Circular No. 45 - Alfalfa Production Under Irrigation

George Stewart
ALFALFA PRODUCTION
UNDER IRRIGATION

By

GEORGE STEWART

CIRCULAR NO. 45

Utah Agricultural College
EXPERIMENT STATION

Logan, Utah

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UTAH AGRICULTURAL EXPERIMENT STATION

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IN CHARGE OF CO-OPERATIVE INVESTIGATIONS WITH
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L. M. WINSOR, B. S., Irrigation Engineer
Alfalfa was first planted and cared for by half-civilized man long before any history was written. In spite of the fact that its line of descent has come thru the Medes and Persians by way of the Greeks, the Romans, the Moslems, and the Spaniards,—in spite of long sojourns in many lands, the heritage is still undefiled. Instead of losing in adaptability, possibly long centuries of trial have made it more fit. At any rate, here it is: high in power to yield, rich in power to nourish.

With its deep roots it laughs at drought and mellows up the subsoil. Its perennial habit enables it to furnish hay, pasture, or seed for several years in succession. Most important of all, however, is its power to take nitrogen from the air and store this essential plant-food element in its roots. Wisdom in crop rotation and livestock growing, intelligence in utilizing alfalfa on the farm, and care in handling manure and irrigation water are all strong links in the chain of permanently profitable agriculture.

In western America, as in arid regions generally, alfalfa is the basis of good farming. Cattle grazing and wheat growing may flourish as lone industries for a time, but in the end they must give way to a diversified and somewhat intensified agriculture. Cattle require feed in winter; wheat must eventually become part of some sort of cropping system; repeatedly tilled land must in the end be replenished. Wherever the rainfall is light, the soils rich in lime, and the climate temperate, there alfalfa will become the foundation of intelligent agriculture.

HISTORY

Alfalfa is probably native to western Asia from Mesopotamia and Persia to Siberia. In 470 B. C. when the Persians invaded Greece, they carried the crop along and planted it in their camps. Thus, the Greeks acquired a new crop of value which they in turn passed on to the Romans. Both of these ancient peoples learned how to handle the crop and where to sow it. Somewhat later when the Moslems swept across North Africa and invaded Spain from Morocco, they carried alfalfa with them. It is from their word alfalfa, which means "best forage", that we have derived "alfalfa".
From Spain, alfalfa spread to France where "lucerne" became the common name. In time all of western Europe received the crop; in England it was so well-known in the eighteenth century that good treatises were prepared on its culture and production. It came to America in time to be somewhat widely grown in the colonies, especially just after the Revolution. Washington and Jefferson grew lucerne on their plantations in Virginia; Livingstone grew it in New York. Altho frequently introduced from Europe, alfalfa did not thrive along the Atlantic Coast, owing in part to the prevalence of wet lands, poor in lime and in part to the expense, inconvenience, and uncertainty of bringing seed from England. Cultural practice as a whole was also sadly neglected in the colonies.

Tho grown for a century along the Atlantic Coast, and in Mexico where it had come from Spain, alfalfa growing did not really begin until introduced into California about 1853 or 1854. Among the gold seekers rushing to the western coast, one shipload rounded Cape Horn and stopped in Chile for a rest. Alfalfa seed was taken aboard and later planted in California. Upon arrival many of the settlers found it easier to earn a livelihood by farming than by prospecting. Since alfalfa grew luxuriantly and produced well, it early became a common crop in the Sacramento Valley. Some of the Mormon emigrants to Utah brought seed with them from California.

Under irrigation there was an immediate response in high acre-yields. Intensive farming brought about favorable cultural methods; the arid soils were rich in lime, phosphorus, sulfur, and potassium. Shortly it was discovered that seed could be easily grown. In a few years after its introduction into Utah, the State shipped seed all over the West—to Montana, Idaho, Colorado, and later on to states east of the mountains. Soon alfalfa reached Kansas and Nebraska, where the great stretches of tillable soil suitable to alfalfa caused it to spread with almost incredible rapidity. Wherever land was irrigated, alfalfa outyielded any other forage plant. Then it was observed that the first crop following alfalfa, or even the second and third, outyielded the same crop in any other place in the rotation. Naturally lucern, for so it was called in the early history of Utah, spread thruout the region; every farming area—practically every farm—grew it for hay and pasturage.

As the crop spread northward into eastern Montana and the Dakotas where winter temperatures were low and snowfall was light, trouble from winter-killing came to be so common that further expansion in this direction was checked. However, a hardy variety, Grimm by name, had been developed and was
spreading outward from Minnesota. In 1857, Wendelin Grimm, for whom it was named, came to Carver county, Minnesota, from Germany. He brought with him 15 or 20 pounds of alfalfa seed which he planted the next spring. Most of his plants winter-killed, but a few survived. From these he gathered seed and multiplied it. In a few years he had fine fields of alfalfa; in 1867 he sold 480 pounds of seed in Minneapolis for 50 cents a pound. It proved to be hardy enough to withstand the severest winters. It is now the favorite strain in the northern Great Plains and in the northern tier of states from Dakota to New York.

REGIONS OF PRODUCTION

Alfalfa is widely grown, being an important crop in almost every arid region of the world. It grows both native and cultivated in the interior region of eastern Europe and central Asia from Arabia and Persia all across the Caucasus Mountains and Turkestan well into Russia and Siberia and eastward across Manchuria—almost if not quite to the Pacific. All the Mediterranean countries of both Europe and Africa grow the crop, Italy, Spain, and southern France being heavy producers. South Africa, Australia, Argentina, Chile, and Peru grow large acreages. In North America, Mexico and western United States use this crop almost exclusively for hay production.
Production in the states of the central Great Plains and of the Rocky Mountain region is limited only by the area of tillable land or by the water supply. In order of total yield in tons the states producing 500,000 tons or more rank as shown in Table I. The acreage and acre-yield are also shown for each state and for the United States. Kansas leads in acreage but is surpassed in total yield by California and Nebraska.

Table I. States of the United States in Order of Production for 1920. (Total Acreages and Acre-yields are also Shown)

<table>
<thead>
<tr>
<th>State</th>
<th>Acres</th>
<th>Acre-yield (tons)</th>
<th>Production (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>873,000</td>
<td>4.00</td>
<td>3,492,000</td>
</tr>
<tr>
<td>Nebraska</td>
<td>1,123,000</td>
<td>3.00</td>
<td>3,369,000</td>
</tr>
<tr>
<td>Kansas</td>
<td>1,140,000</td>
<td>2.00</td>
<td>2,280,000</td>
</tr>
<tr>
<td>Colorado</td>
<td>781,700</td>
<td>2.28</td>
<td>1,779,000</td>
</tr>
<tr>
<td>Idaho</td>
<td>656,200</td>
<td>2.67</td>
<td>1,741,200</td>
</tr>
<tr>
<td>South Dakota</td>
<td>503,000</td>
<td>2.33</td>
<td>1,172,000</td>
</tr>
<tr>
<td>Wyoming</td>
<td>412,800</td>
<td>2.50</td>
<td>1,032,000</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>387,000</td>
<td>2.30</td>
<td>890,000</td>
</tr>
<tr>
<td>Utah</td>
<td>365,200</td>
<td>2.05</td>
<td>748,900</td>
</tr>
<tr>
<td>Nevada</td>
<td>230,900</td>
<td>2.85</td>
<td>658,000</td>
</tr>
<tr>
<td>Washington</td>
<td>228,800</td>
<td>2.87</td>
<td>655,900</td>
</tr>
<tr>
<td>New York</td>
<td>254,400</td>
<td>2.50</td>
<td>636,000</td>
</tr>
<tr>
<td>Oregon</td>
<td>210,600</td>
<td>2.81</td>
<td>592,500</td>
</tr>
<tr>
<td>Montana</td>
<td>374,200</td>
<td>1.57</td>
<td>586,700</td>
</tr>
<tr>
<td>Michigan</td>
<td>223,900</td>
<td>2.30</td>
<td>515,000</td>
</tr>
<tr>
<td>United States</td>
<td>9,383,400</td>
<td>2.74</td>
<td>25,712,000</td>
</tr>
</tbody>
</table>

The following states produced in 1920 between 300,000 and 500,000 tons: Illinois, 497,000; Iowa, 438,000; New Mexico, 430,000; Minnesota, 366,000; Missouri, 365,000; Wisconsin, 346,000. It is worthy of note that all the states except two—New York and Michigan—that produce more than a half a million tons are west of the Mississippi. Every state west of the Mississippi except four—Texas, Arkansas, Louisiana and North Dakota—produce more than 300,000 tons.

THE ALFALFA PLANT

Alfalfa growers should understand the alfalfa plant. Just as a horseman can get more satisfactory response from his horse if he takes good care of him, so the farmer may get a better response from his crop if he husband's it properly. To nurture either plant or animal in the proper fashion, one must understand its structure and growth habits.
Fig. 2.—Map of Utah showing the relative production of alfalfa by counties.

