3) 4) Bulletin 480

August 1943

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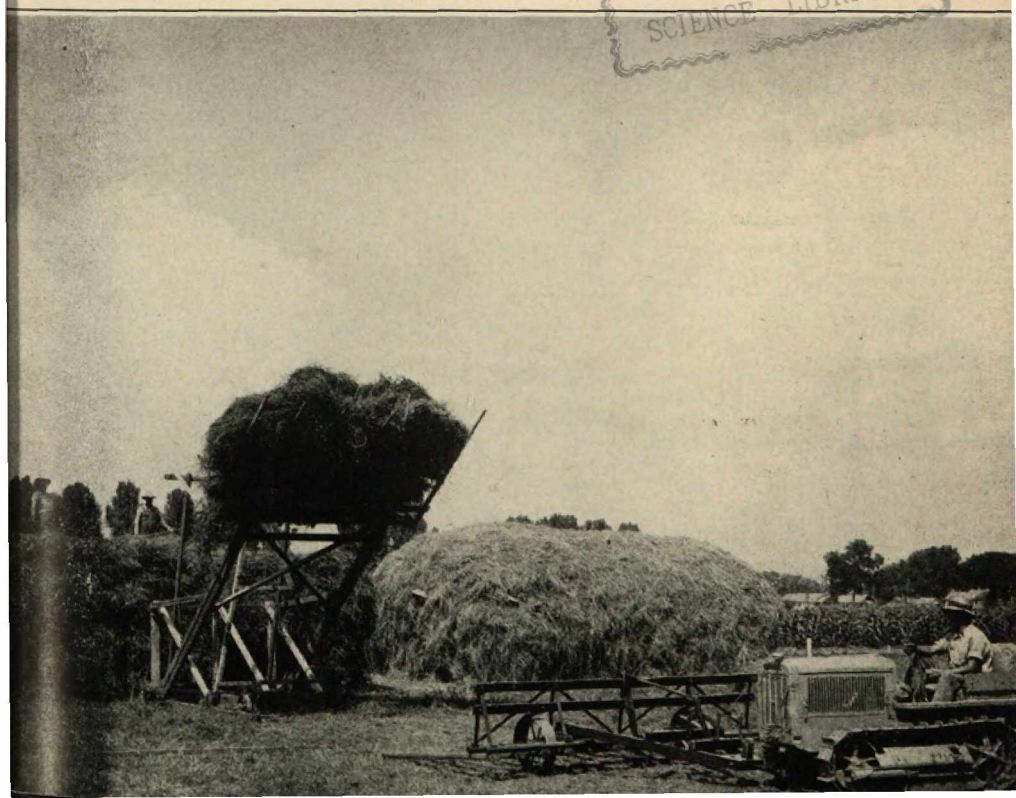

CONTENTS

GROWING ALFALFA IN COLORADO

R. M. WEIHING, D. W. ROBERTSON, O. H. COLEMAN, AND R. GARDNER[1]

ALFALFA is the most important forage crop grown on irrigated land in Colorado. Alfalfa hay is unsurpassed for general feeding. As pasture, it is nutritious and has a high carrying capacity. Alfalfa utilized as long hay, chopped hay, meal, pasture, or silage is a good source of protein, carbohydrates, minerals, and vitamins. In addition to its value as a productive and nutritious feed crop, alfalfa is beneficial in crop rotations on the yield and quality of the succeeding crops.

Amount of Alfalfa Produced Compared with Other Crops

So far as is known, alfalfa was first planted in Colorado in 1863 (*19*)[2] in the vicinity of Denver by Major Jacob Downing from seed procured by him in Old Mexico. From this small beginning it has become the major forage crop in the irrigated areas of the State. For the 10 years, 1930-39, an average of 676,800 acres produced 1,264,900 tons of hay valued at $10,506,700 annually. During this period alfalfa averaged about 12 percent of Colorado's harvested crop acreage and about 15 percent of the State's harvested crop value.

The importance of alfalfa as a crop varies considerably with counties. Figure 1 shows the average number of acres harvested annually for hay during the 10 years 1930-39. The first 10 counties were: Weld, Garfield, Mesa, Prowers, Montrose, Larimer, Delta, Bent, Morgan, and Boulder. Other counties with large acreages are located on streams furnishing irrigation water. The acreages of alfalfa in counties receiving no irrigation water are very small.

Comparative yields of several forage crops grown under irrigation at Fort Collins are given in table 1, showing that alfalfa yielded more than any of the other forage crops. While these data apply only to northeastern Colorado, they typify the order of performance to be expected in most of the irrigated districts of Colorado.

Alfalfa for Soil Fertility and Livestock Production

Alfalfa and livestock production in Colorado are closely associated, and in many parts of the State profitable production of one depends upon the other. Alfalfa is a major source of livestock feed, and livestock supplies a market for the hay crop. The conservation of soil fertility in turn depends upon both alfalfa and live-

[1]Weihing, assistant agronomist now on military leave; Robertson, agronomist; Coleman, former assistant in agronomy; Gardner, associate agronomist, on leave.

[2]Numbers in parentheses refer to literature cited, page 35.

stock. The principal source of nitrogen necessary to replenish that lost from the soil through the production of non-leguminous crops in Colorado is the large acreage of alfalfa.

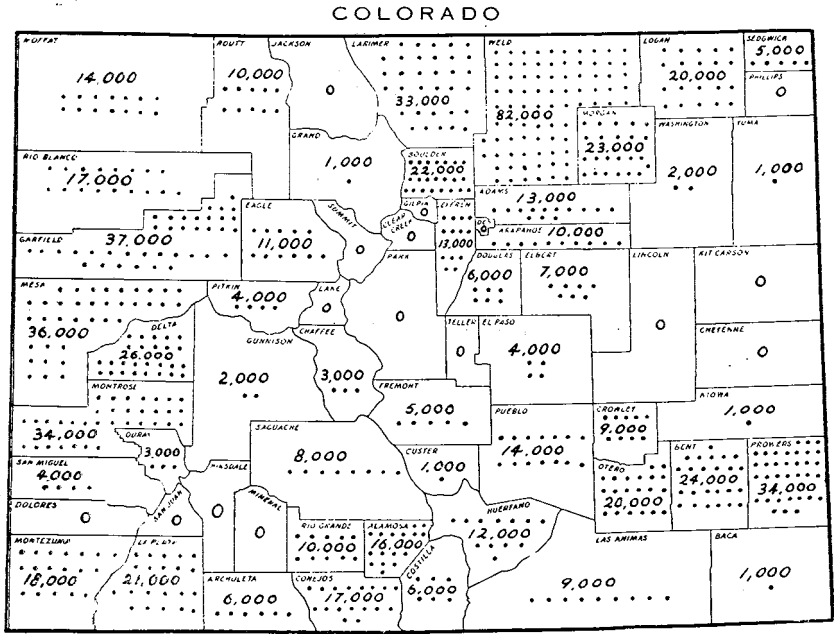

Figure 1.—The average annual harvested acreage of alfalfa in Colorado by counties for the 10-year period, 1930-39 inclusive. Each dot represents 1,000 acres; the numbers are whole numbers.

It is true that alfalfa is a heavy feeder on soil minerals and that growing it continuously on the land without return of mineral nutrients results in depletion of soil fertility. However, when alfalfa is grown in connection with livestock production and the manure is returned to the land, most of the minerals and also much of the nitrogen is returned, resulting in a net gain in nitrogen with only slight loss of minerals. Because of its bulk, alfalfa can in most cases be most profitably marketed through livestock on the farm where it is raised. This fortunate combination of circumstances is responsible for the return of much manure to Colorado land and is the key to the high state of fertility on many Colorado farms. The value of alfalfa to Colorado's agriculture, therefore, cannot be measured in tons of hay produced only, but also should include the greater yields of other crops from increased soil fertility.

Long-time rotation experiments with alfalfa under irrigation at Scottsbluff, Neb., Huntley, Mont., and Belle Fourche, S. Dak., show that after a few years the yields of crops in rotations including

TABLE 1.—*Comparative yields of alfalfa and other forage plants at Fort Collins, Colo.*

Name of crop	Years grown	Moisture-free weights in tons per acre
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*
Foxtail millet (2 varieties)	1923-25	2.63
Sudan grass	1923-25	2.58
San Luis field peas	1923-25	1.81
A K soybeans	1923-25	1.92
Oats	1923-25	1.96
Hubam sweet clover	1923-25	2.41
Yellow sweet clover	1928-31	1.88
White sweet clover	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 oat grass	1924-30	1.65
Slender wheat grass	1924-30	1.38
Brome grass	1924-30	1.28
Orchard grass	1924-30	1.11
Meadow fescue	1924-30	1.08
Crested wheat grass**	1924-30	0.76

*Air dry weight.
**Yields for 3 years only.

the alfalfa are higher in manured than in unmanured rotations. On non-irrigated land these differences might not result for many years, because crop yields are much smaller and the drain on soil nutrients lower than on irrigated land. *To maintain soil fertility alfalfa in a rotation is insufficient.* While it tends to increase yields of succeeding crops for a time because of its nitrogen enriching relations, manure and sometimes inorganic fertilizers, especially phosphates, are necessary to maintain the fertility of a soil producing abundant crops.

