pastures in Northeastern Colorado. Colo. Exp. Sta. Bul. 378, 1931. (Out of print.)

Recommended Mixtures

The following conclusions may be drawn from the studies: (1) A pasture mixture should include one or more productive perennial legumes. (2) Sweetclover should not be used as the sole legume in grass-legume pasture mixtures because it disappears the second year after seeding and thereafter the pasture is no more productive than a mixture of grasses. (3) Grasses should not be used as the sole constituents of a pasture mixture because they are inferior in yield to mixtures containing certain perennial legumes. The



Mixture containing the same kinds of plants and treated like the mixture shown in the illustration on page 22, except that 30 pounds of seed were planted to the acre. October 19, 1926. Courtesy of Botany and Plant Pathology Section.

following grasses can be recommended for irrigated pasture mixtures:

Bromegrass	-----	8 pounds
Orchard grass	-----	8 pounds
Meadow fescue	-----	6 pounds
Timothy*	-----	4 pounds
Legume	-----	4 pounds

The legume may consist of 4 pounds of yellow sweetclover or 2 pounds of yellow sweetclover and 2 pounds of alfalfa or red clover. In either case care should be taken to prevent bloat. The mixture is recommended for well-drained irrigated soils.

In the warmer sections of the State perennial ryegrass may replace timothy. Neither of these grasses persists but they help to thicken the stand of grass for the first 2 years until brome becomes established. If bloat is not a serious problem, alfalfa can replace

*For the cooler sections of the State.

sweetclover in the mixture. Care, however, should be taken to see that an abundance of grass is present in the pasture.

Where the soil is poorly drained and subject to seep, a mixture containing the following grasses and legumes may be used:

Redtop	10 pounds
Timothy	6 pounds
Reed canary grass	4 pounds
Alsike clover	2 pounds
Strawberry clover	2 pounds

In areas which are wet and saline enough to produce salt grass and sedges, strawberry clover seeded at 1 to 2 pounds per acre and disked into the soil will increase the carrying capacity of the area.

Establishing a Permanent Pasture

Source of Seed

Good, sound seed, free of noxious weeds, should be used. In purchasing seed, "bargains" should be looked upon with disfavor since they usually have some defect, such as poor germination, high percentage of trash (broken stems, and so forth) and weed seeds, some of which may be noxious. The tag required by the State Seed Law giving the State Seed Laboratory report should be examined closely on every purchase of seed. Only recommended grasses or legumes should be included in the mixture.

Preparation of Seedbed

To insure a good stand, the seedbed should be firmly packed, fine, free from weeds, and of uniform gradient for irrigation.

Fall-plowed land makes an ideal seedbed if properly prepared. As soon as plowed, the soil should be packed with an implement that packs the soil from the plow sole to the surface. This operation insures a firm, well-packed seedbed, free from air pockets and in contact with the subsoil. In the spring, just before planting, the land should be well harrowed or otherwise tilled to make the surface soil firm and to kill all weed growth and small weeds just starting to grow. This operation should be followed with as much leveling (three times if necessary) as necessary to make a smooth surface of uniform grade for irrigation. The preparation of the seedbed is much the same for spring-plowed land. It should be packed as soon as it is plowed and, just before planting, the growing weeds should be destroyed, and the surface leveled to a uniform grade. The seed should be planted immediately after the growing weeds are destroyed so that the grass seedlings will have a chance to commence growth before the seeds of additional weeds sprout and grow. Place a handicap on the weeds, not on the grass.

Unplowed sugar beet or potato land makes a good seedbed in the spring for pasture mixtures. It should be disked, harrowed, and leveled in preparation for seeding.

For late summer or fall planting, in late July or August, unworked small grain stubble land is desirable because it furnishes a firm seedbed. However, stubble land covered with shattered grain or weeds should not be used since the growth from volunteer grain and weeds may be great enough to kill or smother the young grass seedlings.



A firm seedbed of uniform grade.

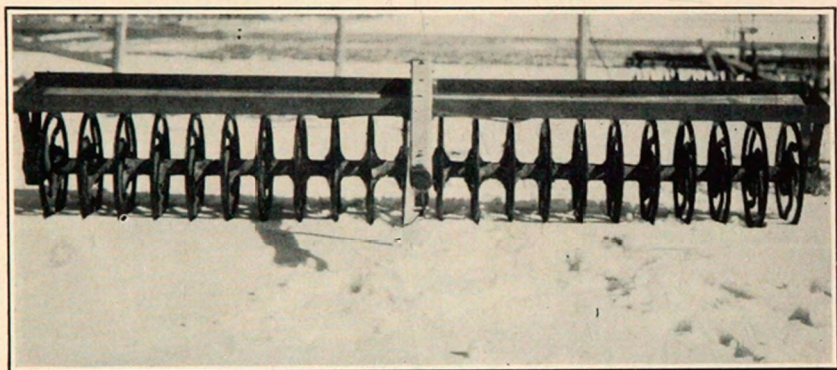
Time of Seeding

Since pasture grasses are generally considered to be a cool-weather crop, the pasture mixture should be seeded in the early spring. Under irrigated conditions it is perhaps best to delay planting until a continuous supply of irrigation water is available so that the seeding may be saved in case of dry weather after the seeds have sprouted. In the nonirrigated intermountain areas an attempt should be made to seed grasses before or during the wet season if previous experience or rainfall records indicate that such seasons occur with reasonable certainty. In many of the higher altitudes which normally have a fair to good winter snow cover, seeding late in the fall, too late for fall germination, has given good stands.