Roots.—The alfalfa plant is a deep feeder. Even in the first year of growth the roots penetrate deeply into the soil, far outstripping stem and leaf development. By the time the plant is 2 months old its roots may be 3 feet long. The mature plant usually roots from 6 to 10 feet in depth, and in favorable soils extends 15 or 20 feet below the surface.

This immense root-system is not much branched except for small hair-like roots which are numerous near the surface and also near the greatest depths of penetration where most of the
water is usually absorbed. An inspection of those fine roots that develop in the surface soil shows them to bear many small enlargements that vary in size from that of a half kernel of wheat to that of a pinhead. These enlargements, known as nodules, are inhabited by colonies of a peculiar kind of bacteria that have the power of taking nitrogen from the air and uniting it with soil-contained elements. Because of this quality of harboring nitrogen-fixing organisms, alfalfa is able to enrich the soil. It also absorbs and manufactures into its tissues a large part of the nitrogen obtained by the bacteria. This is one reason why alfalfa is such a valuable feed.

Crowns.—At or near the surface of the ground the alfalfa root bears a crown, which is really a thickened stem closely united with the root. Since new stems arise from buds on the crown, it is by virtue of the crown that the plant lives over from one season to the other. The buds usually begin at a point just beneath the surface of the ground.

Stems and Leaves.—New shoots grow from the crown buds each spring or after each cutting if there be enough soil moisture to promote growth. The shoot is a single stem at first but soon sends out branches from the axils of its leaves. Where there is room these branch stems may again rebranch, until the plant has a rather bushy appearance. In height, mature stems vary from a few inches to six feet, the normal growth being from 20 to 40 inches.

The leaf consists of three somewhat oval leaflets, varying in length from one-fourth to three-fourths of an inch, with the width about two-thirds as great as the length. These compound leaves usually grow in clusters but may be scattered singly along the stem, in either case being first on one side and then on the other.

Flowers and Seed.—The flowers—small, purple, and pea-like—are borne in rather open clusters at the end of the main stem and of the branches. At the time
when the pollen is ready to be scattered, the weight of a bumblebee, saw-fly, or similarly heavy insect will "trip" the blossom. The stamens dart outward and strike the body of the bee releasing a shower of thousands of pollen grains. The next flower visited repeats the process and may itself be fertilized by pollen clinging to the body of the bee. Sunshine will also trip part of the flowers and cause self-fertilization.

From one to several seeds develop in a spiral pod that forms a coil. If a seed does not touch another, it becomes distinctly kidney-shaped. When the yield is heavy, however, the seeds are close in the pod and press one against the other. In this fashion angular seed is developed, with the position of the flattened surface depending on where the seed lay in the coil.

**VARIETIES**

Until the last few years alfalfa has been merely alfalfa. There was no such thing as varieties. This condition, however, has been upset by the introduction into certain parts of the United States of distinctly different sorts of alfalfa. All told, there are five important groups: (1) common, or ordinary, alfalfa; (2) Turkestan; (3) yellow-flowered, or sickle, alfalfa; (4) Grimm alfalfa; and (5) non-hardy alfalfa, represented by the two varieties, Peruvian and Arabian.

**Common** alfalfa is probably so-called for the want of a better name. It is the sort brought from California and grown in Utah since shortly after its settlement. Until about 1900 it was popularly called "lucern". When the crop began to receive attention in the agricultural press and in the schools, the Spanish name "alfalfa" was used and has now nearly replaced "lucern".

Common alfalfa does well on the Pacific Coast, in the central Rocky Mountain region, and in Kansas, Nebraska, Oklahoma, and adjacent parts of the country. Almost 95 per cent of all the alfalfa grown in the United States is of the ordinary kind. In the northern Great Plains, however, Grimm is spreading rapidly. The northern tier of states east of the Mississippi is also encountering less serious winter-killing when Grimm is used.

**Turkestan,** an alfalfa that closely resembles common, gets its name from the fact that it came from Turkestan. The first seed imported was brought from dry regions and did well in the dryer parts of America. As later importations were not properly selected they lacked desirable qualities. The United States Department of Agriculture now advises farmers not to plant Turkestan seed.

**Yellow-flowered** alfalfa, a native of central Asia and west
central Europe, bears flowers that are all bright yellow in color. It can spread underground by means of rhizomes on its roots, and is very hardy. Owing to its low yield and spreading habit of growth it has not "made good" in the United States as a hay crop. It seems to have promise as breeding stock in producing hardy strains to withstand extreme cold. An attempt is also being made to breed a pasture type that is not injured by trampling.

**Grimm** alfalfa does not winter-kill in regions of extreme cold, at least not to the same extent as does common alfalfa. It resembles the ordinary strain in general appearance but does not start growth so early in spring and does not yield as well in regions of only moderate winter cold. Its crown grows beneath, rather than on, the surface of the ground. It has a somewhat branched root-system, which may account for part of its powers of cold resistance. The most of the blossoms are like those of ordinary alfalfa, they vary in color from pale green thru the yellows and blues to a purple so dark as to be almost black.

These divergent characters have developed as a result of its hybrid origin, yellow-flowered alfalfa having been one of the parents. The yellow-flowered ancestry seems to be the source of its cold-resistant qualities as well of its variegated flowers, open seed coils, and somewhat branching root system.

**Non-hardy** alfalfa, as might be suspected from the name, is adapted only to regions of extremely mild winters, such as the Pacific Coast, southern Arizona and New Mexico, and the Cotton States. Peruvian alfalfa came from Peru in 1899 and has since begun to spread on the Pacific Coast, especially in southern California. It starts growth much earlier in spring than does common alfalfa and continues until stopped by cold weather. After cutting, new shoots spring up at once and grow rapidly. It is from this strain that ten or eleven crops have been grown in southern California. Arabian resembles Peruvian but is too short-lived. Neither can withstand colder weather than 15 degrees above Fahrenheit zero.

**ADAPTATION**

Alfalfa is rather sensitive to some factors in its adaptation but not to others. The factors that deserve consideration fall into two groups: (1) those relating to climatic conditions and (2) those relating to soil conditions.

Climate may be subdivided into (a) rainfall, (b) temperature, and (c) humidity. Soil adaptability requires that consideration to be given to (a) drainage, (b) lime, (c) mineral nutrients.
(d) soil moisture, (e) organic matter, (f) bacteria, and (g) alkali.

CLIMATE

Alfalfa is primarily adapted to arid or semi-arid regions because of both climatic and soil conditions. In the United States, the areas of heaviest production are in regions where rainfall is rather light. Some sections of heavy rainfall, such as the neighborhood of Syracuse in New York and southwestern Ohio grow good alfalfa. These areas are relatively small and have almost ideal soils or else soils that can be made highly favorable. Southwest Asia, the Mediterranean countries of Europe and Africa, South Africa, Australia, India, Argentina, and Mexico all have scant rainfall. England, Germany, northern France and eastern America have wetter climates, and therefore grow alfalfa only on favorable soils. Moreover, curing is always accomplished with difficulty in regions of heavy rainfall.

Alfalfa thrives in the hottest spots in the United States,—southern Arizona and interior California. The air, however, is excessively dry, the moisture for growth being supplied by means of irrigation water. In the Gulf States where both the summer heat and the humidity are intense, the plants languish except on the most favorable soils.

Fig. 4.—Alfalfa requires well-drained soils to permit the full development of its deep roots.

Extreme winter cold can also be successfully withstood provided the land is well-drained and is snow-covered in the coldest weather. In parts of Utah, Idaho, and Montana for example, temperatures frequently drop to 20 degrees and occasionally to 30 degrees below Fahrenheit zero. Occasional winter-killing is experienced but these cases are usually due to the formation of ice or to wet land. On the other hand, where the soil is comparatively dry, or else very wet, and is bare of snow, low
temperatures cause frequent loss by winter-killing, unless hardy strains are grown.

SOIL CONDITIONS

Scant rainfall tends to create in soils a set of conditions favorable to alfalfa. Such soils, in the main, are well-drained, rich in lime and other minerals nutrients, and high in their power to hold water once they receive it. Save for spots so heavily laden with alkali as to require drainage, organic matter is usually the principal need.

Drainage.—Good drainage, either natural or artificial, is an absolute requirement for successful alfalfa production. Water-logged soils are fatal. Since air cannot get more than a few inches below the surface of the water-table, ground water should be at least 4 feet, preferably 8 to 12 feet, below the top of the ground. In land that is naturally wet or that is becoming so on account of seepage or over-irrigation, the alfalfa loses its dark green color and takes on a sickly yellow appearance. Yields are poor on such land and weeds difficult to control. Barley-grass (*Hordeum jubatum*), commonly called foxtail or squirrel tail, persists in spite of cultivation. Blue-grass or other grasses soon overrun the field, causing the alfalfa to be short-lived.