The mineral content as well as yield is reduced in hay from soils low in available minerals. Well-manured land, however, usually is high in mineral nutrients. Experiments (*15*) have shown that there is a high correlation between yield of hay, phosphate in hay, and available phosphorus in the soil on well-irrigated alfalfa land and that both yield and phosphate content are much higher on well-manured or on phosphated land than on land unfertilized.

The mineral content of alfalfa varies with maturity and other factors, but in general it is closely correlated with the available minerals in the soil. Alfalfa hay may vary in phosphorus between values as low as 0.28 percent P_2O_5 (phosphorus pentoxide) and as high as 1 percent, but good hay usually runs 0.4 percent or

higher. When the P_2O_5 drops much below this figure, a low level of available phosphorus in the soil is indicated and is reflected in both yield and quality of hay.

With the exception of phosphorus there is little evidence of acute mineral deficiency in Colorado alfalfa. Not all but many alfalfa soils in the State will respond to phosphate fertilizers. Often one end of a field will respond to phosphate fertilizers, while the other will not, or there may be a great difference in response in adjoining fields. On one series of plots on the Agronomy Farm at Fort Collins from 1930 to 1937 (*17*) no response was obtained from the addition of phosphate. A marked response resulted from phosphate on a new stand in adjoining plots in 1938 (fig. 4).

Alfalfa in the Rotation

In planning a place for alfalfa in the cropping system on a farm, a prime consideration should be the maintenance of fertility of the soil. Because of its ability to take nitrogen from the air, alfalfa if well managed can be a great factor in keeping the soil fertile. To make best use of alfalfa in a cropping system, it is necessary to rotate it with other crops which can take advantage of the added nitrogen.

Alfalfa has many other noticeable effects on the land and also on the crops which follow it in rotations. After alfalfa the soil has a more granular structure than after annual row crops and is more pervious to moisture because of the improved structure and the deeply penetrating tap roots (oftentimes 25 feet or more) which leave opened channels in the subsoil. However, as has been pointed out, even though alfalfa improves the soil in many respects, it depletes it of mineral nutrient elements, especially phosphorus. Due care should be exercised to replace these losses by adding manure, or manure supplemented by mineral elements when needed, to land producing large annual yields. Nitrogen, at present market prices, is the most expensive nutrient element removed from the soil by crops. A judicious use of alfalfa and manure can supply this element and return most of the minerals needed to keep the soil productive.

In many irrigated sections alfalfa stands are too thin for further production after 3 to 4 years of mowing for hay. The death of plants is caused largely by a disease named bacterial wilt caused by *Phytomonas insidiosa* (McC.) Berg. et al. Accordingly, alfalfa is grown in most rotations about 3 crop years, followed by 4 to 6 years of annual crops. A suggested typical rotation is alfalfa for hay 3 years followed by corn 1 year, sugar beets 1 year, small grain

1 year, sugar beets 1 year, and small grain with alfalfa 1 year (*6*). This 8-year rotation is typical of some sections in northeastern Colorado and is easily adapted to other sections where potatoes, onions, cantaloupes, and other cash crops are grown. It is suggest-

Figure 2.—A firm seedbed of uniform grade.

ed that manure be applied twice during the 8 years; it should immediately precede the beets or other cash crops. Experimental results and farm observations indicate that 4 to 6 tons of barnyard manure per acre for each year the land is not in alfalfa are necessary to keep our irrigated soils productive. Accordingly, one 16-ton or two 8- or 12-ton applications are advised in an 8-year rotation which includes alfalfa.

Alfalfa probably should not be grown for hay outside the irrigated districts except where the field will receive extra moisture as runoff from surrounding areas or where ground water may be reached and used by the crop. In such isolated areas the soil usually is free of the bacterial wilt organism and the stands may be productive for many years. Once a stand is obtained under these difficult conditions, it should be kept as long as it is productive.

Establishing and Maintaining a Stand

Preparation of the Seedbed

A well-prepared seedbed is firmly packed, fine, free from weeds, and of uniform grade to facilitate irrigation (fig. 2). A firmly packed seedbed permits the planting of seed in moist soil and insures that the seed will stay in contact with moisture as long as there is any in the surface soil. A weed-free seedbed eliminates

competition between seedlings of alfalfa and weeds, thereby giving to the alfalfa an advantage which may be manifest for several years. Alfalfa planted in a cloddy seedbed is almost certain to fail unless wet weather prevails afterwards.

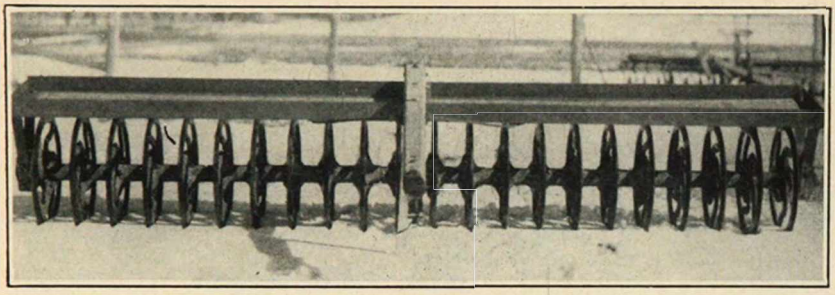

Figure 3.—An implement such as this will pack soil for an alfalfa seedbed better than will a harrow or a roller.

Fall-plowed land is ideal 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 to free the seedbed of air pockets (fig. 3). Just before planting in the spring the land should be well harrowed or otherwise tilled to make the surface soil fine and to kill all weed growth. The field should be leveled as much as necessary to make a smooth surface of uniform grade for irrigation. The preparation of a seedbed is much the same for spring-plowed land. Unplowed sugar-beet or potato land makes a good seedbed for spring seeding after tilling to kill weeds and leveling to facilitate irrigation. *The seed should be planted immediately after the growing weeds are destroyed so that the alfalfa will have a chance to commence growth before additional weed seeds sprout and grow.* Unworked stubble land for fall planting is desirable because it furnishes a firm seedbed. However, if such land is covered with shattered grain the volunteer growth may be so great as to kill the young alfalfa plants.

Time of Planting

In Colorado alfalfa can be planted in the spring or fall. Spring planting may be done about April 1 in the northern part of the State, and about March 15 in the low valleys of the southern and western part. Fall planting should be done before September 1 to insure sufficient growth, especially root growth, for the plants to survive the winter.

Drilling versus Broadcasting

Better stands of alfalfa are obtained from drilling than from broadcasting, since drilling puts more of the seeds in contact with

moist soil and at the correct depth. In heavy soils the seeds should not be placed deeper than 1 inch, but in sandy soils 1½ inches is a safe depth to plant. *Broadcasting is wasteful of seed* and requires double the amount needed for drilling.

Rate of Seeding

Eight pounds per acre of clean, high-germinating seed is sufficient to use in seeding with a drill. This rate provides about 40 seeds per square foot, which is far more than is necessary for a perfect stand. The excessive amount of 15 pounds is advised for broadcasting because many of the seeds are poorly placed in the soil and never grow into plants. At these rates excellent stands have been obtained on the Colorado Agricultural Experiment Station farm and other experimental farms.

Quality of Seed

The 8- and 15-pound rates of seeding are advised for clean, high-germinating seed and must be increased as the purity and percentage of live seed decrease. In 1930 and 1931 the Colorado seed analyst analyzed 216 and 133 samples of alfalfa seed (*11*). The samples varied in number of weed seeds per pound of alfalfa seed from 0 to 153,810 in 1930. Had the weedy sample been planted at 10 pounds per acre, 35 weed seeds per square foot would have been planted, which is nearly equal to the 40 alfalfa seeds per square foot for clean alfalfa seed at 8 pounds per acre. During the 2 years, purity varied from 99.88 percent to 65.95 percent, while live seeds (germination plus hard seeds) varied from 100 percent to 33.5 percent. *The purchaser of seed low in purity, low in live seeds, or low in both will have to plant more seed per acre than the purchaser of seed high in live seeds, and at the same time he risks planting a good many weeds.*

The following table reports the 1930 and 1931 average results and shows what should be expected of the highest-grade seed.

	Average percentage			
	Purity	Germination	Hard seed	Live seed
1930	96.54	66.5	21.4	87.98
1931	97.78	69.0	20.8	89.80
Expected of highest grade afalfa seed	99.81	81.0	17.0	98.00

Scarification

Alfalfa may contain many seeds that do not absorb water sufficiently to germinate during the prescribed 6 days between moist blotters at 20° centigrade in the laboratory germinator.

These seeds are called "hard seeds" because the seed coat is impervious to water. If the seed is scarified (scratched deeply enough) to injure the outer end of the palisade cells, water can be absorbed and germination can occur (*12*). Most of the hard seeds are alive (*13*) and will germinate within 1 year if kept between moist blotters at 20° C. and even faster when placed in moist, warm soil. Field trials indicate that: "Alfalfa seed containing many hard seeds has almost the same agricultural value for planting as alfalfa seed containing few hard seeds" (*23*). Seed with 20 percent to 62 percent of hard seeds germinated 57 percent to 60 percent, only slightly less than seed with less than 20 percent hard seeds, which averaged 61 percent to 64 percent germination. Seedlings emerged faster for samples with few hard seeds than for those with many, but 2 to 3 weeks after planting all samples had nearly equal number of plants. Accordingly, *scarification of alfalfa seed is not advised and seed with many hard seeds is practically as good for planting as seed with few hard seeds provided* the sum of hard seeds and live permeable seeds is high.