Methods of Seeding

A grain drill with grass-seeder attachment is the best equipment for seeding grasses. The light grass seed such as brome, orchard, meadow fescue, and the wheat grasses, should be thor-

oughly mixed and put in the grain box. If a companion crop is used, these grasses may be mixed with the grain, but they work best when seeded separately. Some difficulty will be experienced in making the chaffy grass seed feed down into the drill. Therefore, careful attention will be necessary to assure a uniform rate of seeding. The heavier seeds, such as sweetclover, red clover, alsike, and timothy, should be seeded through the grass seeder.



Subsurface packer which aids in preparing a firmly packed seedbed.

Some farmers mix a little cracked wheat or corn chop with the light seed in the drill box to make the grass seed feed through the drill. Others use barley or heavy oats in small amounts. In either case an occasional stirring will be necessary, and the drill openings should be watched to make sure that grass seed is being dropped. A better distribution of the seed can be obtained by drilling half the seed one way and then cross drilling the remainder. There is less danger of the drill operator exhausting his seed before the field is planted if cross drilling is practiced.

Broadcasting by hand is wasteful of seed, though in the absence of a drill and on small acreages it may give good results if the field is lightly harrowed and rolled with a corrugated roller immediately after seeding. This method of seeding has been used successfully in obtaining a stand of grasses when a small-grain companion crop has already been established.

Companion Crops

If a companion crop, sometimes wrongly called a nurse crop, is to be used, Colseess barley seeded at about half the usual rate (40 to 50 pounds per acre) is the best of the small grains. Field peas seeded at the rate of 60 pounds per acre and cut for hay are also considered a good companion crop for grasses, clover, or alfalfa. In case either of these companion crops is used, it should

be drilled immediately before and deeper than the grass. If every other hole in the drill is stopped the companion crop will be thin enough to allow sunlight to reach the small grass seedlings and more rapid growth will result. Frequent irrigations may be necessary, especially during early growth, to save the seedlings during droughty periods. Such irrigations may be damaging to the companion crop, and if Trebi barley, oats, or wheat is used, lodging is likely to occur, causing smothering of the young pasture plants. It is important to remember that **the pasture plants should be given first consideration**. This may mean that if irrigation water is short the companion crop must be harvested for hay in order to save the pasture stand.

Management

Livestock should not be allowed to graze the pasture in the year of seeding. Grazing while the pasture seedlings are establishing themselves is likely to damage the young seedlings causing excessive winter-killing and a delay in establishing a sod. If a thin stand is obtained, it is advisable to allow the pasture grasses to produce seed the following year, with pasturing beginning late in the season or in the winter. Such a practice allows maximum growth and spread of the plant roots as well as the production and scattering of more seed for reseeding. Some farmers cut two crops of hay instead of pasturing the second year's growth of grasses. Others cut one crop of hay and then allow livestock to graze during the remainder of the season.

It is a good practice to divide a pasture by fencing it into two or three areas. When one area is being grazed the other areas may be irrigated and allowed to make considerable regrowth. When the pastures are too closely and continuously grazed, sufficient food reserves cannot be assembled and the plants gradually starve; thus vigorous growth with high carrying capacity is impossible.

Irrigation

Under Colorado conditions irrigation is required for maximum yields. There is no one method applicable to all regions. In the Arkansas Valley and western Colorado the furrow or corrugation method is used successfully and is, in most cases, better adapted to existing conditions. In northeastern Colorado the flooding method is generally used. The general practice is to flood between field laterals. In the Brush-Fort Morgan section the border method of irrigation is sometimes used. In either of the two methods last mentioned the laterals or borders should not be too far apart (50 to 150 feet) and the length of the land should

not exceed 500 to 600 feet. On longer lands the upper end is overirrigated if sufficient water is applied to the lower ends. Fortier¹¹ makes the following statements regarding the border method of irrigation:

"The border method of irrigation consists essentially in the division of the field into a series of strips by low, flat levees extending in the direction of the slope. Water is turned into the upper end of each strip and moves down the slope in a thin sheet.

"The factors favoring the border method are: A smooth, regular surface having a slope in one direction of about 2.5 inches in 100 feet is ideal for the border method. It is possible to make borders on slopes one inch or less and on steeper slopes up to two feet and more in 100 feet.

"The quantity of water which can be turned in depends on the size of each strip, its slope, and other conditions. On heavy soil and on narrow, short strips, the head may be cut to half a cubic foot per second and on wide strips and permeable soil 10 cubic feet per second may be none too much. A large volume of water cannot be handled successfully on steep slopes, but it is always possible to divide a head between two or more strips."

The corrugation method of irrigation offers a way to irrigate uncultivated crops with small heads of water which would ordinarily be too small for practical use. Its greatest advantage is in its adaptability to watering steep slopes and to irrigating with water that carries heavy amounts of silt. In this method the water is distributed by means of corrugations or furrows placed at close enough intervals to allow the lateral soaking of the soil by the time the water has penetrated to the depth desired. Too wide spacing of the furrows may be wasteful since water may percolate down beyond the feeding roots of the plants before the space between furrows is properly wet. When this method is used, short runs are advisable since long runs waste water at the upper end if the water is allowed to run long enough to irrigate the lower end. Its best use is on land with too steep a slope to be practical for the border method of irrigation or when only small heads of water can be used.