Conversely, porous soils are highly favorable to the crop. Possibly well-drained loams of high porosity are the most favorable of all soils, but coarse sands and gravels are not highly unfavorable. With enough surface soil to start the seedings, a soil can scarcely be too porous, provided it not indefinitely so; for alfalfa to succeed. It will also succeed on clay loams or even heavy silts and clays that are not water-logged.

Lime, another necessity for alfalfa, is usually abundant in arid soils. Where the soil is low in its lime content, a supply must be provided before alfalfa will thrive. Ground limestone is a favorite form, but quick-lime and air-slacked lime are also used. After being ground to a flour-like powder, the lime is usually distributed over the land by means of drills at the rate of a few hundred pounds to two or three tons an acre, depending on the relative deficiency of lime.

Minerals, such as phosphorus, potassium and sulfur are used in larger proportions by clovers and alfalfa than by grasses. Nitrogen may be rather scarce, for alfalfa takes large quantities from the air when the soil supply is low. Arid soils are generally well provided with phosphorus, potassium, and sulfur because of little leaching having there taken place as compared with the soils of wet regions. Where minerals nutrients are not present, they must be supplied either in farm manure or in
commercial fertilizers. Utah soils as a whole are not yet aproaching the stage where either phosphorus or sulfur is likely to become a limiting factor. Potassium scarcity is probably far in the future.

Soil Moisture must be available for all plant growth. Except for starting the crop, alfalfa does not require much soil moisture near the surface. Altho not a necessity, abundant soil moisture is desirable, since it promotes rapid and continuous growth. High acre-yields come only on land that has a uniform supply thruout the summer months.

Organic matter is highly important in the seedbed in order to give the seedlings a good start. It is valuable mainly because it assists in holding soil moisture. It permits a better soil aeration, favorable both to alfalfa roots and to bacteria, part of which also derive their food from the soil organic matter.

Bacteria occur everywhere, but some soils lack the kind that lives in the root-nodules. These soils require inoculation. Fortunately, Utah has had no trouble on this score, an application of manure from animals fed on alfalfa hay usually precedes sowing and thereby provides inoculation. Even where no manure has been applied, the soil seems already inoculated or becomes so by natural means, except on alkali land or on newly broken virgin land low in organic matter. After a few years in grain or cultivated crops with an occasional manuring, alfalfa does well even on these stubborn soils, provided drainage conditions are right.

Alkali in small quantities is not particularly detrimental to alfalfa. Since larger quantities may prevent proper germination of seed and rapid growth of the young plants, alkali lands usually cause difficulty while new stands are being started. On some tracts heavy flooding and a thorо working of a well-manured seedbed keeps the alkali away from the surface during the first season, after which the roots become corky and more or less insolated against alkali injury. Stands once secured on alkali lands are usually left as long as possible to avoid the difficulty of getting new stands. The real remedy for alkali, however, is under drainage.

GROWING THE CROP

Growing alfalfa involves a series of somewhat distinct operations. As with any other crop, the problems of production vary with the locality and method of farming. Many of the principles, however, are of general application. These fall naturally under seven headings: namely, (1) place in the cropping system, (2) preparing the seedbed, (3) choice of seed,
(4) planting, (5) care during the first season, (6) irrigation, and (7) pest control.

PLACE IN THE CROPPING SYSTEM

Alfalfa, being the basic crop for the arid region, should be a part of every cropping system. The only probable exception to this, may be in one or two trucking sections of the state where the high-priced land requires more frequent planting to hoed crops than an ordinary rotation with alfalfa would permit. Even in truck farming, some kind of legume ought to be grown. Possibly annuals—such as peas, beans, or vetches—may be found better adapted; it may be that even here alfalfa will prove the best crop, on account of the great quantity of organic matter it leaves in the soil in addition to restored nitrogen. Peas and beans restore the nitrogen but do not leave any appreciable quantity of organic matter in the soil. Truck farmers may find it wisdom to plant alfalfa to be plowed under as green manure after occupying the land but one year; they may find it more profitable to fertilize heavily and grow some annual legume as a cash crop instead of alfalfa.

In all other types of farming of any importance in Utah, alfalfa should be grown as a principal crop, that is, it should occupy from three to six years in a cropping system of five to ten years' duration. Farmers of Utah are just coming to realize the great importance of systematic crop rotation. There are many reasons for crop rotation, one of the chief of which is pest control. Unless good cropping systems are followed almost from the beginning, it is only a matter of time until some weed, insect, or disease seriously interferes with profitable production.

Need of Rotation.—For approximately 50 years after Utah was settled, there were no general attacks of potato diseases. Careless farming invited pests; now it has practically a full quota. Sugar-beets ran the same course with similar results. Both insect and disease pests are now numerous enough seriously to hamper the growing of beets. Rhizoctonia and Fusarium wilt of potatoes; Phoma, Rhizoctina, and nematode on beets; write grubs, wire worms, army worms, and cutworms on both crops,—all these and many other pests either were brought into the region, or else are now encouraged, by careless farming of one kind or another. Pests have been encouraged most frequently by offending the principles of good agriculture in three major ways:

1. Over-irrigation
2. Neglect of fall plowing
3. Failure to practice good crop rotations.
Irrigation and fall plowing are ordinary farm operations, practiced every season. Crop rotation, however, requires a long-sighted view of affairs and a working plan that includes several cropping seasons.

Pests are nearly always avoided or controlled most economically by some indirect method, such as fall plowing or crop rotation. In fact, it frequently happens that other control methods, such as spraying with poisons for insects or dipping seed in poisons for disease trouble, are only partly successful when not combined with good crop rotation. In addition, there are some troubles such as nematode on sugar-beets that can be controlled in no way except by rotation.

**Principles of Rotation.**—The most thorø students of cropping systems have concluded that the following things should be done in a combined system of crop rotation and diversified farming:

1. To raise approximately the same acreage of each crop every year
2. To grow at least one cash crop
3. To have a hay crop
4. To have a crop that lasts several years and is sod-forming
5. To include a legume crop
6. To alternate tilled and non-tilled crops
7. To alternate deep-rooted and shallow-rooted crops
8. To arrange crops in such a way as to distribute the seasonal requirements of labor, equipment, irrigation water, and personal supervision
9. To follow such a sequence of crops as will help to maintain good soil sanitation and at the same time be convenient
10. To keep livestock
11. To apply manure to the most profitable crop
12. To be prepared to make use of all by-products in order to avoid waste.

Probably no rotation will fulfill all these requirements, but the nearer one approaches it the better.

**Alfalfa the Basic Crop.**—At a glance, it is apparent that alfalfa occupies an extremely important place in filling the needs of a good rotation. It answers (1) for hay, (2) for the legume, (3) for the non-tilled crop, (4) for the deep-rooted crop, (5) for feed for livestock, and (6) for fall pasturage. In addition to filling directly six of the twelve requirements for a rotation, it may also serve as a cash crop; in fact, about the only require-
ments it cannot fill are those of (1) a tilled crop and (2) a shallow-rooted crop. Such an analysis merely accentuates the pre-eminent importance of alfalfa as a basic crop for agriculture in the West.

Until just recently the tendency has been to leave a field of alfalfa as long as it produces anything like a fair crop. This is not good practice (1) because the yield of alfalfa generally decreases after about the fifth year, (2) because weeds or grass get into the land, and (3) because other crops and other parts of the farm do not then derive the benefit from alfalfa.

Alfalfa Improves the Soil.—The improvement derived by other crops from following alfalfa is materially great. The highest yields nearly always come just after alfalfa. The soil is enriched by plowing under the alfalfa roots and stubble which not only add to the soil organic matter but also nitrogen obtained from the air. The deep roots, also penetrate the subsoil and make it pervious to water and air; the lack of surface tillage for 3 to 5 years allows plant residues to create a layer of leaf-mold similar to that which occurs on unbroken virgin land. As a result of these direct benefits, there is encouraged a uniformity of soil moisture, soil temperature, and bacteriological activity.

Finally, it should be kept in mind, that the soil and crops other than alfalfa are more benefited by breaking a field of alfalfa that is in its prime than by breaking a field that has been planted for 20 years. The less aged alfalfa accomplishes a greater improvement on account of its producing more organic matter. Old stands get thin and coarse. Alfalfa can be grown on all parts of the farm just four times as often when allowed to remain only five instead of twenty years. It seems that three or four years is long enough time for the crop to be left on sandy soils.

Suggested Cropping Systems.—Where sugar-beets, potatoes,
corn either for silage or grain, alfalfa, and wheat or oats are good crops to grow, the following cropping system is suggested: alfalfa, 3 to 6 years; potatoes or corn or both, 1 year; sugar-beets, 1 to 3 years with manure; wheat or oats, 1 year, and then back to alfalfa. The acreages can be adjusted to meet the needs of any area. The system should pass regularly from one crop to another and not move about helter-skelter.