Inoculation

The importance of alfalfa, as well as all legumes, from the standpoints of good growth, highest nitrogen content of their forage, and enrichment of the soil with nitrogen, is based upon their ability in combination with bacteria (*Rhizobium* spp. or *R. meliloti* for alfalfa) to fix nitrogen from the air. These bacteria commonly are present in most irrigated Colorado soils now producing alfalfa or sweetclover. *In areas where alfalfa or sweetclover have not been grown, or in nonirrigated fields that have never grown alfalfa or sweetclover, the seed should be inoculated before planting.* On acid soils application of limestone, as well as inoculation, is advised before each seeding. However, few soils in Colorado need lime. The necessary cultures of bacteria for inoculation may be obtained from commercial seed stores.

Seed Treatment

Destructive organisms may attack and kill or stunt the seedling plants during germination. In some cases the plant is killed before emerging, while in other cases it emerges but the stem decays just at or above the ground line. These injuries result from the activity of soil- and seed-borne organisms which are active when germination begins and for a short time thereafter. The organisms are most destructive during cool, damp, cloudy weather and are almost non-destructive during warm, clear weather. Under the former conditions, treatment of the seed with commercial mercury dusts should improve the stand, but under the latter conditions,

which generally prevail in Colorado, commercial dusts generally do not improve stands. At Fort Collins, in the greenhouse where the soil was kept moist and the air humid, stands were increased from 26.8 percent to 60.4 percent by use of organic mercury dust, but in the field in the spring of 1940 this compound did not improve the stand (*24*). *For Colorado in general seed treatment is not advised.*

Companion Crops

Companion crops, or so-called "nurse crops," generally are used in seeding alfalfa on irrigated land. Those most often used are the spring grains: barley, oats, spring wheat, or field peas. The cereals are grown for grain, while the field peas are used for hay or threshed peas. Experiments at Fort Collins show that alfalfa planted in the spring without a companion crop averages about 1.5 to 2.0 tons of hay the year of planting. Also, it averages 0.5 ton more hay per acre each year thereafter (*17*) than alfalfa seeded with spring grain. Accordingly, spring grain companion crops reduce the amount of hay per acre about 3 tons for the usual 3-year duration of an alfalfa stand in Colorado. A companion crop of field peas cut for hay yielded 1 to 2 tons per acre and did not reduce alfalfa yields in subsequent years. *On irrigated land in this State the advantages and disadvantages from using companion crops nearly offset one another and should be decided upon by the individual raising the crop.* Winter wheat or winter rye should not be used because they may use enough moisture or produce enough shade to kill the alfalfa seedlings. *On dry land, companion crops should not be used because there isn't sufficient soil moisture for both crops; the alfalfa usually dies because of the competition for moisture.*

When alfalfa is planted with a companion crop, it should be given primary consideration in irrigation and other cultural practices. The companion crop should be planted about one-half the usual rate for planting alone. A better stand of alfalfa may be expected if the drill is set at the normal rate for the companion crop with every other drill opening closed than by planting one-half as much seed in every drill row. It is preferable to drill the companion crop by itself 3 inches deep and the alfalfa by itself about 1 inch deep. If both crops are drilled at the same time with the seed of both passing through the same spouts, the depth should be 1 to 1½ inches or that for the alfalfa.

Burning of Aftermath

In some instances, especially the spring after the first year of seeding, there is considerable trashy material on the field which

should be removed to prevent its being cut and incorporated in the next year's first cutting of hay. This trashy material when present usually is removed either by burning or by mowing followed by raking. A spring seeding of 1940 was given these treatments in the spring of 1941. The plots burned off produced 4.86 tons while the mowed plots produced 5.14 tons an acre. Burning is least harmful when done early in the spring before there is much green growth and at a time when the soil is moist and there is sufficient wind to cause rapid movement of the flames across the field.

Irrigation

Because of high yields of forage more water is required for alfalfa than for many crops, and in order to avoid wasting water the fields should be properly irrigated. The importance of alfalfa irrigation in Colorado is apparent when it is realized that nearly all of the alfalfa hay fields receive irrigation water. There are many methods of applying irrigation water to this crop, their suitability depending upon the character of the surface soil and subsoil, climate, size of head, and other factors. The methods most used in this State and probably most applicable are flooding between borders, flooding from laterals, and corrugation. No doubt several methods have been tried in each community and only those suited to local conditions are now in use.

Since it is easy to apply more water than is necessary to light sandy soils and less than is necessary to heavy soils, each field should be studied to determine the method or methods by which to apply about 6 inches of water at one irrigation. Amounts in excess of this may percolate beyond the root zone (*17*). Irrigation can be regulated by adjusting the head, the width of lands, length of fields, and duration of the runs. Each farm is a specific problem and each field may require different treatment. The following general recommendations (*5*) may serve as a guide: For the *border method*, 20 to 50 feet between levees, 200 to 600 feet for length of lands; the smallest dimensions are for sandy soils and heads of 1 second-foot of water and the largest dimensions for heavy soils and heads of 8 second-feet. For *flooding from laterals* the laterals usually are placed nearly on the contour with 50 to 200 feet between them and with the intervening slope as uniform as possible. For the *corrugation method* shallow furrows spaced 18 inches apart in tight soils, up to 36 inches apart in porous soils, conduct the water over the field. The distance between laterals varies from 150 feet on open porous soils up to 600 feet on tighter soils.

Additional suggestions concerning irrigation might well include the use of a soil probe for determining when the field has re-

ceived sufficient water. This instrument is nothing more than a small-diameter pointed metal rod about 4 feet long used to push vertically into the soil. In saturated soil this is easily done; in dry soil it requires driving with a sledge. Soil that can be hand-probed to 4 feet is saturated to that depth, has received sufficient water, and the head should be changed. Water applied beyond this point may be lost to the alfalfa through percolation into the water table. Alfalfa in dry soil is more easily killed by cold weather during the winter than alfalfa in moist soil. Winter-killing of winterhardy varieties in Colorado can be largely eliminated by having the soil moist throughout the winter.

No exact time is recommended for irrigating, but in general it is best to irrigate as late as possible before mowing and again after stacking *only* if the water is needed. Irrigations should precede the cutting date by sufficient time to allow the surface of the soil to dry. The appearance of the crop is a good indicator. Light-green color indicates that the crop is in no immediate need of water.

New seedings planted alone or with a companion crop are lost more frequently because of drought than any other cause. They should be watched and irrigated as often as necessary to keep the alfalfa plants in continuous growth. After the first year the plants can withstand long periods of drought and live, but during the first summer droughty conditions may kill all plants or enough of them to cause a thin stand that will require plowing up after 1 or 2 years of cutting for hay.

Cultivation

Experiments at the Arkansas Valley substation at Rocky Ford conducted for several years (*10*) indicated that cultivation of hay fields of alfalfa did not pay. Cultivation might be beneficial to loosen baked soil or to kill weeds in a thin stand which is still thick enough to use for hay. Such conditions, however, are not general in Colorado alfalfa-hay fields. For seed production where stands are purposely thin or the crop is planted in widely spaced rows (about 3 feet apart), one cultivation, or more if needed to kill weeds and seedling alfalfa plants, ordinarily is profitable.

Reseeding in Thin Stands

Planting seed into established fields to thicken the stand usually results in wasted effort and wasted seed. If the stand is too poor for hay production, it is best to prepare the land for a new seeding. Fields 3 or 4 years old that originally were thick but have thinned because of disease should be plowed and planted several years to other crops before replanting to alfalfa.

Manure and Fertilizers

Suggestions concerning use of manure were made in the section "Alfalfa in the Rotation." An average of 4 to 6 tons of manure per acre per year during the time the land is not in alfalfa is needed to maintain soil fertility. This is best applied in one 16-ton or two 8-ton applications, preferably on the cash crops. Some of the irrigated soils are now deficient in available phosphorus (fig. 4), and increased growth of alfalfa and other crops is noted from applications of 100 to 200 pounds per acre of treble superphosphate, even when manure is applied. The phosphate can be applied before beets or other cash crops and its carry-over effects will still be noted in the alfalfa.

In many Colorado soils the application of phosphate fertilizers determines success or failure in growing an alfalfa hay crop. Since many farms are not deficient, it is not advisable to apply phosphate to an entire field unless it is known that it is needed. A farm or field may be checked for phosphorus deficiency by applying treble superphosphate before planting time in strips and noting whether or not the treated areas are better than the untreated. The phosphate should be placed rather deeply in the soil (4 to 6 inches at least). Surface application is not satisfactory.

Time of Cutting

Alfalfa should be cut for hay when in the one-tenth to one-fourth bloom stage. If the blossoms are scarce, as happens in some seasons, the crop should be cut when the new basal shoots show in the crown. Alfalfa cut at this stage can be cured into a leafy hay high in feeding value. Later cutting results in a hay with coarser stems, fewer leaves, and lower digestibility. Four, three, and two cuttings a year can be taken in sections of the State with long, medium, and short growing seasons if the principles just mentioned are followed. The last cutting in the fall should be taken about the average date of the first killing frost to eliminate danger of freezing before cutting and to allow some time for the plants to renew growth before winter. There is less danger of winter injury if the plants make some growth before cold weather stops all growth.