The soils vary in Colorado's irrigated districts. Many types of soil may be found in one district, and the treatment of one soil type may not necessarily be the best for the other soil types. In the high mountain areas where the soils are thin, frequent irrigations have been found to give the best results. In such areas where hay meadows are irrigated, it is often the practice to let the water run continuously on the meadow throughout the summer and stop

¹¹Fortier, S. The Border Method of Irrigation. U.S.D.A. Farmers' Bul. 1243, revised, 1937.

irrigation only in time to dry the ground before the hay is cut. The following statement by McLaughlin¹² represents, in general, the irrigation treatments which give the best results in the plains area: "The character of the soil and the subsoil determines, to a considerable extent, the proper time to irrigate. A heavy soil with a tight subsoil will receive and hold large quantities of moisture, making it possible to irrigate copiously and at long intervals. If a heavy soil is underlain with gravel, the water will drain out and



Flooding from field laterals.

more frequent irrigations will be necessary. This same principle holds true with lighter soils; the lighter the soil and the more open the subsoil, the more frequently will irrigation be necessary because the water-holding capacity of the light soils is less than that of the heavy soils."

Since sod-forming grasses are comparatively shallow rooted, it is necessary under Colorado conditions to irrigate pastures frequently. Little information is available on the amount of water necessary for maximum production of grasses.

In the pasture studies made at Fort Collins, from four to six light irrigations were applied during the season at intervals of about 25 days. The first irrigation was applied in May and the last irrigation in September. Good yields are obtained when normal growth is maintained throughout the growing season. The grass should not be allowed to suffer from drought.

¹²McLaughlin, W. W. Irrigation of Small Grains. U.S.D.A. Farmer's Bul. 1556, 1937.

From studies made in Idaho and Montana the following recommendations are made:

Idaho¹³—since grasses are comparatively shallow-rooted, light, frequent irrigations will give better and more economical results than larger amounts applied at greater intervals. Pasture grasses require more frequent irrigations and a greater total amount than most other farm crops. On the Station farm our grasses require water at least once every 10 days and a total amount during the season averages about 2½ acre-feet per acre.

Montana¹⁴—irrigation water was applied during the grazing season at intervals of from 2 to 4 weeks, depending upon conditions of growth and natural rainfall. The object was to keep, at all times, the surface soil thoroughly supplied with moisture. The irrigations, while frequent, were comparatively light.

These recommendations are essentially the same as those at the Station at Fort Collins. Light, frequent irrigations are necessary to keep pastures growing normally. The amount and intervals between irrigations depend upon weather conditions and soil types.

Use of Manure and Fertilizers

Pastures respond favorably to a top dressing with barnyard manure. Manure applied in February or March, with reasonable moisture, stimulates rapid, early growth of the pasture, and as a result 2 weeks more grazing in the early spring is usually possible. After several years in pasture, soils are likely to become trampled and packed as well as "root-bound"; disking or renovating with an alfalfa renovator following an application of manure is a means of aerating the soil and stimulating new growth.

In some pastures commercial fertilizers may be applied to advantage. Before an application of commercial fertilizer is made, a test strip across the pasture should be treated to find out whether the field will respond to the fertilizer used.

Temporary Pastures

Sweetclover

Sweetclover alone is considered an excellent pasture crop. When planted in April or May, at the rate of 10 to 12 pounds per acre without a nurse crop, sweetclover will provide some pasture in August, September, and October. Close fall grazing of this spring-seeded clover will cause a reduced growth in the early spring of the second year. Sweetclover plants will live only 2 years.

Danger of bloat may be reduced by drilling a light seeding

¹³Welch, J. S. Grass Pastures for Irrigated Lands. Idaho Exp. Sta. Bul. 80, 1914.

¹⁴Hanson, D. Irrigated Pastures. Montana Exp. Sta. Bul. 166, 1924.

of oats or barley in the clover field as growth starts in the spring of the second year. Livestock relish straw or some dry feed when being pastured on sweetclover. Straw fed to cattle and sheep while they are grazing on clover, or giving them access to a straw pile, will reduce the danger of bloat.

Winter Rye

Winter rye and Sudan grass can be grown to supply pasture during all the year except midwinter. Winter rye can be seeded as early as August 1 in the lower altitudes to supply pasture during the fall and early spring months. July seeding can be practiced at the higher altitudes. An additional seeding of winter rye in April will supply pasture until the old rye field which has been grazed during the fall and early spring months can be prepared and seeded to Sudan grass for summer pasture. Winter rye or winter wheat, seeded in the spring after heavy freezes cease, will produce only a few heads and will furnish pasture through the early summer.

Sudan Grass

Sudan grass is a hot-weather crop; therefore it should not be planted until late May or in June. When drilled at the rate of 20 to 25 pounds of seed per acre, it will provide excellent pasture until frost. Because of danger of poisoning it is unsafe to graze cattle or sheep on stunted or frosted Sudan grass. Spring grains or winter wheat may be substituted for Sudan grass to provide summer pasture.

Spring Grain

Spring grain may be used to supply pasture in order to give the native-grass sod time to reach maturity and produce a seed crop. Oats and barley are more leafy than wheat and therefore are preferred as pasture crops.

Field Peas

In some localities field peas are harvested by pasturing with hogs, sheep, or cattle. This method of harvesting is applicable to regions near livestock ranges and where there is very little rain or snow during the fall and early winter, but pasturing is a wasteful method of harvesting the pea crop even under favorable conditions. When the weather is bad the animals cannot feed properly; consequently, they are likely to lose flesh. They also greatly increase loss of the crop by trampling the peas into the ground. Field peas alone or in mixtures with oats may be sown for pasture. The animals may be turned into the field when the peas are beginning to harden in the lower pods. Feed must be plentiful if good results are to be obtained.