Where potatoes are important, but not sugar-beets, the system could be alfalfa, 3 to 6 years; potatoes, 1 year; corn, 1 year; wheat or oats, 1 year; and back to alfalfa. Where only small-grains and hay are commonly grown the greatest need will be to get at least 1 year of cultivated crop. The system might then be: alfalfa, 4 or 5 years but not to exceed 6 or 7 years; oats, 1 year; cultivated crops, 1 year; wheat or oats, 1 year; and back to alfalfa. Corn or sunflowers for silage, some potatoes, and some mangels for feed may make up the one year of cultivated crop. This year of intertillage is highly important in order to control weeds.

Where alfalfa and wheat are alternated on the dry-farm, the alfalfa may be left 8 or 10 years and the wheat grown in alternate years on the other part of the farm. The alfalfa may then be sown where the wheat has been and the wheat grown on ground previously planted to alfalfa. On account of difficulty in getting stands or in getting much hay from young alfalfa in extremely dry seasons, it is usually wise to break only from one-tenth to one-fifth of the alfalfa each year, at the same time sowing about the same area to new alfalfa.

PREPARATION OF THE SEEDBED

Proper preparation of the seedbed for alfalfa is highly important. Not only must the seedbed be such as will favor good germination and rapid growth of the seedling plants, but it must be such as will permit easy irrigation and mowing. Great stress should be laid on the seedbed because the crop remains in the same land for a number of years. Any troublesome defects cause annoyance over and over again so many times that they become serious even tho the hindrance is slight for any single operation.

Four points need to be kept in mind. The order in which attention is necessary is: (1) preparation of the land for irrigation, (2) manuring, (3) plowing, and (4) top-working the seedbed with harrows and drags.

Preparation for Irrigation.—When the field of alfalfa is to be irrigated, the first, among various considerations, is to have the slope of the land uniform. Any high places should be
worked down lest dry spots be left after each application of water. Low places that would permit the ponding of water should by all means be filled, for a great excess of water permits the rapid coming in of grass where it does not kill the alfalfa outright by shutting off air from the soil. Old ditches, washes, and "double" and "dead" furrows need particular attention.

**Manuring.—** It is usually profitable to apply some farm manure to land on which alfalfa is to be seeded. Sometimes this is best accomplished by manuring the preceding crop rather heavily. In other cases the manure is applied directly to the land while the seedbed for alfalfa is being prepared. On new land, particularly if it is somewhat heavy, and more particularly if it carries a little alkali, this practice is probably safer. Long-tilled soils of a compact nature may also find direct manuring the better method. When the manure is to be applied to the alfalfa seedbed, it is best done at the earliest opportunity after the preceding crop is removed. Heavy lands should be fertilized with manure in which the straw is well decomposed.

The best time for manuring is in the fall early enough to permit plowing under before winter sets in. The second choice is to have the land plowed in the fall with the manure applied any time during the winter. In spring the manure may be thoroughly worked into the soil with a disk or spring-tooth harrow. A third choice in method is an early spring application with plowing done at the earliest possible time and followed at once with the spiketooth harrow, going over the land several times if that is required to pack the soil around the manure. The poorest method is delayed spring manuring and plowing, especially if followed by a dry spring which permits a rapid drying of the seedbed and thereby causes germination to be poor.

It is to be emphasized that spring application of the manure is risky, since this may delay planting too late in the season for safety. This risk is increased when the straw in the manure has not begun to decompose.

**Plowing.—** As already indicated, fall plowing is best for alfalfa. This permits clods or pieces of sod to be mellowed by frost action. There is nothing so effective in putting a seedbed in the proper tillth as alternate freezing and thawing and alternate wetting and drying, particularly when organic matter has been previously added. Time is also allowed for the manure to decompose into fine particles. Incidentally, mineral plant-foods are made more soluble by exposure to frost and winter moisture. Since unharrowed land is more thoroly exposed during the winter the soil should be left just as the plow turns it up.

Spring plowing for the spring planting of alfalfa must be
done early to get good results. Soils that puddle easily cannot be plowed until dry enough, but no time should be lost after the soil is sufficiently dry for good plowing. Whereas clods may be turned up in the fall with no cause for worry, spring plowing must leave the land mellow and with a fine crumb structure or seedbeds satisfactory for alfalfa cannot be prepared without great expense.

**Top-working the Seedbed.**—Fall-plowed land may be smoothed down as soon as the surface is dry enough to bear up the horses. Loose seedbeds are to be guarded against, for the soil should be well-packed around the manure or stubble. Natural settling will accomplish this when the land is plowed in autumn, but help in settling is often necessary after spring plowing. The disk harrow set straight, the culti-packer, and a weighted spike-tooth harrow are effective in the order named.

It is usually wise to allow a few days after plowing for the seedbed to pack and for weeds to germinate before planting is done. Just before seeding a thorough treatment with the spike-tooth harrow will fine the surface, break any crust, and drag out weed seedlings that have just begun to grow. The surface, however, should not be worked into a fine dust.

**Sandy soils** deserve special treatment in some cases. In very loose sands fall plowing is not particularly advantageous from the standpoint of the soil except to let the manure decompose. Cutworms, army worms, wire worms, grubs, and grasshoppers are, however, exposed to frost by fall plowing on any type of soil. It is therefore apparent that fall plowing is good for alfalfa seedbeds even on loose sands.

**CHOICE OF SEED**

The choice of seed is of vital importance in getting a good stand of alfalfa. No seed can give a perfect stand on a coarse or loose seedbed; on the other hand, poor seed can not produce a good stand on the best of seedbeds. Because of this, attention should be given to the quality of the seed.

Quality of alfalfa seed, may be determined approximately by observing the color, the plumpness, and the number and kind of weed seeds it contains.

Seed of a bright yellow color with an occasional tint of light green is best, for this indicates maturity. Stains of any sort indicate weakened vitality, particularly if many seeds are decidedly dark brown or even reddish brown. Well-matured seed may become badly discolored if thoroly wet during harvest. A distinctly green color indicates lack of maturity or frost injury.
Seed will be of a bright yellowish color only when properly matured and properly harvested in favorable weather.

Immature seed may be badly shrunken, but usually it will also be dark-colored or distinctly green. Immature seed, or mature seed that has been discolored by wet weather, is usually low in power to germinate. Moreover, the seeds that do germinate are likely to produce sprouts too weak to start proper growth. Bright seed that is too old will take on a dull color and gradually change from yellow to brown. Vitality ordinarily decreases about in proportion as the brightness fades and the color darkens.

Some lots of otherwise good seed bear too many weed seed to permit their being planted with safety. The weeds, being for the most part annuals, root quickly and grow so rapidly that the slow-growing alfalfa seedlings have little chance to keep up with them. Many samples contain as many as 1,000 weed seed to the ounce of alfalfa seed, or 16,000 to the pound. If 10 pounds of seed be sown to the acre, then 160,000 weed seed are sown, or about 4 to each square foot. This number of weeds would soon crowd out the young alfalfa plants. Some seed contains even more weed seed than this.

Fig. 6.—Which kind do you plant?

**Dodder** is troublesome in damp spots or in damp regions. On this account it is counted more noxious than other weeds. In Utah, it is doubtful, however, whether it is worse in fields that are grown only for hay than some of the more common weeds. In fields to be used for seed production, it must be kept out at all costs because a few dodder seeds reduce the price of alfalfa seed one to several cents a pound.
PLANTING

Alfalfa seeding is best done by means of the grass-seed attachment on the ordinary grain drill. This insures greater uniformity in both distribution and depth than can be secured by broad-casting. Depth and amount of seed may also be adjusted to suit each case. About 1 inch is ordinarily the proper depth on a well-prepared seedbed. The seed should be usually planted in the moist soil just beneath a thin, mellow surface mulch.

The rate of planting varies with the kind of soil, the fineness of seedbed, and the quality of seed. Extremely porous and unusually heavy soils both necessitate more seed than do medium loams; coarse seedbeds, more than well-mellowed ones; and immature or badly discolored seed, more than bright, plump seed. Fine, moist seedbeds on loamy soils well-firmed beneath but mellow on top will require about 10 pounds of seed to the acre, with the rate increasing to 20 pounds for less favorable soils and poorer seedbeds.

On the dry-farm early spring planting is necessary because of midsummer moisture's being extremely scarce. Where irrigation water comes mostly as high water early in the season, July or August seeding is also impracticable owing to lack of water to irrigate the seedbed.

Nurse Crop.—Sowing alfalfa in spring with a crop of small-grain is the most usual seeding plan. In most cases, especially on newly broken land, this seems to give the best results because the grain starts at once and shades the ground. The alfalfa seedlings might not be able by themselves to force their way thru a soil crust; the stronger seedlings of wheat, oats, or barley easily break thru and leave the soil in such a condition that the alfalfa can readily emerge. On this account, it may be wise always to use a nurse crop on heavy soils that crust readily. In districts where blowing causes trouble, the nurse crop protects the alfalfa seedlings from injury by the moving soil particles.