Studies are in progress at Fort Collins to determine the practicability of cutting alfalfa in prebloom stages to produce high-protein, low-crude-fiber forage for feeding and for milling of alfalfa leaf meal. At Fort Collins the normal dates of cutting are June 15, July 25, and September 15. Taking four cuttings of prebloom hay on or about June 1, July 5, August 5, and September 15 in 1939 and 1940 reduced the average yield of protein from 0.87 ton to 0.68 ton and the average yield of hay from 4.93 tons an acre to

about 3.30 tons. The protein in three-cutting hay was 16.2, 17.8, and 20.4 percent for first, second, and third cuttings, respectively, and 22.8, 23.1, 18.6, and 21.0 percent for the first, second, third and fourth cuttings of four-cutting hay. For three-cutting hay crude fiber was 33.9, 33.6, and 30.6 percent for the first, second, and third cuttings, while for four-cutting hay it was 26.7, 24.7, 27.4, and 26.3 percent for the first, second, third, and fourth cuttings, respectively. The frequently cut plots gradually became weedy

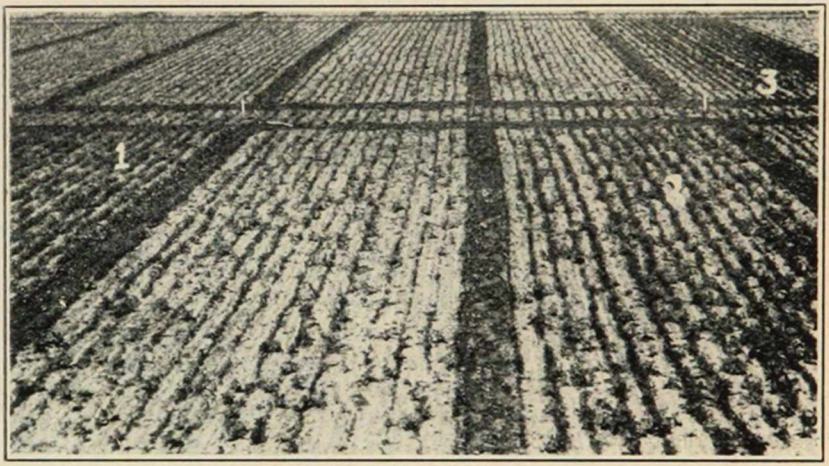

Figure 4.—An alfalfa stand 6 weeks old. Areas 1, 2, and 3, were treated with treble superphosphate. The others received no phosphate. Application of treble superphosphate is beneficial to alfalfa on phosphate deficient soil.

and some cuttings contained as much as 50 percent foxtail (*Setaria* spp.). *Since yields of hay were reduced by 33 percent, the grower will need considerable premium for cutting hay in pre-bloom stages.*

Quality of Hay

Quality and feed value in alfalfa hay are so closely associated that they are often thought of as the same thing. They may be estimated for most purposes from the following factors: (1) stage of maturity when cut, (2) percentage of leaves, (3) amount of natural green color, (4) amount of foreign material, (5) amount of spoilage, (6) size and pliability of stems, and (7) aroma. Alfalfa cut in the stage recommended in the section "Time of Cutting" will be of excellent quality if cured and handled to save the leaves, to retain the natural green color, to keep it free of dust and other foreign matter, and prevent molds during storage. Methods of handling hay should be adjusted to meet these requirements for reasons discussed in the following paragraph.

From a chemical standpoint, quality refers to the amounts of nutritive substances in the forage that will be supplied to animals. Broadly these are protein, carbohydrate, minerals, and vitamins. Good alfalfa hay will contain 50 percent leaves. The leaves contain 2/3 or more of the total protein of the hay as well as being higher than the stems in calcium, phosphorus, and vitamins. The apparent digestibility of the protein and crude fiber is higher in the leaves than in the stems. In one experiment with sheep (*21*) leaves were three and one-half times as efficient as stems in supplying digestible protein. Alfalfa contains a good amount of vitamin A (*4*) which diminishes in quantity with delay in cutting, loss of leaves, exposure to rainy weather, and molds in storage. These facts show why bright-green, leafy hay is the best to feed and why at times it sells for twice as much as the poorest hay sold in the large hay markets of the United States (*16*).

Bright Green Hay

For bright-green, leafy hay, alfalfa should be cut in the early bloom stage or just before the new basal shoots appear. It should be allowed to cure partially in the swath, but it should be raked into windrows before it is dry enough to lose the leaves. The remainder of the curing may be done in the windrow or in cocks, depending upon subsequent operations. The hay may be stacked from the windrow or cocks using sweeps, slings, or other conveyances. A leafier, cleaner hay usually results from sling stacking than from sweep stacking, although the former method is more laborious. Windrow baling is a comparatively new practice which may solve serious labor shortage problems during the haying period (fig. 5). Hay for baling should be a little drier than hay for stacking. Stacking, storing, or baling hay too wet results in spoilage by molds and heating. Hay is safe to stack if the stems crack and crackle on twisting, but too wet if the outside layer of the stem peels when scratched with the thumbnail.

Salt

Salt is sometimes added to hay during stacking because it is supposed to aid in the curing and reduce the danger of heating. Experiments (*16*) show that the amounts of salt necessary to prevent mold and heating are so great that the hay is rendered unpalatable. Twenty to 30 pounds a ton may make the hay more palatable, but it will not prevent heating or molding.

Brown Hay

Brown hay is made by stacking the hay before it is sufficiently cured to produce bright green hay and too dry to produce silage. The only time it should be made is when the weather is too humid

to cure the hay thoroughly. Brown hay is very palatable, but it is of lower total feeding value than well-cured hay because of greater stack losses from heat during curing. A stack of brown hay was produced on the Agronomy Farm at Fort Collins in 1938 because of humid weather during the curing period for the first cutting. The moisture during stacking was about 40 percent, and two-fifths of the dry weight of the hay was lost, a loss many times that expected

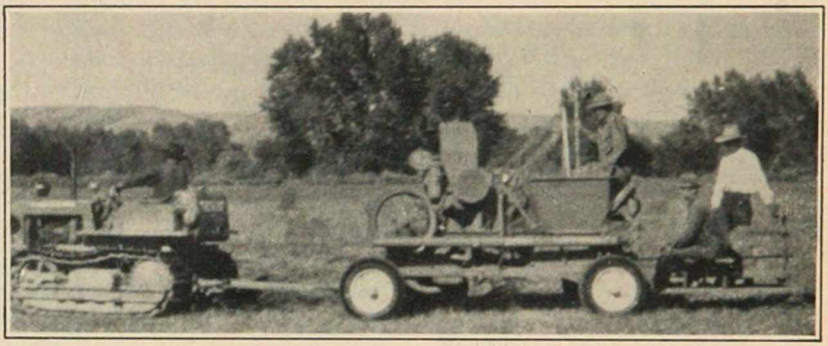

Figure 5.—Baling with a windrow baler.

in curing bright green hay. Besides tremendous losses in dry matter (40 percent is the average amount), there is danger of fire from spontaneous combustion, a negligible factor in the production of bright green hay.

Grass-Alfalfa Mixtures

Grass-alfalfa mixtures are sometimes grown because it is believed that better quality hay is produced. At Fort Collins and Fort Lewis (*26*) alfalfa alone and alfalfa with bromegrass or orchard grass yielded approximately equal amounts of hay per acre. The protein in the first cutting of mixed hay averaged less than alfalfa hay because the grass was lower in this constituent. In protein the second and third cuttings of pure alfalfa and mixed hay analyzed nearly the same. All cuttings of pure alfalfa were higher in calcium than the mixed hay, because the grass contained approximately half as much calcium as the alfalfa. Phosphorus content of the hay was not greatly influenced.

Yield and Quality of Cuttings

At Fort Collins the first, second, and third cuttings amount to about 45 percent, 30 percent, and 25 percent of the total yield (*17*). In most areas of Colorado, yield is greatest for the first cutting and diminishes with the second, third, and fourth cuttings. In 1939 and 1940 at Fort Collins alfalfa with all its leaves averaged 16.2 percent, 17.8 percent, and 20.4 percent protein for the first,

second, and third cuttings, respectively, and for corresponding cuttings 33.9 percent, 33.6 percent, and 30.6 percent crude fiber. The phosphate content was 0.35 percent P_2O_5 for the first crop, 0.40 percent for the second, and 0.52 percent for the third on unfertilized land slightly deficient in available phosphorus. On phosphated plots the P_2O_5 content was 0.47 percent for the first crop and 0.51 for the second crop. No data are available for the third crop on phosphated plots. These data indicate that feeding value or quality of alfalfa hay cured without loss of leaves is highest for third; lowest for first; and intermediate for second-cutting hay. Loss of leaves or weathering or stage of maturity may change the value of any one cutting.