In pasturing hogs on field peas the Idaho Station¹⁵ found that "in all the experiments with both spring and fall pigs, the pounds of pork produced per acre credited to peas consumed, the average under all conditions is 406 pounds, with a variation of 604 pounds to 228 pounds. The gains are influenced by the yield of peas, the size of the pigs used, and the length of time the pigs are kept in the pasture."



Sudan grass is an excellent pasture or hay crop. If cut for hay as the first heads appear, it makes a high quality feed.

Tests were conducted by the Colorado Agricultural Experiment Station¹⁶ in the San Luis Valley on pasturing pigs on pea fields and on using combinations of available feeds in conjunction with field peas. It was found that hogs on pea fields alone made unsatisfactory gains and that the ration was not balanced. The rate of gain was increased and the cost of gain was decreased when the pea forage was supplemented. Either alfalfa meal or tankage was found to be a desirable protein supplement. Skim milk and cull potatoes, when available, may be added profitably to the pea-field ration.

Field peas have been pastured extensively with sheep in the San Luis Valley. Formerly, the lambs were pastured exclusively on pea fields with very little loss. In recent years the death losses under this method of feeding have been difficult to control. Feeding trials conducted by the Colorado Agricultural Experiment Station have shown that a ration of cull potatoes and alfalfa, readily

¹⁵Gongmer, R. E. Field Peas for Pork Production. Univ. of Idaho Bul. 125, 1921.

¹⁶Osland, H. B., and Morton, G. Field Peas for Fattening Pigs. Colo. Exp. Sta. Bul. 381, 1931. (Out of print.)

available feeds, is beneficial in checking death loss in lambs pastured on pea fields.

Peas seeded at the rate of 60 to 90 pounds per acre proved to be a better companion crop for alfalfa than small grain alone in experiments at Fort Collins.

HAY, FODDER, AND SILAGE CROPS

Legumes

Alfalfa Hay

Alfalfa hay¹⁷ is the standard winter roughage in most irrigated sections of Colorado. From tests conducted at the Experiment Station at Fort Collins (table 4) the following recommendations are made:

Meeker Baltic, Grimm, and Hardistan are very productive and are winter-hardy in Colorado. Meeker Baltic and Grimm are recommended for short rotations (3 years or less), while Hardistan, which is resistant to bacterial wilt, is recommended for longer rotations. Meeker Baltic and Grimm outyield Hardistan for the first 3 years but are so badly affected by wilt at the end of this period that the stand and yield are reduced to the stage where it is advisable to plow them up. Ladak produces more hay on the first cutting than any other variety tested. When only one or two cuttings of hay are obtained each year, Ladak should be used. Ladak is winter-hardy but is not resistant to wilt. It should be grown where irrigation water is short and only one irrigation is available for alfalfa, and in high altitudes where short seasons limit the cuttings to one or two.

The common varieties are not recommended unless it is possible to trace the source of seed to winter-hardy productive fields.

In Colorado most alfalfa is grown under irrigation. It is exceedingly important that the field be smooth and of uniform grade, permitting rapid and easy irrigation. Since the crop is usually left in for 3 years or more, the leveling of the seedbed before planting may save additional expense in seed, water, and labor at a later date. Besides proper leveling, a smooth, firmly-packed, moist seedbed, free of weeds, is necessary for the germination and development of the small alfalfa seedlings.

Good stands have been obtained from planting high grade seed in the spring. The seed should be drilled 1 inch deep in moist soil. If a companion crop (nurse crop) is used, field peas or Colless barley is recommended. A good practice is to stop up every

¹⁷Robertson, D. W., Weihing, R. M., and Coleman, O. H. Alfalfa in Colorado. Colorado Exp. Sta. Bul. 450, 1938.

TABLE 4—*Yield of alfalfa seeded in various strain tests at Fort Collins, Colo., between the years 1930 and 1936.*

Variety	Average annual yield of moisture-free hay in tons per acre					Yield in percent of Meeker Baltic
	3 years 1930-32	4 years 1931-34	3 years 1934-36	All Tests	Years grown	
Meeker Baltic	5.45	5.41	5.97	5.61	10	100
Grimm	5.28	5.24	5.42	5.31	10	95
Hardistan		5.33	5.59	5.46	7	96
Cossack	4.96		5.77	5.36	6	94
Ladak	4.87		5.72	5.29	6	93
Nebraska Common			5.90	5.90	3	99
Colorado Common	5.32			5.32	3	98
Grimm and Ladak			5.69	5.69	3	95
Utah Common		5.02		5.02	4	93
Baltic, F. C. I. 19001			5.37	5.37	3	90
Hardigan	4.89			4.89	3	90
Ontario Variegated	4.82			4.82	3	88
Turkestan	4.28			4.28	3	79

second spout of the drill when drilling the grain. This results in a thin stand of grain, enabling the light to penetrate and producing a more vigorous stand of alfalfa. At Fort Collins three irrigations, one on each cutting, gave good yields. To give the best yields of good quality hay, alfalfa should be cut when about one-tenth of the flowers are in bloom. The growth and appearance of the shoots which will produce the next cutting are better guides for the time of mowing than the condition of bloom. Alfalfa should be cut when these shoots get 1 to 2 inches long.

Red Clover

Red clover, although quite productive, is not grown to any extent for forage in Colorado. It has been replaced almost entirely by alfalfa. The amount and quality of hay from red clover are not equal to alfalfa and there is no apparent reason for using it as a hay crop in Colorado. Red clover mildews badly in northern Colorado and the hay is dusty. In tests at the Station two cuttings of hay were obtained. The yield averaged about 4 tons (table 5).