Altho planting with a nurse-crop has been the general practice, it frequently happens that where the grain is not planted thinner than is usual for a high yield of grain, the alfalfa is smothered by the heavy stand. Dense shade for any long period of time is fatal to the young plants. Sometimes there is a good stand of alfalfa when the grain reaches the booting stage, but by harvest time it has been appreciably thinned or killed entirely in spots. Should the grain lodge, and not be mowed at once, it is highly probable that the alfalfa will be completely
smothered. Therefore on highly fertile soils, spring planting with a nurse-crop tends either to cause a reduction of the grain yield on account of thinner planting or to produce uneven stands of alfalfa due to smothering by dense shade of heavy grain.

This condition has encouraged some farmers to experiment with midsummer planting. The most fertile soils are naturally the ones that produce the heaviest grain and the most lodging, and consequently, the most failures to get alfalfa stands under the nurse-crop system. On such lands, then, it may be wise to plant for a maximum grain crop, haul off the crop at once after harvest, and sow to alfalfa as soon as a seedbed can be made.

Another method is to plant the nurse crop thick and cut it for hay. Still another way is to plant for grain but to use varieties that have small leaf growth or that mature early. Oats are more leafy than wheat or barley; Little Club, New Zealand, and Dicklow wheats produce denser shade than do Marquis or Sonora, both of which, however, are counted of only mediocre value under irrigation in Utah. Since the grain does not get too dense for the alfalfa on any except the richest soils, nurse-crop planting is probably satisfactory on both extremely porous and compact soils. On soils slightly impregnated with alkali, shading by the nurse crop is beneficial in that it reduces evaporation and consequently retards salt accumulation at the surface.

On the dry-farm, spring planting without a nurse-crop is the accepted method. Sometimes five to eight pounds of wheat to the acre may be sowed at the same time as the alfalfa. In this case no attempt is made to harvest it for grain. Moisture is usually too scarce to supply both alfalfa and a large enough wheat crop to pay to harvest for grain.

Occasionally, alfalfa is sown alone on irrigated land in the spring. In this case no crop is harvested from such land during the season. This loss usually compels either the use of a nurse-crop or the planting of alfalfa after the grain is removed. The three methods give about equal crops the second season and thereafter, provided the stands secured are equally good.

CARE DURING THE FIRST SEASON

When sown with a nurse crop, alfalfa should receive enough attention during the first season to make sure that it is not killed by too much shading. Since thick stands, or the lodging of relatively thin stands, of the grain used as a nurse crop may prove fatal to the alfalfa, the grain should be cut at once on any spots where lodging occurs. The mowed grain may be cured
for hay and the alfalfa saved. Lodged wheat, oats, or barley is not likely to produce much grain; consequently, the hay made from the early-cut stems and leaves is likely to be worth more than the grain obtained at maturity. Sometimes it is advisable to cut the whole field for hay to prevent the young alfalfa’s being smothered. The wisdom of doing this will depend on the relative value of grain and hay, and on the importance of getting a stand of alfalfa as compared with replanting after the grain is harvested or the following spring.

When the nurse-crop ripens for grain, it may be advisable to cut high so as to leave a tall stubble. This affords some protection to the alfalfa seedlings that have become rather tender due to being grown in the shade. Being exposed suddenly to the hot sun may be too severe a shock to some of the young plants. Cutting the nurse crop high also avoids clipping the young alfalfa close to the ground, which operation might remove so much of the green stem and leaves as to prevent rapid development of either top or root.

In case there are spots where the stand is poor, it will ordinarily be profitable to sow more seed on such areas. This avoids a poor stand of hay, and incidently discourages weeds, which are more troublesome in places not occupied by crop plants. Should weeds be rather numerous either in such spots or in other parts of the field, clipping them off with the mower before they begin to seed will lessen trouble the second season, and also improve the quality of the hay. Clipping during the first season ought not to be close to the ground; even if there is enough growth to make a small cutting of hay, let the mower bar be set high. This leaves enough of the green top growth to maintain the constant food supply essential to full development of the root system. It is well to remember that loss of soil moisture on a newly cut grain field is rapid. Where available, a light irrigation may be profitably given to help maintain growth until danger of frost becomes imminent.

On the dry-farm, about all that can be done is to assist in controlling weeds. Properly prepared seedbeds on which clean seed is planted will largely avoid trouble from weeds, and weeds ought to be avoided rather than struggled with. Occasionally, weeds become aggressive enough to warrant clipping. If necessary, two or three clippings may be given during the season to prevent their ripening seed.

Some farmers allow animals to pasture newly planted alfalfa fields but ordinarily this is not counted good practice unless the stand is thick and well-established. Heavy trampling is also
likely to be highly detrimental to the stand, particularly when the land is wet.

IRRIGATION

The great variation in the soils on which alfalfa is grown brings about a great diversity in irrigation practice. Variation in depth, porosity, retentiveness of moisture, and under-drainage are the chief soil factors that cause variation in the time, method, and amount of irrigation. Moreover, the amount and seasonal distribution of rainfall and of irrigation water demand serious consideration in irrigation problems that pertain to alfalfa.

Time to Irrigate.—Where the streams from which the irrigation water comes are principally spring or summer flood-waters, there is no choice as to time of application. The water must be applied when it is available; in general all possible flood-water should be used, at least where the soils have sufficient depth and water-holding powers to insure reasonable storage. Usually, however, not more than 8 or 10 inches\(^1\) are profitable. If more water than this is available, it should be put on other land. Excessive irrigations causes water-logging. In parts of the state much water is wasted that should be applied to alfalfa fields; the water available only in the early spring or late autumn it may, to an extent, be stored in the soil until time of need. Possibilities of flood-water storage in private or company reservoirs ought also to be considered.

On the other hand, where the supply of water is available throughout the growing season, time of application demands attention. Extremely porous sands or gravels usually require frequent application whereas deep, fine-grained soils high in their power to hold water require relatively few but heavy applications at longer intervals. Heavy winter or spring rainfall decreases the value of early spring irrigation as compared with applications that come later in the season. Moderately dry winters and springs naturally accentuate the importance of early irrigation.

If it be kept constantly in mind that alfalfa makes its best growth with a rather abundant and constant supply of soil moisture, an understanding of when to apply water is not difficult. Let the applications be so timed as to accomplish this end without allowing water-logging to begin.

On deep loams or clay loams in those parts of Utah that have heavy winter and spring rainfall, early irrigation is not primar-

\(^{1}\)An ordinary irrigation stream of 2 second-feet will supply 10 inches to an acre in 5 hours.
ily essential. On the Greenville experimental farm at Logan, no increase in yield has resulted from applying water before the first cutting is half grown, and a surprisingly small increase from irrigating before the first crop is ready to cut. With only moderate amounts of water available, a heavy application just before or just after mowing the first crop and one at the same stage in the second crop give good yields. On more porous soils or where more water is available, it would probably be good practice to irrigate when the first crop is half-grown, just before or just after cutting the first crop, when the second crop is half-grown, when it is ready to cut or has just been cut, and when the third crop is two or three weeks old.

Amount of Water to Apply.—If a soil is well-drained and deep, the greatest yields of alfalfa are secured by a liberal supply of water. Since alfalfa is harvested from 2 to 5 times in Utah (2 to 10 or 12 times in the southern parts of California and Arizona), and since stem growth is more rapid for the first few days after an application of water, it follows that alfalfa requires more water for the highest yields than do grains or root crops. As a consequence, where water is plentiful it pays to apply more to alfalfa than to small-grains. Best results come when each cutting is given at least one application, sometimes more. It does not necessarily follow, however, that great quantities are more profitable than moderate amounts. Usually the smaller applications give higher yields for a given amount of water. Where land is abundant and water scarce, it will be more profitable to spread the water over more acres and take a somewhat smaller acre-yield. This practice permits a greater use of the rainfall, irrigation water serving merely as a supplement.

A few favored valleys have abundant water; these may irrigate heavily in order to produce large acre-yields rather than large yields to the acre-foot of water. Southern Arizona obtained its highest yields with 7 to 8 acre-feet of water. This does not seem so excessive when one remembers that this was applied to 8 to 12 cuttings during the season. For three or four cuttings, such as are grown in Utah, probably 30 to 40 inches of water applied in 3 to 8 applications scattered throughout the season, will give the highest yield. Wherever heavy irrigating is being done, at least over large areas, water-logging should be guarded against. The rise of the water-table kills the alfalfa roots and ruins the land for subsequent plantings of alfalfa as well as for the crop that now occupies the land. A heavy irrigator must recognize that unless his land is naturally well-drained, he is courting disaster by using excessive water.