Alfalfa Varieties for Hay

Yields at Fort Collins

The hay yields of 21 varieties of alfalfa grown at Fort Collins are compared in table 2. Several varieties or strains have yielded well in these tests. Those varieties producing about the same amounts of hay as Meeker Baltic and productive Colorado Common were: Grimm, Hardistan, Ladak, and most northern grown commons such as Nebraska, Montana, and Idaho. These varieties and strains are suggested for growing in most sections of the State. Those varieties or strains producing less hay than Meeker Baltic or productive Colorado Common were mostly of southern and foreign origin and were: Hardigan, Ontario variegated, Turkestan, Arizona Common, Utah Common, Dakota 12, Argentine, and Chilean. *Since Colorado annually produces about enough alfalfa seed for its own needs of the adapted and productive strains such as Meeker Baltic, Grimm, Ladak, and Colorado Common, it appears that growers should buy this seed in preference to imported and southern strains which may be lower in yield and winterhardiness.*

Yields at Fort Lewis (Table 3)

At Fort Lewis where the altitude is 7,610 feet and the season limits growth to two cuttings a year, Ladak was the most productive. Grimm, Baltic, and Colorado Common all averaged good amounts of hay each year and are suggested for growing in this or similar areas when Ladak is not used. Hardistan did not yield well in this experiment.

Yields at Rocky Ford (Table 4)

The growing season in the Arkansas Valley is long enough to permit taking three or four cuttings of hay a year. Some growers take three, others four, while others vary from three to four a year.

TABLE 2.—*The yield of hay of varieties of alfalfa grown at Fort Collins, Colo.*, 1930-41.

Variety	Tons per acre of oven-dry hay										Yield in % of	
	3 years 1930-32	3 years 1930-32	4 years 1931-34	3 years 1934-36	3 years 1934-36	4 years 1936-39	3 years 1937-39	3 years 1938-40	2 years 1940-41	Years grown	Colo. Common	Meeker Baltic
Meeker Baltic	5.45	—	5.41	5.97	—	—	4.36	4.72	5.60	18	102	100
Grimm	5.28	—	5.24	5.42	—	—	4.09	4.50	—	16	99	95
Hardistan	—	—	5.33	5.59	—	—	4.34	4.77	5.36	15	—	97
Cossack	4.96	—	—	5.77	—	—	—	—	—	6	93	94
Ladak	4.87	—	—	5.72	—	—	4.20	4.60	—	12	92	96
Baltic	—	—	—	5.37	—	—	—	—	—	3	—	90
Hardigan	4.89	—	—	—	—	—	—	—	—	3	92	90
Ontario variegated	4.82	—	—	—	—	—	—	—	—	3	91	88
Turkestan	4.28	—	—	—	5.27	4.56	—	—	—	10	89	78
Colorado Common	5.32	5.04	—	—	5.43	5.00	—	—	—	13	100	98
Kansas Common	—	4.88	—	—	5.62	4.82	—	—	—	10	99	—
N. Mexico Common	—	5.07	—	—	5.19	4.84	—	—	—	10	98	—
Nebraska Common	—	—	—	5.90	5.64	4.92	4.54	4.70	—	16	101	101
Montana Common	—	5.21	—	—	—	—	—	—	—	3	103	—
Idaho Common	—	5.19	—	—	—	—	—	—	—	3	103	—
Arizona Common	—	—	—	—	5.13	—	—	—	—	3	94	—
Utah Common	—	4.59	5.02	—	—	—	—	—	—	7	91	93
Dakota 12	—	4.57	—	—	—	—	—	—	—	3	91	—
Argentine	—	4.50	—	—	—	4.24	—	—	—	7	89	—
Chilean	—	—	—	—	4.33	4.49	—	—	—	7	85	—
Orestan	—	—	—	—	—	—	—	—	5.29	2	—	94

Accordingly, eight varieties now under test at Rocky Ford are being cut three and four times a year. Only 1 year's results are available, but they indicate that Ladak is the best three-cutting variety and Meeker Baltic the best four-cutting variety. Because Ladak is slow to start new growth after cutting, its use should be limited to three cuttings, and only quick-recovering strains such as Meeker Baltic, Grimm, and certain productive commons should be used for four cuttings. Hardistan and Orestan appear to be the least productive of the eight varieties, although final conclusions must be withheld for 2 or 3 more years.

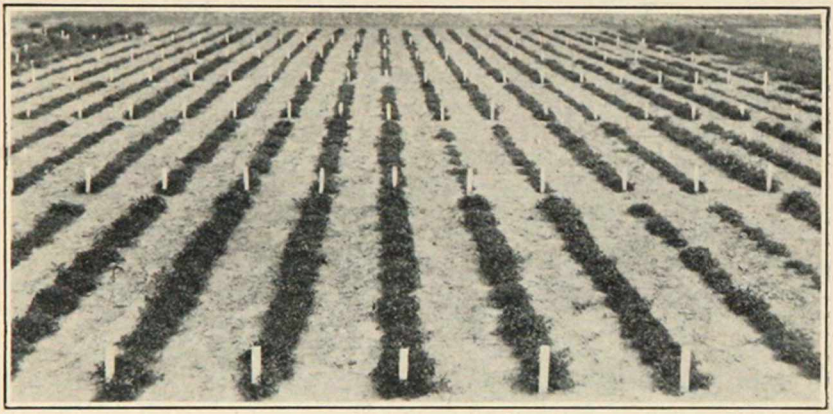

Figure 6.—Many strains of alfalfa are tested at Fort Collins. The picture shows nursery rows of 55 strains from many sources under preliminary evaluation and elimination. The better sorts are tested later in larger plots.

Yields at Akron (Table 5)

At Akron and in similar dry-land areas of Colorado a ton or more of alfalfa hay per acre in most years can be produced on low ground receiving runoff water from surrounding higher ground. On the high ground it is not successful because of too little water. Where it can be grown it furnishes pasturage or hay high in nutritional elements (proteins, minerals, and vitamins). Dry lands may be low in amount of annual hay and pasture crops. During the 6-year period, 1933-38, alfalfa plots on land receiving runoff at Akron averaged 1.12 tons of hay per acre. The annual yields varied from nothing in 1937 to 1.99 tons in 1935. Ladak and Meeker Baltic were the highest yielding varieties in this experiment.

Longevity of Alfalfa Varieties

The chief reasons for loss of alfalfa stands in Colorado are killing from cold or bacterial wilt. Winterkilling can be overcome by growing winter-hardy varieties such as Meeker Baltic, Ladak,

TABLE 3.—*The yield of hay of varieties of alfalfa grown at Fort Lewis, Colo.*, 1937-40.*

Variety	Tons per acre of air-dry hay						
	4-year average			Annual totals			
	1st cutting	2nd cutting	Total	1937	1938	1939	1940
Ladak	2.98	2.14	5.12	4.47	5.68	4.63	5.70
Grimm	2.75	2.06	4.81	4.13	5.36	4.33	5.42
Grimm Maslem	2.73	2.05	4.78	4.16	5.28	4.29	5.41
Baltic	2.72	1.94	4.66	3.81	5.47	4.14	5.22
Colorado Common	2.70	1.93	4.63	3.88	5.03	4.60	5.00
Hardistan	2.46	1.83	4.29	3.73	4.59	4.12	4.74
Average	2.72	1.99	4.71	4.03	5.24	4.35	5.25

*This experiment was conducted by Dwight Koonce, associate agronomist, Colorado Agricultural Experiment Station.

Grimm, Hardistan, and northern commons. After 3 to 4 years of cutting for hay, most plants of varieties susceptible to bacterial wilt are dead and the stand is too thin for further use. The varieties Hardistan and Orestan are sufficiently resistant to alfalfa wilt to remain productive 2 or 3 years longer than others. Meeker Baltic, Grimm, Cossack, and most commons are the most wilt-susceptible varieties. Ladak is slightly resistant but less so than Hardistan and Orestan.

Characteristics of Superior Varieties (Table 6)

The yields of the recommended varieties were nearly equal in some cases so that other characteristics must be taken into account

TABLE 4.—*The yield of hay of varieties of alfalfa grown at Rocky Ford, Colo.*, 1941.*

Variety	Tons per acre of oven-dry hay in 1941									
	Three cuttings				Four cuttings					Av. totals for 3 and 4 cuttings
	1st	2d	3d	Total	1st	2d	3d	4th	Total	
Meeker Baltic	1.56	1.29	0.91	3.76	1.69	1.38	0.87	0.66	4.60	4.18
Grimm	1.73	1.17	0.94	3.84	1.39	1.12	0.81	0.46	3.78	3.81
Ladak	2.15	1.40	0.82	4.37	1.99	1.41	0.73	0.21	4.34	4.36
Hardistan	1.51	1.30	0.90	3.71	1.46	1.02	0.91	0.49	3.88	3.80
Orestan	1.57	1.12	0.78	3.47	1.48	1.01	0.79	0.43	3.71	3.59
Colo. Common	1.24	1.15	0.94	3.33	1.37	1.01	0.95	0.55	3.88	3.60
Nebr. Common	1.34	1.11	0.98	3.43	1.41	1.11	0.88	0.64	4.04	3.74
Argentine	1.40	1.28	1.08	3.76	1.34	1.04	0.89	0.56	3.83	3.80
Average	1.56	1.23	0.92	3.71	1.52	1.14	0.85	0.50	4.01	3.86

*Agronomy Section and Arkansas Valley Substation, Herman Fauber in charge, cooperating.