Ladino Clover

Ladino clover is poorly adapted for forage production. It is a pasture type of legume. Yields of about $2\frac{3}{4}$ tons (table 5) of hay have been obtained at Fort Collins. It is rather succulent and difficult to cure.

Hubam Clover

Hubam clover is an annual sweetclover. It has not proved successful under irrigated conditions. The hay is inclined to be weedy and the yields are low.

TABLE 5—*Comparative yields of forage plants at Fort Collins, Colo.*

Name of crop	Period of years grown	Moisture-free weights in tons per acre	5 year ave 1923-27
Alfalfa (Meeker Baltic)	1930-36	5.61	
Alfalfa (4 varieties)	1928-30	5.15	
Corn (Golden Glow)	1930-33	4.60*	
Forage sorghums (6 varieties)	1934-35	4.51*	
Hay millet	1923-25	2.63	
Sudan grass	1923-25	2.58	2.84
Oats and peas	1923-25	2.26	2.56
Colsess and peas	1923-25	1.98	2.12
San Luis field peas	1923-25	1.81	2.10
A K soybeans	1923-25	1.92	1.84
Oats	1923-25	1.96	
Hubam sweetclover	1923-25	2.41	2.48
Yellow sweetclover	1928-31	1.88	
White sweetclover	1928-31	2.44	
Red clover (2 varieties)	1928-30	4.17	
Ladino clover	1928-29	2.74	
Alsike clover	1928-29	2.40	
Tall oatgrass	1924-30	1.63	
Slender wheatgrass	1924-30	1.38	
Brome grass	1924-30	1.28	
Orchard grass	1924-30	1.11	
Meadow fescue	1924-30	1.08	
Crested wheatgrass**	1924-30	0.76	

*Air dry weight

**Yields for 3 years only

White Sweetclover

Several strains of white sweetclover have been grown for hay at the Station. It produces about 2½ tons of a rather coarse-stalked hay in the second year. It is not recommended where alfalfa can be grown.

Yellow Sweetclover

Yellow sweetclover is better adapted to pasture mixtures than to forage production. In tests conducted at the Station, yields of less than 2 tons have been obtained (table 5).

Alsike Clover

Alsike clover is a succulent clover and the hay is difficult to cure. Yields of about 2½ tons (table 5) of hay were obtained when it was grown alone. It should be grown in hay meadows at high altitudes on soils inclined to be wet.

Field Peas

Field peas may be grown alone as a hay crop where an annual legume hay is desired. It is better adapted to the higher, cooler climates and should be grown in a mixture with oats or barley.

Results at Fort Lewis¹⁸ indicate that when grown alone peas will yield 2 to 3½ tons of dry forage. Great care, however, has to be taken in handling the hay in order to prevent too great a loss of leaves. At Fort Collins (table 5) field peas yielded about 2 tons per acre. The better yielding varieties of peas are: Golden Marrow, New Canadian Beauty, Agnes, and French Gray.



Peas alone or in mixtures with oats or barley make excellent forage.

Soybeans

Different methods of planting and several varieties of soybeans have been tried for hay production at Fort Collins. None of these has given satisfactory yields (table 5).

Korean Lespedeza

Korean lespedeza has been tested and is not adapted to conditions at Fort Collins. It is a nonhardy crop.

Miscellaneous Crops

Corn

Corn will produce a high yield of forage or silage when grown under favorable conditions at the lower altitudes. Seed corn adapted to lower altitudes will not mature a grain crop when planted at higher altitudes, though a heavy forage yield may be obtained. At the Experiment Station at Fort Collins May 1 to May 10 plantings have averaged 2 bushels more of U. S. No. 1 corn per acre than later plantings. On good soils adapted varieties of corn will yield best when planted four stalks to the hill in check-rowed hills, 36 inches by 36 inches, or when dropped in the rows,

¹⁸Koonce, Dwight. Field Peas in Colorado. Colorado Exp. Sta. Bul. 416, 1935. (Out of print.)

single stalks 9 inches apart. Ten pounds of good quality seed are considered to be sufficient to plant an acre.

The corn crop can be entirely converted into a succulent feed by storing the crop in a silo. The trench silo is an economical means of storing silage. Corn cut as the shanks turn brown but while the leaves are still green may be cured in large shocks. Cattlemen, sheepmen, and the experiment stations report excellent results with corn stover, shredded or whole, when fed with proper protein and mineral supplements.

In the last few years good yields have been obtained from some of the better adapted hybrids.¹⁹ Tests have been conducted both at the Station at Fort Collins and at the substation at Rocky Ford.

The recommended field varieties are Colorado 13 and Minnesota 13 for the northern sections of the Platte Valley, and Reid's Yellow Dent, Iowa Silvermine, and Crawford's Yellow Dent for the Arkansas Valley and the southern and eastern parts of the State.

Sorghums

Tests at Fort Collins have shown sorghums to yield about the same amount of air-dry forage as adapted varieties of corn (table 5). In these trials (table 6) the greatest amount of forage per acre was obtained from Kansas Orange, Early Sumac, Black Amber, and Red Amber. Of these varieties, Black Amber and Red Amber mature seed at Fort Collins, while the others do not. If the grower must produce mature seed each year, Black or Red Amber can be used. For those who buy seed from areas which will mature Early Sumac and Kansas Orange, these varieties will produce an abundance of feed. Sorghums, if planted for fodder, should be planted in rows to facilitate irrigation and harvesting. In the Arkansas Valley later varieties mature and may be grown. Good yields and maturity were obtained with Leoti Red, Early Sumac, Kansas Orange, and Atlas.