The test most comparable to Utah conditions was one made
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at Davis, California, from 1910 to 1915\(^1\), inclusive. The number of cuttings is 5 or 6 instead of 3 or 4, but otherwise conditions are much alike. As a six-year average a total of 36 inches was found to give the greatest and also the most profitable yields; the 30 inches produced nearly as good results. Applications of 48 inches and 60 inches gave smaller total yields and of course appreciably less profitable ones for the water used. In addition, the 60-inch total application had reduced the stand from 63 per cent at the beginning to 27 per cent at the end of the sixth year.

Economical irrigation of alfalfa under Utah conditions will probably therefore be from 2 to 7 applications of 3 to 8 inches each, making a total of 10 to 35 inches. The amount of seasonal application must in all cases be determined by three factors: (1) the relative abundance of land and water, (2) the nature of the soil, and (3) the seasonal distribution of the water supply.

**Head of Water to Use.**—Good-sized streams should be used in irrigating alfalfa, especially where the soil is rather porous. It is also profitable to have the head-ditches rather close together except on soils so heavy as to be nearly water "tight." For the latter type of soils the water should run slowly because considerable soaking is necessary to get the soil sufficiently wet. Ordinarily, there is considerable water wasted by using heads too small to scatter rapidly over the field or by using runs so long as to saturate the upper part of the field before the lower end is more than wet at the surface.

Several parts of the State use streams divided into such small portions that they are not economical. Labor is wasted in tending small heads and water is lost excessively by seepage from the ditches themselves, to say nothing of the difficulty of getting a small stream over any considerable area. Appreciably more land could be served by compounding these small streams, and give each farmer the stream for a shorter time. This would also free the farmer to do other work a part of the time.

**Fall or Winter Irrigation** is a common, and apparently, an economical practice in some parts of the State where the winter rainfall is light and where the rights to water during the growing season are limited. In rather large parts of western and southern Utah the amount of natural precipitation during the fall and winter is so small that even with good summer water-rights, winter irrigation is necessary to insure vigorous early growth in spring. In some parts, the only water that is

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\(^1\)California Department of Engineering, Bul. 3.
available for alfalfa is from the time other crops are removed until they require irrigation the next season.

Under such conditions on well-drained land, it is probably wise to see that the alfalfa fields are given a good irrigation, preferably in the fall but even in the winter or very early spring. About the only trouble would be some winter-killing in case the water froze into ice and remained unthawed for several weeks. Usually our cold spells are not so protracted as to cause any trouble on this score. The value of water storage in the soil should not be lost sight of in any valley where the winter rainfall is not sufficient to saturate the upper several feet of soil.

"Irrigating up" the seed is a general practice in some parts of the state. Experiments at Logan and Richfield have shown this to be poor practice. Where seedbeds are too dry for proper germination of seed, it is usually better to irrigate the seedbed, re-work the surface, and plant as soon as ready. Irrigating before planting rather than after avoids the danger of a crust on heavy soils. It also gives the operator a chance to kill many weeds that would otherwise begin to grow and cause trouble in the young alfalfa.

**PEST CONTROL**

Alfalfa pests consist principally of weeds and of two insects—grasshoppers and the alfalfa weevil. There are several diseases and several other insects that attack the growing crop, but none has as yet become a major pest. Rodents are also serious in some localities, but they must usually be handled on a community scale. Since this is also true of grasshoppers, only weeds and weevil are left to be combated by the individual farmer.

**WEEDS**

Since old fields of alfalfa are poor producers, and since weeds are much less troublesome in young stands, frequent breaking is the best method of weed control. Where clean farming is practiced in the neighborhood, weeds do not trouble particularly until the alfalfa is more than five years of age. As already pointed out, this is a good age at which to plow up the alfalfa fields.

Weeds may begin to creep into the fields sooner, or in some cases it may be advisable to leave the fields longer, as on the dry-farm. In either case, harrowing with the spring-tooth harrow is usually effective in keeping out weeds. In districts where water is scarce, June-grass (*Bromus tectorum*)—cheat-
grass, military-grass, bearded-grass, it is variously called—is usually the most troublesome. In well-irrigated fields, Kentucky blue-grass is the greatest trouble maker. As fields get older, this grass commonly crowds out the alfalfa, unless regular and vigorous harrowings are applied.

Harrowing may be given either in late fall or in early spring before growth begins. It may also be practised in midsummer, with advantage to the alfalfa. This has been the recommended treatment for weevil until lately. Great rush of work makes summer cultivation inconvenient. Were it not for the weevil, no cultivation would be applied except in spring or autumn. Fortunately, a considerably more economical method of weevil control has been found in spraying.

A light harrowing in the spring of the second season may be applied with the spike-tooth harrow. Unless weeds are coming in, the spring-tooth harrow will probably be too vigorous for year-old stands. Thereafter, the spring-tooth is the proper implement to use for cultivating alfalfa. Even when no weeds are in the fields, at least one yearly harrowing will be profitable unless the soils are mostly sand. Harrowing loosens compact soils, thereby encouraging aeration and penetration of rain or melting snow, and also of early spring warmth. The desirable effect of all these conditions on bacteriological activity, to say nothing of the effect on the alfalfa plants themselves, counts for greater yield. Incidentally, the surface is smoothed down and mowing made more pleasant.

Dandelions occasionally over-run a field, greatly decreasing the yield, but usually not until the fields are long past the proper age for breaking. Whatever the age of a field may be when dandelions become noticeable, it is then time to break without further delay.

When sedges, wire-grass, barley grass (foxtail), dock, or joint-rushes begin to show in a field, they may be regarded as indicating the presence of a water-table too near the surface, usually accompanied by alkali. It is not more harrowing that is now required, but drainage, and possibly planting for a few years to some crop less sensitive to an excess soil moisture than is alfalfa.

Ditchbanks and fence lines need to be kept free from willows, wild parsnips, and other coarse plants. These injure the quality of the hay; a willow-grown line tends to become wider each year. One of the wild parsnips, water hemlock, is violently poisonous to livestock. Losses occur, principally from animals’
eating the roots that have been pulled out or thrown out when the ditch was cleaned.

**ALFALFA WEEVIL**

The alfalfa weevil was brought to Utah a number of years ago, probably from Italy in the packing around furniture. In Europe the weevil is of general occurrence but is prevented from doing great damage to the crop by parasites that prey on the larvae. One of these parasites was introduced into Utah a few years ago and in some parts of the state is killing many weevil, but not enough to permit the omission of other control methods.

**Life History.**—The adult weevil winters over in weeds and rubbish along ditches and fences, but principally on the field itself under coarse alfalfa crowns or stubble. Just after the alfalfa starts spring growth, the adults become active and begin laying eggs. They puncture the stems and lay several eggs in a place. These begin to hatch sometime before the first-crop is ready to cut, the larvae usually become most numerous about one or two weeks before time for cutting. The larvae are about as long as a person’s finger nail and thick as tooth-pick; they are green in color with white and dark dots; they seem to have insatiable appetites for the tender growing parts of the alfalfa. They crawl up to the terminal buds and eat out the new tissues, retarding growth and causing the fields to look whitish when the pest is abundant.

When the first crop is mowed, the larvae drop to the ground and feed on the young shoots of the second growth, sometimes keeping the ground bare for two to four weeks, sometimes merely retarding growth. Then the larvae weave a whitish cocoon about themselves and pupate. They remain in the dormant stage for about 10 to 14 days and emerge as adults to fly hither and thither until frost, when they hibernate for the winter.

**Control.**—Early experiments favored the cutting of the first crop as soon as growth was seriously checked, a thoro spring-tooth harrowing, and dragging with a brush drag or with a spike-tooth harrow with several layers of fine screen wire under the teeth, held in place by being wired to the harrow frame. The idea was to create a dust mulch over all the surface. The hot summer sun heated this mulch and literally cooked the weevil if he could not find shade. As high as 95 per cent effectiveness was reported. The harrowing also benefited the
alfalfa by freeing it from weeds and had it not been required when other work was pressing, would have been profitable.

During the last two years, it has been found that spraying with lead arsenate is highly effective. The spray is made up of lead arsenate powder at the rate of 2 pounds to 100 gallons of water in which three or four bars of common laundry soap has been previously dissolved. About 100 gallons of spray covers an acre. When good outfits were used, a power sprayer can treat from 10 to 20 acres a day at a cost of about one dollar an acre in addition to the work of the owner and his team. The spray is applied when the weevil are destroying the crop as rapidly as it is growing. Spraying is much more economical than the harrow-dragging method. Besides, the first crop may be allowed to complete its growth, being cut at just the right stage.