TABLE 5.—*The yield of hay of varieties of alfalfa grown at Akron, Colo.,* 1933-38.*

Variety	1933	1934	1935†	1936	1937§	1938	Average
Grimm (Moffat Co.)	0.98	0.90	1.85	0.85	0	1.23	0.97
Grimm (Grand Junction)	0.95	1.00	1.83	0.80	0	2.38	1.16
Meeker Baltic	1.05	1.40	2.08	0.98	0	1.95	1.24
Ladak	0.90	0.98	2.35	1.00	0	2.40	1.27
Colorado Common	0.72	0.80	1.85	0.83	0	1.43	0.94
Average	0.92	1.02	1.99	0.89	0	1.88	1.12

†Two cuttings in 1935

§No flooding in 1937; crop too short to cut and severe grasshopper damage.

*The U. S. Dry-land Field Station, located in northeastern Colorado at an altitude of about 4,600 feet, is operated by the Division of Dry-Land Agriculture of the U. S. Dept. of Agriculture, in full cooperation with the Colorado Agricultural Experiment Station. The yields for the above test were obtained from the annual reports of the U. S. Dry Land Field Station, Akron, Colo. Mr. J. F. Brandon, associate agronomist, Division of Dry-Land Agriculture, U. S. Department of Agriculture, is superintendent of the Field Station

in selecting the variety to grow. Earliness of spring growth, amount of fall growth where fields are to be fall pastured, and inherent seed productivity where the field may be cut for seed a part of the time, as well as wilt resistance, are characteristics of interest.

Measuring Hay in the Stack

The tonnage of an immense amount of Colorado hay is estimated in the stack. The United States Department of Agriculture, through the Bureau of Agricultural Economics, carried on experiments in cooperation with the western states for a series of years in an effort to get more accurate rules for measuring hay in the stack. The results of these studies are published in Leaflet 72 of the United States Department of Agriculture (*9*), which gives rules for three types of stacks commonly found in this territory (fig. 7). Quoted from page 3 of Leaflet 72, these rules are as follows:

> The three types of stacks with the rule for each type are as follows:
>
> For square, flat-topped stacks (0.56 x O) - (0.55 x W) x WL
> For high, round-topped stacks (0.52 x O) - (0.46 x W) x WL
> For low, round-topped stacks (0.52 x O) - (0.44 x W) x WL
>
> In these rules O equals the over, W equals the width, and L equals the length.
>
> Example.—To determine the volume of a rectangular stack of the high, round-topped type that is 20 feet wide, 45 feet over, and 50 feet long.

Volume = (0.52 x 45) - (0.46 x 20) x (20 x 50).

45	20	50
0.52	0.46	20
90	9.20	1,000
225		
23.40		
—9.20		
14.20		
1,000		

14,200.00 cubic feet in the stack.

These rules estimate closely the number of cubic feet in a stack. To get at the number of cubic feet to allow for a ton, the following table, taken from page 4, Leaflet 72, is used:

	30 to 90 days	Over 90 days
Number of cubic feet to allow for a ton of alfalfa hay	485 cubic feet per ton	470 cubic feet per ton

To obtain the number of tons in the stack divide the number of cubic feet in the stack by the number of cubic feet to allow for a ton. The 14,200 cubic feet in the foregoing example would be divided by 485 cubic feet where the stack had settled from 30 to 90 days, or by 470 cubic feet if the stack had settled for more than 90 days.

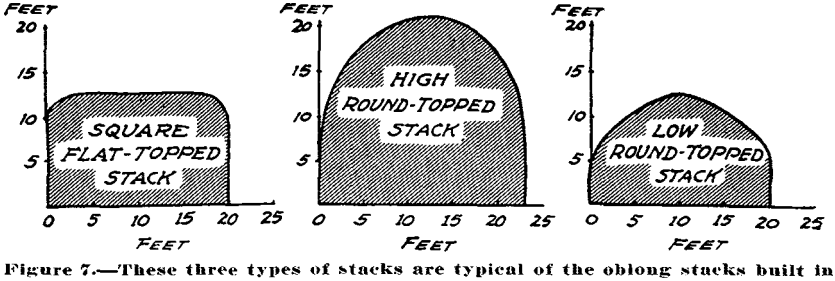

Figure 7.—These three types of stacks are typical of the oblong stacks built in different parts of the United States. The square, flat-topped stacks are found principally in the Sacramento and San Joaquin Valleys of California; the high, round-topped stacks are common in the inter-mountain states of Utah, Nevada, and Idaho; and the low, round-topped stacks are the type built in the Great Plains states, where the overshot stacker is used.

Uses Other Than Hay

Silage

Alfalfa is not thought of as a silage crop, and it is usually cured for hay when weather is favorable. Headden (7) in 1896 re-

TABLE 6.—*Some agronomic characteristics of varieties of alfalfa recommended for growing in Colorado.*

Variety	Where recommended in Colorado	Yield	Spring growth	Fall growth	Recovery from cutting	Resistance to				Seed setting
						stem blight	leaf spot	wilt	mildew	
Meeker Baltic	All parts	Good	Early	Tall	Good		Some	Poor	Some	Good
Ladak	All parts; especially areas cutting once or twice a year and Arkansas Valley	Good, large 1st cutting	Late	Short	Slow	Some	Some	Fair	Some	Good
Grimm	All parts	Good	Early	Tall	Good	Some	Some	Poor	Some	Good
Colorado and northern commons	All parts	Good	Early	Tall	Good		Variable	Poor	Some	Good
Hardistan	Areas similar to Fort Collins	Good	Early	Tall	Good		Poor	Good	Poor	Poor

ported that palatable alfalfa silage had been made and fed in Colorado. The fact that there has been no appreciable use of alfalfa silage during the past 45 years suggests that growers and feeders in this State prefer to feed alfalfa in other forms.

Where good hay can be made, there is little reason to silo alfalfa. Where it is siloed, the alfalfa should be cut fine and well packed. Sometimes alfalfa silage is foul smelling, moldy and slimy, and unfit for use. The danger of this happening can be overcome, first, by using partly wilted (50 to 68 percent moisture) rather than green unwilted (75 to 80 percent moisture) alfalfa, and, second, by mixing corn, sorghum, small grains, or 60 to 80 pounds of molasses per ton with the green alfalfa as it goes through the cutter. The corn, sorghum, small grains, and molasses are relatively high in carbohydrates and are conducive to the right kind of fermentation to produce a palatable silage (*29*).

Pasture

Alfalfa makes a good pasture crop for several classes of livestock. With horses little, if any, supplementary feed may be necessary even during the working season. Sheep and cattle thrive on it, but are subject to bloat. The Animal Investigations Section of the Colorado Agricultural Experiment Station after collecting data from many sheepmen concluded that losses can be kept down to 5 percent by following precautions that are recommended for pasturing cattle. Old ewes and their lambs are less subject to bloat than young ewes and wethers. Hogs do well on alfalfa pasture and do not injure the stand provided the number pasturing is not too large and a small amount of grain is fed. All kinds of poultry relish green alfalfa, which is a good addition to their ration.

An acre of irrigated alfalfa pasture will carry about eight ewes and their lambs from April 15 to October 1 (Animal Investigations Section of Colo. Agr. Exp. Sta.) (*1*). An acre of alfalfa pasture will carry about 20 fall pigs during the spring period and 30 spring pigs during the summer period (*1*, *8*) when fed about 2 pounds of corn per head each day.

The pasture ought to be divided into two or more sections. There are two reasons for this. First, it permits keeping the animals in one while irrigating the other; and, second, it permits grazing one while the other is renewing growth after a period of pasturing, a practice which increases the carrying capacity as well as longevity of stands.

The consumption of soil water by alfalfa is reduced, as is the yield, by frequent clipping or close pasturing. This fact affords a

means of adjusting crop growth to the available water supply and of permitting the most growth in spring and fall when the amount of water required to produce a pound of dry matter is lowest (*2*). If during the summer moisture is short of the amounts necessary to produce normal hay crops, summer grazing is a practical means of obtaining a return from the land commensurate with the available moisture.

Orchard Cover Crop

In certain orchard sections alfalfa has been used as a cover crop. It probably is best to leave the alfalfa in permanently and to leave the entire season's growth to maintain or to increase the productivity of the soil. Alfalfa is the best-known cover crop for correcting certain soil troubles and certain physiological diseases in orchards. Pasturing or feeding the hay of alfalfa in orchards requires caution because poisonous arsenical sprays used on the trees fall on the cover crop.

Seed Production

Colorado produces annually about 1,500,000 pounds of alfalfa seed on about 10,000 acres. The yield per acre of seed approximates 150 pounds, an amount which is greatly exceeded in good seed years.

There are certain climatic, soil, cultural, insect, and inherent factors which affect the seed-setting of alfalfa. Repeated observations by many people in various locations indicate that seed yields are best under the following conditions: First, thin stands; second,

Figure 8.—For seed production thin stands are superior to thick stands.