Sudan Grass

Sudan grass is a hot-climate crop, and therefore is best adapted to regions favorable to the production of corn. Sudan grass drilled at the rate of 25 pounds per acre has yielded an average of 2.58 tons of moisture-free hay in tests conducted at the Experiment Station at Fort Collins (table 5). Under favorable conditions two cuttings of hay may be harvested. Sudan grass hay, if cut at the

¹⁹Leonard, W. H., Fauber, H., and Tucker, R. H. Annual Mimeographed Reports of Hybrid Corn Tests.

TABLE 6—*Forage sorghums, Fort Collins, Colo., 1934 to 1938 inclusive.*

	Tons per Grain	acre Total forage	No. years	Pct. Bu. Grain	Amber Total forage	Maturity Sept. 15-20
Black Amber F. C. 7038	1.08	4.47	5	100	100	Dough-Mature
Red Amber	1.20	3.86	5	111	86	Dough-Mature
Sumac	0.23	5.31	5	21	119	Milk
Kansas Orange	0.03	5.72	4	3	131	Blooming-Milk
Fremont	1.30	3.44	3	116	77	Dough-Mature
Cheyenne Sweet Sorgo	0.45	2.88	5	41	64	Milk-Dough
Honey Cane (Texas Ribbon)						
(Red Amber)	0.79	4.54	3	71	102	Dough
Leoti Red	0.38	4.76	2	37	105	Blooming-Milk
Atlas Sorgo	0.12	4.58	2	12	101	Blooming-Milk
Leoti Red x Feterita	0.13	4.28	2	13	94	Blooming-Milk

boot stage, may contain from 9 to 11 percent protein. The first cutting should be made when the heads first appear.

Small Grains

Oats make an excellent hay crop if cut as the heads begin to ripen. Several cases of livestock poisoning have been reported in recent years from feeding oat hay.^{20 21} There have been more cases of cattle poisoning reported, probably because cattle were more generally fed on this feed where the oat hay was used.

Work at Wyoming²² showed that sheep and horses react in the same way as cattle. W. B. Bradley, H. F. Eppson, and O. A. Beath showed that the killing was due to potassium nitrate in the hay.

Gardner²³ and others have shown that nitrates tend to accumulate in the soil where dry conditions prevail. Oats and other plants growing under such dry conditions tend to accumulate high nitrate concentrations in the stems and leaves.

Oat hay made from oats whose growth was retarded from a shortage of moisture may become toxic because of high nitrates in the oat stems and leaves. Hay produced under such conditions may be dangerous. A simple chemical analysis will show whether the hay is safe or dangerous.

The normal rate of seeding oats is 80 to 90 pounds. In a 3-year test at the Experiment Station at Fort Collins (table 5) oats

²⁰Newsom, I. E., et al. Oat Hay Poisoning. Jour. Amer. Vet. Med. Assoc., 90:66-75, 1937.

²¹Thorp, F. Further Observations on Oat Hay Poisoning. Jour. Amer. Vet. Med. Assoc., 92:159-170, 1938.

²²Bradley, W. B., Eppson, H. F., and Beath, O. A. Livestock Poisoning by Oat Hay and Other Plants Containing Nitrate. Wyoming Bulletin 241, July, 1940.

²³Gardner, Robert, Kezer, Alvin, and Ward, J. C. Nitric Nitrogen in the Soils of the Arkansas Valley. Colorado Tech. Bul. 6, 1934.

alone have averaged about 2 tons of oven-dry forage. Oats are used in some districts to increase tonnage of hay from a thin stand of alfalfa or sweetclover.

Foxtail Millet

Foxtail millet has been grown under irrigation as a hay crop at the Experiment Station. The foxtail millets make excellent hay when planted thickly (about 60 pounds per acre). They should be cut for hay just as the seeds are leaving the milky stage and before the soft dough stage is reached. The average yield at Fort Collins (table 5) and Fort Lewis was about 2½ tons.

Sunflowers

Sunflowers for silage may have a place in Colorado where summer temperatures are so low that corn yields are poor. However, where nearly as much corn fodder can be produced per acre, the sunflower should not be grown, since sunflower silage is inferior to corn silage and sunflowers are very much harder to harvest. Sunflowers must be cut in the early bloom stage in order to produce a silage which is palatable and which gets away from the resinous taste contained in sunflowers which have been allowed to mature in the field before ensiling.

Single Grasses

Various grasses have been tested alone at Fort Collins and Fort Lewis. The yields (table 5) are lower than when they are grown in mixtures with legumes. There is very little difference in the yields of the various grasses under irrigation. Crested wheatgrass gave the lowest yields and showed some difficulty in establishing a stand. The grasses tested were: Bromegrass, tall oatgrass, orchard grass, meadow fescue, slender wheatgrass, Grazier ryegrass, and crested wheatgrass. Reed canary grass which was tested in later years shows possibilities, but no comparative yields have been obtained.

Grass-Alfalfa Mixtures

In 1937 plots were seeded to mixtures of certain grasses and alfalfa, grasses alone, and alfalfa alone on the Experiment Station farm at Fort Collins. Table 7 gives the yields of the various mixtures for the years 1938 and 1939. Alfalfa slightly outyielded the grass-alfalfa mixtures. In the mixtures very little grass was produced in the second and third cuttings, the bulk of the grass being found in the first cutting. The grasses alone yielded about one-half ton of hay. The growth after the first cutting was very slight, although some pasture was available.