MAKING THE HAY

The feeding value of alfalfa may be materially influenced by its treatment during the process of hay-making. The yield, too, is affected by both the time of cutting and the manner of curing. The time of cutting the first crop for example regulates the time at which the second crop may start growth. When several cuttings are made in one season, each crop may be given an early or late start as the farmer wishes. The yield for the whole season is roughly proportional to the earliness with which the crops are mowed after the first bloom appears.

Not only does the time of cutting affect the total yield of hay by regulating the growing period of each cutting, but it also regulates to a surprisingly great extent the relative content of protein, fat, fiber, and ash. Exposure to sunshine and rain permit loss of soluble food nutrients, especially of protein. Color and aroma in the hay, both vital to highest palatability, may be either lost or preserved according to the way in which the hay is handled after cutting. Important, however, as are all these factors on the final quality of the hay, the loss or preservation of leaves is of still greater importance. In the leaves are the greater percentages of protein, fat, and ash; they are also the most palatable part of the hay when cattle, sheep, or hogs are concerned. Method of curing has almost entire control over the proportion of leaves that is lost or saved.

CUTTING

The problems related to mowing alfalfa for hay fall under two heads, (1) time of mowing, and (2) method of mowing.

Time.—Merrill and Foster of the Utah Station report a thoro-
going experiment on the time to cut alfalfa for hay. This experiment extended from 1893 to 1898 except for 1896. They tested early, medium, and late cutting. “One of the sections was cut just before the blossoms appeared; another section was cut about a week after first blooming; and the other section was cut about one week after full bloom.”

Their results as to yield for the entire year, that is, for all the cuttings made, are shown in the following table which gives the average for five years.

_Table II._—_Average Yield of Alfalfa Hay—Three Cuttings for Five Years (1893-1898)_

<table>
<thead>
<tr>
<th>Time of Cutting</th>
<th>First Crop</th>
<th>Second Crop</th>
<th>Third Crop</th>
<th>Total Acre-Yield (Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Cutting</td>
<td>Date of Cutting</td>
<td>Date of Cutting</td>
<td>Date of Cutting</td>
<td>Acre-Yield (Pounds)</td>
</tr>
<tr>
<td>Early</td>
<td>June 19</td>
<td>July 29</td>
<td>Sept. 24</td>
<td>2847</td>
</tr>
<tr>
<td>Medium</td>
<td>June 29</td>
<td>Aug. 14</td>
<td>Oct. 3</td>
<td>2195</td>
</tr>
<tr>
<td>Late</td>
<td>July 11</td>
<td>Sept. 14</td>
<td>Oct. 19</td>
<td>286</td>
</tr>
<tr>
<td>Crop Avr’age</td>
<td>4553</td>
<td>3554</td>
<td>1776</td>
<td></td>
</tr>
</tbody>
</table>

If these yields be expressed in percentages with the early-cut hay as 100, then the proportional yields are 100, 92, and 85 for the early, medium, and late cuttings, respectively. Altho Merrill and Foster make no mention of it, there is in addition the aftermath on the early-cut fields that would grow up between Sept. 24 and Oct. 19 when the last cutting was made for the plots mowed in early bloom and late bloom, respectively. It is also worthy of notice that the second cutting in the late bloom stage was mowed only 10 days before the third cutting in the early bloom stage.

A study of the relative composition of the first and second crops was also made. The third crop is all thrown together.

In the early-cut hay not only is the total yield greater but also the valuable feed constituents are carried in higher percentages. The ash, proteins, and fat are all appreciably higher in the hay cut just ahead of bloom than in hay cut at either of the other two stages of growth. The nitrogen-free extract (starches, sugar, etc.) is nearly constant, but the crude fiber (largely indigestible) increases with age of the alfalfa at cutting.

1Utah Station Bul. 61, pp. 160-214.
Table III.—Relative Composition of Early-, Medium-, and Late-cut Alfalfa Hay. (Average Three Years—1893, 1894, and 1895) (Dry Basis)

<table>
<thead>
<tr>
<th>Time of Cutting</th>
<th>Average Composition of First and Second Crops for (three years) (1893, 1894, 1895)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ash</td>
</tr>
<tr>
<td>Early</td>
<td>10.10</td>
</tr>
<tr>
<td>Medium</td>
<td>9.14</td>
</tr>
<tr>
<td>Late</td>
<td>8.62</td>
</tr>
<tr>
<td>All Third Crops (Average)</td>
<td>10.07</td>
</tr>
</tbody>
</table>

Hay of the early, medium, and late mowings were fed to beef steers, and a record kept of their gains, of the food eaten daily, and of the amount of dry matter required for each pound of gain.

Table IV.—Relative Value of Early, Medium, and Late Cuttings of Alfalfa. (Average of First and Second Crops of Alfalfa for Five Years, 1893-1898)

<table>
<thead>
<tr>
<th></th>
<th>Early</th>
<th>Medium</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>First weight</td>
<td>889</td>
<td>913</td>
<td>927</td>
</tr>
<tr>
<td>Last weight</td>
<td>1033</td>
<td>1010</td>
<td>1031</td>
</tr>
<tr>
<td>Gain per day</td>
<td>1.18</td>
<td>1.00</td>
<td>.89</td>
</tr>
<tr>
<td>Food eaten per day</td>
<td>20.86</td>
<td>20.58</td>
<td>20.18</td>
</tr>
<tr>
<td>Digestible matter for 1 lb. gain</td>
<td>9.98</td>
<td>13.06</td>
<td>16.60</td>
</tr>
<tr>
<td>Dry matter for 1 lb. gain</td>
<td>16.82</td>
<td>22.07</td>
<td>28.02</td>
</tr>
</tbody>
</table>

The value of early mowing is shown here. Approximately the same quantity of hay was eaten but there was more rapid gain on the early-cut hay, the greater economy being expressed by the smaller quantities of dry-matter and digestible matter required to produce one pound of gain.

From these data, there is no doubt that it is wise and profitable to cut alfalfa just as soon as blossoms begin to appear. The relative production of beef to the acre from early-, medium-, and late-cut alfalfa is 100, 79 1/2, and 69 1/2, respectively.

In the more humid parts of the United States, and even in damp seasons in the semi-arid regions, alfalfa does not bloom readily. It is not safe to depend on bloom alone as a guide for the proper time of cutting. New shoots, however, begin to grow from the crown at just about the time that blooming would normally begin. Farmers in damp regions may find it wise to observe the starting of these shoots and to mow at once.
Method.—A few wise precautions in laying-off fields and in mowing may greatly reduce waste. Losses frequently occur due to (1) rough ground which prevents close mowing; (2) small or irregular fields with many corners to turn; (3) dull, loose, or broken sickle sections and cutter-bar guards or a wobbly trail-board; (4) careless cutting of back swaths; (5) wet spots; and (6) tramping down the alfalfa before cutting is begun.

These causes of waste are all so easily remedied, that a farmer ought not to permit any of them. The fields should be laid-off with respect to convenience in cutting. The size and shape of the field and the location of ditches both deserve attention. Narrowing at least once a year and care in applying irrigation water will tend to keep the fields smooth enough for efficient mowing. Sickle sections should be kept tight and well-ground; when much worn or badly broken, they should be replaced with new ones. Guards should be kept tight and replaced when badly battered. Good trail boards aid in handling the mower and in avoiding the crushing down of partly lodged alfalfa with the inside mower wheel or with the shoe of the cutter-bar.

In cutting back swaths, care should be taken to get all the hay possible in corners and along fence lines or ditchbanks. Some days before mowing, all inlets from irrigation ditches should be closed to avoid wet ground during mowing. Clean mowing is out of the question when the wheels strike mud. The turning of horses or tillage machinery on alfalfa at ends of rows of inter-tilled crops should be avoided to as great an extent as possible.

Attention to these details will not only avoid waste of hay, but will do much to lessen wear and breakage of the mower. Frequent stops, turning bad corners, and much jolting also slow up the operation, to say nothing of making the work unpleasant. Rough land, much backing, and many turns tire the horses and tend to make their necks sore.

CURING

Method of curing has much to do with the preservation of leaves and of aroma, and with the avoidance of dust or mold. Certain factors are of course beyond the control of the farmer, such as unexpected showers for example, but in the main curing depends rather on the idea of the man who is handling the hay than on unavoidable weather conditions. If the grower understands two things and the reasons that lie back of them, he is much more likely to make first-class hay than would be the case otherwise. These two facts are (1) that alfalfa ought to be
cured slowly and so far as possible in the shade and (2) that the quality of alfalfa is easily injured after curing has begun by undue exposure either to sunshine or to rain.

Fig. 7.—Alfalfa should be put in small cocks while it is still green. This saves most of the leaves and helps to develop aroma.

Curing in the shade means that drying should be done rather gradually and by means of air rather than sunshine. Rapid drying at first is the chief cause of excessive loss of leaves. It should always be borne in mind that a plant is alive at the time of mowing, and that moisture is therefore passing rather rapidly from root to leaf and is there being largely evaporated,—"transpired" the botanist says. Somewhere between 600 and 1000 pounds of water are passed thru the plant and evaporated away by the leaves for each pound of growth made by the plant.