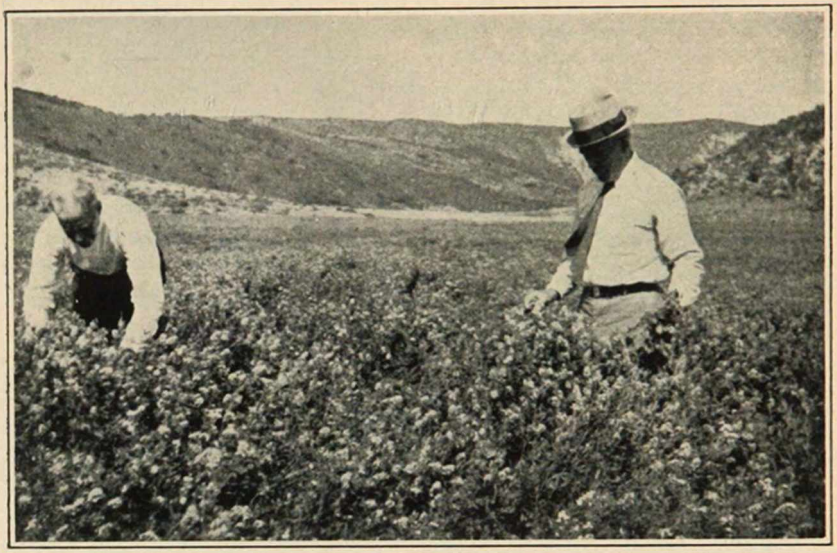

Figure 9.—Meeker Baltic grown for seed. Unless flowering and pod setting are abundant the field had better be cut for hay.

continuous sunny weather during pollination and pod-setting; third, land requiring no irrigations or only one early in the spring; and, fourth, fields surrounded by barren areas.

A satisfactory method of planting is in rows about 3 feet apart using 1 to 3 pounds of seed per acre. The stands should be kept thin and free of weeds by cultivating between the rows. In widely spaced rows, lodging sometimes makes harvesting difficult. This can be overcome by planting in rows about 2 feet apart, or in sugar beet areas 20 inches apart.

At Fort Collins (fig. 8) in 1940 seed yields averaged 65 pounds per acre for solid stands, 84 pounds for rows 21 inches apart, 97 pounds for plants 21 x 24 inches apart, 96 pounds for rows 35 inches apart, and 102 pounds for plants 35 x 36 inches apart. These results indicate the merits of thin stands for seed production.

Amounts of irrigation water insufficient for good hay yields at times are sufficient for seed production, especially where thin stands are used. In certain cases where the water table is close to the surface (6 to 12 feet), fields may require no irrigation because the roots draw moisture from the water table. In such fields a mini-

mum of cultivation is necessary to kill weeds and new seedlings because no surface irrigations are needed.

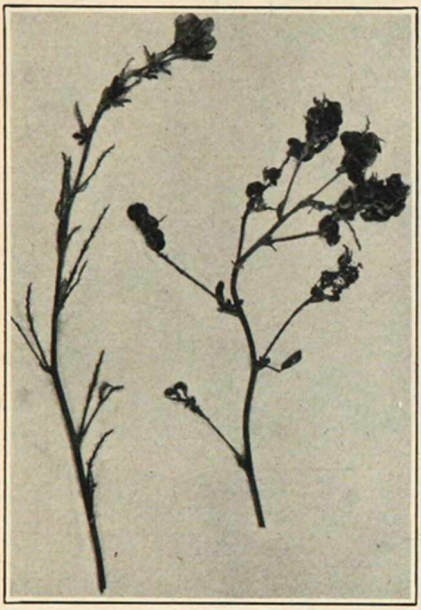

Figure 10.—For several reasons alfalfa flowers may strip, that is, fall off without forming pods. The stem on the left shows the stripped condition; the one on the right has a good set of pods. Stripping may be caused by lack of tripping, insect injury, adverse weather conditions, and by inherent qualities of the plant.

The abundance of certain harmful insects may cause failure of seed-setting. Grasshoppers may devour floral and other plant parts, blister beetles may cause the flowers to drop by eating the colored portion. Lygus bugs are known to cause dropping of flowers and shriveling of seed in pods as a consequence of their feeding on buds and seeds. Others may also have injurious effects. Some control of the insects is possible by dusting with pyrethrum, but experimental evidence is insufficient to advise for or against it. Lygus damage might be minimized by cutting the seed crop at one operation to prevent migration of the insects from cut to uncut fields (*20*).

Certain varieties are better seed yielders than others. Fortunately most varieties are relatively good if conditions are favorable. If conditions are right, Meeker Baltic, Grimm, Ladak, Cossack, and most commons set seed in good amounts. The variety Hardistan and certain other strains originating from Turkestan are notoriously poor seed yielders. Certain plants in alfalfa have been found which do not set seed well when self-pollinated or cross-pollinated (*25*). The variety Hardistan and certain other Turkestan strains appear to have a large percentage of such plants.

Tripping of alfalfa flowers is a prerequisite for good seed-setting (fig. 11). This has been proved several times in the past 40 or 50 years in controlled experiments. It is thought that insects cause most of the tripping as they visit flowers seeking nectar and pollen and at the same time cause much cross-pollination which is more

conducive to seed-setting than self-pollination. The ground bee (*Megachile* spp.) trips most of the flowers visited, the bumble bee a majority, while the honey bee trips about 1 percent (*22*). A large number of honey bees must be present before many flowers will be tripped by them. The ground bee lives in hard, dry soil, a fact which may account for the good seed-setting noted in isolated seed fields adjoining dry, barren areas. Increased seed-setting is occasionally reported for portions of fields where hay rakes or other things were dragged during flowering. This suggests that tripping was effected. Experiments designed to repeat these results seldom show such increases. Even though increases are obtained, this type of tripping favors self-pollination, which in turn is undesirable because it reduces vigor of the crop.

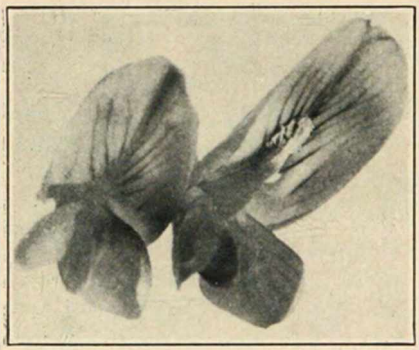

Figure 11.—Tripping is a prerequisite to seed setting in alfalfa. The flower on the left is untripped; the one on the right is tripped.

The seed crop should be cut when two-thirds to three-fourths of the pods are brown or black. Earlier cutting produces many green seeds, while later cutting may result in much shattering. The self-rake reaper designed for alfalfa and clover is very satisfactory but generally is not available. A mower with windrowing attachment is often used. Threshing from stacks will probably net more seed of bright color than other methods. A clover huller does the best job of threshing, but ordinary threshers and combines can be used. Before threshing is started, the machine should be clean because many good lots of seed are contaminated by the threshing machine. Information on growing "Registered Seed" can be obtained by writing to the Seed Registration Service, Colorado State College, Fort Collins, Colo.

Diseases

Bacterial Wilt

Bacterial wilt (*Phytomonas insidiosa* (McC.) Berg. et al.) occurs in nearly all irrigated sections of the State. The bacteria inhabit the soil and infect the plants through wounds caused by mowing, freezing, and so forth. A plant infected one season will likely be dead by the end of the following season. Ac-

cordingly, after about 3 years of cutting for hay most of the plants of susceptible varieties are dead (fig. 13). The disease is recognized by a dwarfing and yellowing of the tops and by some wilting on hot days. The root of an infected plant has a brownish ring which can be seen on cutting across the root (fig. 12). Healthy roots show no discoloration. Certain varieties are partially resistant to this disease, the most resistant being Hardistan and Orestan. Ladak has slight resistance. The following varieties are susceptible: Meeker Baltic, Grimm, Cossack, Hardigan, and common. While control lies chiefly in the use of resistant varieties, alfalfa may be caused to live a year longer by avoiding certain harmful practices. Some of these are: First, alfalfa should not be planted after alfalfa, but other crops should be grown between; second, frequent cutting or late fall cutting reduces the vigor of the stand and may result in rapid increase in the disease; weak plants die sooner than strong plants; third, cultivation or pasturing when the ground is wet may cause wounds through which the bacteria can enter; and, fourth, excessive irrigation may increase the amount of the disease.

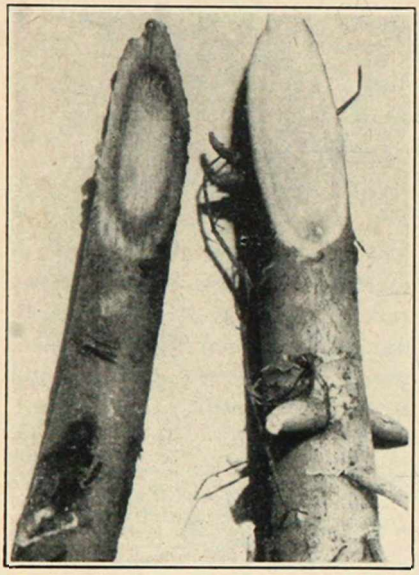

Figure 12.—The discoloration in the root on the left was caused by bacterial wilt. The root on the right is healthy.

Bacterial Stem Blight

Bacterial stem blight (*Phytomonas medicaginis* (Sack.) Berg. et al.), which is sometimes called Sackett's disease, is most severe at higher altitudes in the Rocky Mountain area. It appears as watersoaked, dark green, linear areas on the young foliage and stems (*18*). The spots turn dark brown and then light brown with age. The disease appears early in the spring during cool, wet weather following temperatures low enough to injure the young stems ("break the bark") by freezing, or when the plants are injured by other causes. The bacteria which cause the disease seem to be present in the soil and available to infect the wound tissue. Badly infected fields cease growing. Cutting and removal of the crop as soon as the disease is recognized is recommended to permit the next

crop to start growth immediately. The varieties Ladak, Grimm, and Cossack have been reported more resistant to this disease than others. Resistance is thought to be associated with resistance to frost injury.