TABLE 7—*The yield of grass, alfalfa, and grass-alfalfa mixtures at Fort Collins, Colo., 1938 and 1939.*

Crop	Tons per acre of oven-dry hay								
	First cutting		Second cutting		Third cutting		Total		Grand total
	Grass	Alfalfa	Grass	Alfalfa	Grass	Alfalfa	Grass	Alfalfa	
Bromegrass	0.46						0.46		0.46
Bromegrass and orchard grass	0.56						0.56		0.56
Meeker Baltic alfalfa		2.41		1.72		0.90		5.03	5.03
Bromegrass and Meeker Baltic alfalfa	0.78	1.67	0.08	1.60	0.02	0.86	0.88	4.13	5.01
Orchard grass and Meeker Baltic alfalfa	0.66	1.74	0.09	1.49	0.07	0.81	0.82	4.04	4.86
Bromegrass, orchard grass and Meeker Baltic alfalfa	0.57	1.87	0.10	1.44	0.05	0.82	0.72	4.13	4.85

Small Grain and Pea Mixtures

When used in a mixture, peas and oats may be drilled at the rate of 60 pounds of peas and 50 pounds of oats, under average irrigated conditions in Colorado. Oat and pea mixtures have yielded about $2\frac{1}{2}$ tons per acre of moisture-free hay in tests conducted at the Experiment Station in Fort Collins (table 5). Oats and peas can be drilled in April with maturity expected during the last of July or the first of August. At the medium altitudes Colorado 37 oats will ripen at approximately the same time as peas when grown in mixtures. At higher altitudes, early-maturing oats, such as Nebraska 21, Kherson, or Brunker, mixed with Perfection or Yellow Admiral canning peas, when drilled in May or June, will mature together. Oat-pea mixtures may be harvested with a binder as the oats begin to ripen. Bundles of this forage are easily handled in stacking and feeding. Some growers cut the oat-pea mixture with a mower, raking into large shocks as soon as the hay is wilted. These large shocks are allowed to remain in the field and this forage is pastured off during the winter. In regions of heavy snowfall it would be best to stack the hay and feed it by hand. Peas that shatter during harvest will readily be picked up by hogs or sheep when the land is free of snow.

Peas grown in mixtures with Colsess barley are finding favor among sheepmen in some districts. A mixture of Colsess barley and peas yielded 1.98 tons of forage (table 5) in tests conducted at Fort Collins. The forage of mixed oats and peas, or barley and peas, is of better quality than oats or barley alone, and the hay is easier to care for than are peas alone.

APPENDIX TABLE 1—Area occupied by each species in quadrats located in the various grass mixtures at Fort Collins. The plots were clipped when 6 inches high.

Mixture Number	1		1		2		3		4		4	
Pounds of seed	20		20		24		16		50		50	
Year planted	1923		1925		1923		1923		1923		1925	
Year count made	1925	1930	1926	1930	1925	1930	1925	1930	1925	1930	1926	1930
	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.
Bromegrass -----	1,021	682	90	153	484	2,101			87	51	133	693
Orchard grass -----									1,984	2,826	1,111	2,604
Slender wheatgrass -----	1,055	98	504	1,973			756	251				
Meadow fescue -----					1,168	1,018	462	1,056	107	94	131	408
Timothy -----									0	0	102	41
Red top -----												
Tall oatgrass -----												
Canadian bluegrass -----												
Kentucky bluegrass -----												
Perennial ryegrass -----												
Yellow sweetclover -----	4	13	5	193	219	14	213	39	26	70	2	26
Red clover -----												
Alsike clover -----												
White Dutch clover -----												
Weeds -----	36	119	702	222	31	67	115	345	49	20	49	8
Percent weeds -----	1.7	13	33.3	9	1.5	21	6.9	20	2.1	0.6	1.8	0.2
Percent cover -----	21.4	9.11	21.1	25.4	20.5	32	16.7	16.9	23.7	30.6	27.8	27.7

APPENDIX TABLE 1—Continued

Mixture Number	5		6		7		8		9		10	
Pounds of seed	30		30		28		27		30		29	
Year planted	1923		1923		1923		1923		1925		1923	
Year count made	1925	1930	1925	1930	1925	1930	1925	1930	1926	1930	1925	1930
	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.
Bromegrass -----	97	40	539	288	214	153			256		328	12
Orchard grass -----	1,169	2,342	1,125	2,555	1,786	3,760	1,682	4,339	1,392		2,031	3,877
Slender wheatgrass ----												
Meadow fescue -----	294	87	470	175					40			
Timothy -----									2,435			
Red top -----			0	0			72	0			0	0
Tall oatgrass -----					0	92	0	0			T*	0
Canadian bluegrass ----												
Kentucky bluegrass ----							135	2,564				
Perennial ryegrass ----	0	0										
Yellow sweetclover ----									1			
Red clover -----	712	328	346	80	276	143	238	49			276	187
Alsike clover -----					264	15						
White Dutch clover ----							10	0			137	72
Weeds -----	9	43	64	99	13	6	16	25	16		2	100
Percent weeds -----	0.4	1.4	2.5	3.0	0.5	0.1	0.7	0.3	0.5		0.5	2.3
Percent cover -----	22.7	31.6	26.6	32.8	25.5	41.6	21.5	69.7	33.7		28.7	42.6

*T—trace.