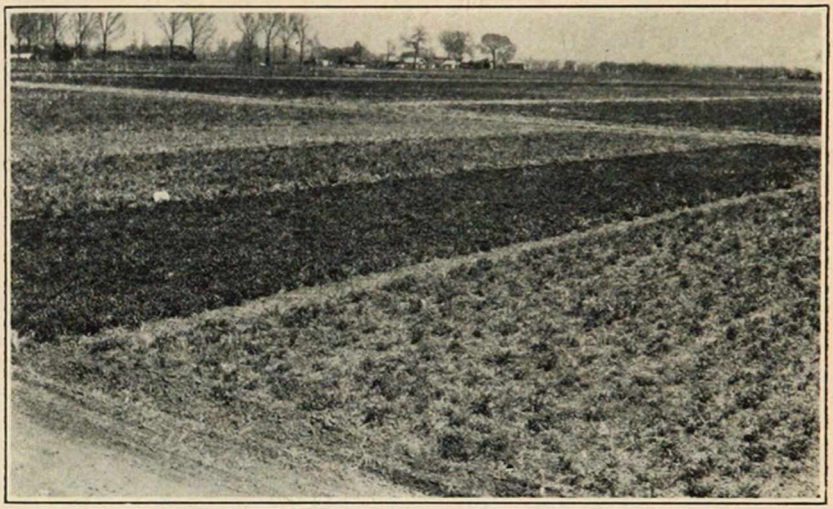

Figure 13.—Alfalfa plots seeded in the spring of 1935 and photographed April 27, 1939, to show the difference in stands of a bacterial-wilt-resistant strain and susceptible varieties. Chilean is in the foreground, the dark strip is a resistant strain of Turkestan (F.C. 22, 175), the plot beyond that (division line marked by white hat) is Colorado Common, and the plot without growth is Argentine.

Leaf Spots

Leaf spots are caused by at least three organisms. The most common, *Pseudopeziza medicaginis* ((Lib.) Sacc.), is recognized by small, brown spots about one-sixteenth inch in diameter on the leaves. The lower or oldest leaves are attacked first, show many spots, turn yellow, dry up, and finally drop off before or during cutting. The quality and quantity of hay are reduced by the loss of leaves. This disease is common in Colorado, occurring every year on every cutting, infection increasing during cool, wet weather and being least and hardly noticeable when the crop develops in dry, sunny weather. The organism overwinters on diseased leaves that fall to the ground and escape decay. This source of infection is present early in the spring and throughout the growing season. When leafspot infection is severe, the crop probably should be cut immediately to conserve the leaves before falling and to permit a new crop to grow. Varieties differ in their susceptibility to the disease, but none is entirely resistant. Many of the Turkestan types (Hardistan and Orestan are Turkestan types) are most susceptible.

Downy Mildew

Downy mildew (*Peronospora trifoliorum* De Bary) is noticeable only during wet, humid weather, which seldom occurs in some areas but which occurs every year in others. The first and last cuttings are most likely to be affected. This disease is recognized by irregular discolorations on the leaflets, usually at the outer edges. At first the areas are light green, but they change to yellowish and reddish hues. The under surface of the leaf becomes covered with a gray to white felt-like mass with pin-point black specks. Losses from this disease usually are minor, but in severe cases 5 to 20 percent of the leaves may be lost and the hay may be dusty. Fields severely infected should be mowed to conserve as many leaves as possible and to allow new growth to start. Some varieties and strains are more susceptible than others. Hardistan is susceptible and cannot be safely grown in humid areas. This variety, although susceptible, is safe to grow in most sections of Colorado.

Insects[3]

Alfalfa Weevil

At one time weevil-infested areas were quarantined to prohibit movement of alfalfa hay and straw from those areas. This quarantine was removed December 1, 1941, so that movement of alfalfa hay into all states except Wisconsin, Michigan, and Kentucky is allowed.

The adult weevil overwinters principally in the alfalfa crowns and stubble. It is a brown-colored snout beetle about three-sixteenths inch long. As the alfalfa starts spring growth, the adults begin laying eggs within the stems of the plants. The eggs hatch early enough to produce numerous larvae which cause maximum damage about 2 weeks before the date to mow the first cutting. The mature larvae are about one-fourth inch long and of a green color with a characteristic white line extending the full length of the back. The newly hatched larvae crawl to the tip of the plant where they feed upon the unfolding leaves. Many larvae may be present before injury is apparent, but later the tips of the plants appear ash gray because of loss of green matter of the leaves and terminal shoots. Severe cases of weevil injury may destroy 50 to 90 percent of the total plant tissue of the first cutting. Mowing of the field will cause them to drop to the ground where they feed upon the new growth of the second cutting. This will often retard the starting of the second crop as much as 7 to 10 days.

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[3]Much of the information in this section was taken from a paper by J. H. Newton (14), presented Feb. 9-11, 1939, at the Forage School and Conference, Colorado State College, Fort Collins, Colo.

Control demands the maintenance of a thrifty, vigorous stand which can withstand much injury. Healthy plants may grow away from a nominal infestation. Rotation of crops will help keep the weevil population at a minimum. Spraying for control has been found practical under some conditions. Calcium arsenate or zinc arsenite used at 1 pound in 50 gallons of water at 100 gallons an acre will save the first cutting and protect the return growth of the second crop. The spray should be applied 10 to 14 days before the first cutting with a spray boom adjusted to cover thoroughly the growing tips of the alfalfa. It has been used successfully without danger to livestock.

Web Worms

Three different species of web worms attack alfalfa. They usually are not noticed until they have caused serious injury; then it is best to cut and stack the hay immediately and destroy the remaining larvae by rolling, brush-dragging, or disking. Much of the trouble originates from neglected weedy areas harboring heavy populations which later move to cultivated crops. Fall or winter plowing of such fields lessens the danger of web-worm infestation. Spraying with calcium arsenate at the rate of 1 pound to 50 gallons of water is successful in early stages of infestation.

Aphids

During April, May, or June aphids often reach endemic proportions. Often heavy infestations are unnoticed because of the small size and green color of the insect, yet their presence certainly reduces the quality and tonnage of hay. Control of the aphid is difficult because it is small and reproduces rapidly. Practices which stimulate early vigorous plant growth probably are most useful in contributing to its control. Factors such as frost which retard or stunt plant growth contribute to noticeable injury.

Figure 14.—The lack of growth in the foreground was caused by cutworms.

Cutworms

Several species of cutworms cause damage to alfalfa. The army cutworms overwintering in alfalfa become active early in the spring, feeding on the young shoots at night or in the afternoon of cool, cloudy days. Numerous larvae completely destroy all growth so that the field or parts of it stay bare when it should be green (fig. 14). Similarly, the variegated cutworms may cause damage to the new growth of the second cutting. The army and variegated cutworms may be poisoned by a mixture of 50 pounds of wheat bran free of shorts, 2 pounds of paris green or crude white arsenic, 1 gallon of cheap molasses, and 4 to 6 gallons of water. The bait should be scattered late enough in the afternoon so that it will still be moist when the worms emerge to feed.

Grasshoppers

The feeding of large numbers of grasshoppers can cause serious damage to alfalfa especially to that renewing growth after cutting. The spreading of poison bait (same formula as for cutworms) is one means of control. On limited areas flocks of turkeys and chickens can be used to aid in control. Shallow tillage or harrowing of fields and areas containing many eggs will cause winter exposure and destruction of many of them.

Blister Beetles

Occasional sudden outbreaks of blister beetles, whose larvae devour large numbers of grasshopper eggs annually, may quickly destroy alfalfa foliage. The beetles are ash gray, black, green, yellowish, or black and yellow striped, with long legs and long bodies. These beetles also cause reduced seed-setting by eating the flowers. Sometimes spraying with paris green or lead arsenate or dusting with sodium fluosilicate and hydrated lime is advisable. Infestations are seldom severe enough for spraying or dusting.

Tarnish Plant Bug

The tarnish plant bug (*Lygus* spp.) commonly occurs in alfalfa fields and causes serious reductions in seed-setting when present in large numbers. As a result of the feeding of this insect, contacted flowers and flower buds fall off and contacted pods contain some or all shriveled seeds. No absolute control measures are known. Dusting with pyrethrum has improved seed-setting, but does not appear practical (3). Lygus damage within localities might be minimized by starting and cutting the seed crop at one time to prevent migration of the insects from cut to uncut fields.

Chalcid Fly

The adult chalcid fly is a tiny black, four-winged wasp less than one-tenth inch long. It deposits a single egg into the develop-

ing seed of one-fourth to one-half grown pods (*28*). In a few days the egg hatches and the larvae eats the interior of the growing seed. After the insect has matured, it emerges through a hole that it gnaws in the shell of the seed. Such seeds are worthless. Some of the insects emerge from the seed the same summer, while others hibernate inside the seed that winter and emerge the next growing season. Control measures consist largely in sanitation. Alfalfa and clover plants in out-of-the-way places which might harbor the insect should be eliminated. Isolated plants along fences, ditches, and other places should be prevented from setting seed early and thereby becoming a source of infection. All screenings should be destroyed immediately.

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