APPENDIX TABLE 1—*Continued*

Mixture Number	10		11	
Pounds of seed	29		30	
Year planted	1925		1923	
Year count made	1926	1930	1925	1930
	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.
Bromegrass -----	256	76	776	507
Orchard grass -----	1,392	4,216	1,346	3,317
Slender wheatgrass ----				
Meadow fescue -----				
Timothy -----				
Red top -----	40	14	85	0
Tall oatgrass -----	243	8	0	0
Canadian bluegrass -----				
Kentucky bluegrass -----				
Perennial ryegrass -----			204	0
Yellow sweetclover -----				
Red clover -----	559	486		381*
Alsike clover -----				
White Dutch clover -----	67			
Weeds -----	16	40	14	75
Percent weeds -----	0.5	0.8	0.5	1.8
Percent cover -----	33.7	48.4	26.5	42.9

*Not seeded in original mixture.

**T—trace.

12	13	9
27	26	27
1923	1923	1923
1925 1930	1925 1930	1925 1930

Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.
---------	---------	---------	---------	---------	---------

194*	0	960	3,306	1,709	4,061
		988	38		

1,329	3,207				
90	0	0	0	0	0
		0	0	0	0
				0)	269
)	

		63	101		
410	527			467	307
95	0				
753	269			123	80
12	469	1	34	2	141
0.4	10.4	T**	1.0	T**	2.9
28.8	44.7	20.1	34.8	23.4	48.6

APPENDIX TABLE 2—*Area occupied by each species in quadrats located in the various grass mixtures cut for hay at Fort Collins.*

Mixture Number	1		2		3		4		50	
Pounds of seed	20		24		16		50		50	
Year planted	1923		1925		1923		1923		1925	
Year count made	1925	1930	1926	1930	1925	1930	1925	1930	1925	1930
	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.
Bromegrass -----	1,581	1,800	758	1,997	791	1,451			217	88
Orchard grass -----									1,818	3,395
Slender wheatgrass ---	795	158	677	120			404	174		
Meadow fescue -----					1,257	666	762	810	255	5
Timothy -----									0	0
Red top -----										
Tall oatgrass -----										
Canadian bluegrass ----										
Kentucky bluegrass ----										
Perennial ryegrass ----										
Yellow sweetclover ----	70		6	2	96		123	308*	2	12
Red clover -----										
Alsike clover -----										
White Dutch clover ----										
Weeds -----	1,225	1,838	420	50	76	1,043	886	2,332	12	0
Percent weeds -----	33	48	22.6	2	311	33	40.0	64	T§	0
Percent cover -----	37.0	37.9	18.6	21.6	24.8	31.6	21.9	36.2	22.9	35
	</									

* Alfalfa not seeded in mixture.

**Red clover not seeded in mixture.

§T—trace

APPENDIX TABLE 2—Continued

Mixture Number	5		6		7		8		9	10	
Pounds of seed	30		30		28		27		30	29	
Year planted	1923		1923		1923		1923		1925	1923	
Year count made	1925	1930	1926	1930	1926	1930	1926	1930	1926	1926	1930
	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.
Bromegrass -----	150	79	64	58	70	37			133	174	48
Orchard grass -----	1,665	3,808	1,793	2,906	1,017	3,151	1,727	2,610	1,442	1,988	3,393
Slender wheatgrass -----											
Meadow fescue -----	126	32	247	31					32		
Timothy -----									1,807		
Red top -----			0	0			0	0			
Tall oatgrass -----					0	0	0	0			
Canadian bluegrass -----											
Kentucky bluegrass -----							5	67			
Perennial ryegrass -----	0	0									
Yellow sweetclover -----									1		
Red clover -----	267	171	782	405	636	277	930	88		558	17
Alsike clover -----					0	0					
White Dutch clover -----							0	0		0	0
Weeds -----	17	8	67	0	13	0	4	9	50	26	2
Percent weeds -----	0.7	0.2	2.3	0	0.7	0	T§	0.3	2.4	0.9	T§
Percent cover -----	23.1	41.0	28.9	34.0	17.4	34.6	26.7	27.8	21.1	26.8	34.6

§T—trace.

APPENDIX TABLE 2--Continued

Mixture Number	10		11		12		13		9	
Pounds of seed	29		30		27		26		27	
Year planted	1925		1923		1923		1923		1923	
Year count made	1926	1930	1926	1930	1926	1930	1926	1930	1926	1930
	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.	Sq. Cm.
Bromegrass -----	133	26	464	122						
Orchard grass -----	1,442	2,342	1,874	2,794	256‡	447‡	2,586	3,612	1,471	2,126
Slender wheatgrass -----							302	16		
Meadow fescue -----										
Timothy -----					1,298	2,235				
Red top -----	32	0	0	0	59	0	8	0	0	0
Tall oatgrass -----	200	235	0	0					0	0
Canadian bluegrass -----										
Kentucky bluegrass -----			0	0					0	1
Perennial ryegrass -----			20	0						
Yellow sweetclover -----										
Red clover -----	256	545		262‡	588	569	2	20	568	94
Alsike clover -----					0	0				
White Dutch clover -----	1	0			1	0			0	0
Weeds -----	50	2	15	17	418	69	61	124	60.7	229
Percent weeds -----	2.4	T§	0.6	8.7	15.9	2.1	2.1	3.3	2.9	9.3
Percent cover -----	21.1	31.5	23.7	32.0	26.2	33.1	29.6	37.7	21.0	24.5

‡Orchard grass not seeded in mixture.

§T--trace.

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