If exposed to rapid drying, the cut plant is unable to keep up a flow of water to the leaves because the slender leaf stems dry out to such an extent that they cease to function. The leaves and the main stem of the plant are so comparatively coarse that they may still be moist when the leaf petioles are dry enough to become brittle.

The leaves are mechanically good excretors of moisture whereas the stems lack evaporating surface. It therefore happens that drying more slowly at first may in the end result in a more rapid curing. It most assuredly results in the preservation of more leaves, thereby increasing the yield and improv-
ing the quality of the hay. Alfalfa ought not, therefore, to be exposed in the swath to direct sunshine any longer than is necessary. Farmers are more and more adopting the practice of curing in the windrow and cock rather than in the swath.

Cock-Curing.—There is a growing tendency to rake the hay immediately after mowing and to cock at once, usually by hand. The best growers advocate getting all the alfalfa cut on a given day into the cock by night. More conservative farmers at first objected on the ground of poor hay and extra labor. The first objection was almost at once abandoned because this makes the best possible hay. There is some extra labor in handling green alfalfa but not enough to counterbalance the saving that comes from clean and rapid handling in loading and unloading.

Fig. 8.—Sweep rakes are sometimes used where there is much alfalfa to handle. Great care is necessary or many leaves are lost.

In cocking, one pitchforkful of hay should be lifted free from the remaining windrow and placed directly on top of the swath on which the haycock is being built. It is rapidly becoming a practice to make cocks just large enough to be handled in one good forkful at loading time. The pitcher does not then have to tear the hay apart in loading. In unloading, the derrick fork also does cleaner and more rapid work.

Aroma and Color.—If alfalfa is cut for hay before the buds are formed, the hay is lacking both in substance and in palatability. When flowering begins, certain chemical juices known as enzymes given off by cells on the interior of the plant render soluble much stored food that has hitherto been insoluble. These soluble foods begin to move from stem and root toward the flower where seed is soon to develop.

Cutting in the bloom period catches this plant-food in its most soluble form and also when the plant is beginning to develop the sweet-smelling aroma characteristic of alfalfa in bloom. If the hay be dried out rapidly or exposed to direct sunshine in
the swath, the enzymes are at once made inactive and only a small part of the aroma is allowed to develop. On the other hand, if the curing is done in the windrow, cock, and mow rather than in the swath, the plants continue to live and the enzymes to work. Alfalfa cut early and cocked green will continue to pass thru enzymatic changes for some time after stacked.

Direct sunshine and oxygen from the air decompose soluble protein and permit the escape of a part of it into the air. Rain leaches away soluble protein and ash, particularly after bleaching has loosened it. In the swath every leaf or stem is wet in a light shower and then exposed to still more active bleaching while it re-dries.

Hay in the cock is not exposed except on the outside to sunshine or to rain unless it is a heavy shower. Dew cannot affect more than the outside of the cock whereas hay in the swath is all exposed to repeated wetting and drying. Even when wet thru small cocks will dry out rather readily. In case of prolonged wetting, it is probably wiser to allow the top to dry and then merely to lift the cock to one side and set it on dry ground. Tearing it to pieces causes the loss of too many leaves and exposes the hay to a possible second shower in a condition that would make heavy loss inevitable.

STACKING

In Utah much alfalfa hay is lost in out-door stacks. The surest method of avoiding this loss is to put the hay under cover. However, exposed stacks can be built so as largely to overcome spoiling in the stack. Some loss always occurs on the ground, but this may be almost entirely avoided by putting the stack on well-drained ground and by putting poles, brush, straw, or old hay on the ground beneath the alfalfa.

There will also be some loss on top due to storms and on the entire outside surface of the stack due to bleaching. Good-sized ricks will prevent the bleaching from becoming proportionately appreciable. Proper stacking will prevent most of the loss caused by storms. Sometimes canvas, grass, or straw cappings are put on top to turn or catch the moisture, but where much hay is handled these makeshift roofs are not generally feasible.

A skilled man on the haystack while it is being built can put
up a rick of hay that will spoil only on the very top. There is no need for "shoulders" in the stack that may allow rain or melting snow to go several feet into the hay, sometimes causing it to spoil in streaks right down to the ground.

Most men who build haystacks pay too much attention to the sides. The middle is the important part. The first load, or the first several loads, should be dropped along the middle with the flakes of hay flattened down and thoroughly tramped. As more hay is unloaded, the sides may begin to grow but with the middle always three or four feet higher and sloping down uniformly toward the edges, even on the ends for the last few feet. Tramping should be such that the hay gets progressively looser from middle to edges.

Most stacks are kept nearly level during the process of erection with the sides and middle well tramped but with a few feet between that has been neglected. When hay settles, it naturally settles most where it is loosest. This causes somewhat flattened places known as "shoulders" to develop near the edges. Fig. 10.—A, Stack improperly built with hollow middle; B and C, properly built with full middle. When stack B settles the hay slopes downwards as in C.

Better stacks can be built with flat, flaky hay that has been properly cocked than with tangled rolls that result from improper bunching. Finally, hay ought not to be unloaded so fast as to forestall each derrick-forkful's being evenly distributed across the stack. This is highly important, as unscattered derrick-loads of hay are sure to leave joints between.

An ideal shape for a haystack is for it to widen gradually until about half-built. It should then taper very gradually toward the middle and finally be topped with nothing but an extra full middle. As much height as convenient is desirable in
order to expose as little hay as possible to storms. Narrow stacks are easier to build than wide ones. They can also be topped more effectively without a later development of shoulders.

When complete, stacks should be well-weighted, especially on the end facing the most common direction of storms. Heavy weights hung on long wires are better than pieces of timber because water drains to the underside of the short poles or slabs often used.

Stacks ought never to be so built that the broadside faces the direction of most frequent winter storms. Snow will drift on the protected side, later to melt and drip into the hay. After heavy storms, the snow should be removed from the top of the stack.

SEED PRODUCTION

Alfalfa seed production is a highly localized industry. A little seed is grown in practically every section where alfalfa has become important, but nearly all the commercial crop is grown in a relatively few tho widely separated localities.

When an abundant supply of soil moisture is at hand alfalfa grows rapidly, producing a rank vegetative growth that sets but few seed pods. Such a condition is favorable for high yields of hay but unfavorable to heavy seed production. Like other plants, alfalfa seems to "run" to seed only when vegetative growth is considerably retarded. This retardation must not, however, be great enough to cause dying or even browning of the top growth due to lack of available soil moisture. It seems necessary that there should be a constant supply of moisture somewhere within reach of the plant but that it be always, during the growth of the seed crop, obtained at a sufficiently slow rate to prevent any period of rapid top growth.

Too frequently old fields are used for seed production without enough cultivation being applied to keep weeds under control.

Fig. 11.—Alfalfa flowers and seed pods. Lower left—blossoms; upper left—position of stamens before and after tripping; right—seed pods.
Besides cultivation, the use of high-grade alfalfa seed for planting seed fields can not be too strongly urged.

There is always the temptation to sell the best grade of seed and plant that which does not sell readily. Fortunately, most farmers now understand this practice to have the worst of all vices—short-sightedness. Low vitality in discolored seed may be overcome by heavy seeding, but the weeds introduced into the fields in low-grade seed become a lasting hindrance to good quality in the seed produced for market.

**Dodder**, or "love vine", grows as a twining vine that fastens itself to the stems of the alfalfa and feeds as a parasite by abstracting the sap from the stem of the alfalfa. Its seed, which ripen ahead of alfalfa, drop to the ground and sow it for another year. A part of the dodder seed clings to the plant and contaminates the threshed alfalfa seed when it is sold, thereby much reducing its commercial value. Since all the dodder can not be screened from alfalfa seed, there is only one way to get clean seed for sale, and that is to have clean fields. The first step is to plant only good seed; cultivation should also be practiced to prevent weeds coming into a field and to eradicate those already there.

**What about Grimm?**—Grimm alfalfa is much talked of, but is not widely grown in Utah. There is some grown for seed in Idaho and a little in Utah and other of the Mountain States. Its great popularity in regions of rigorous winters has caused the price of seed to be much higher than that of common alfalfa. Grimm alfalfa is unquestionably a superior strain of alfalfa where extremely cold winters or wet lands cause heavy winter-killing of common alfalfa. The northern tier of States from North Dakota to New York are just now seeking Grimm seed. This has made it high-priced. For the next few years, the scarcity is likely to continue. It needs to be borne in mind, however, that were Grimm seed plentiful its price would be no higher than that of common alfalfa because the demand is limited to regions of unusually severe winters.

In regions of moderate winter cold, or in arid regions where the ground is snow-covered in cold weather, common alfalfa is a much more profitable crop to grow. The hay yield is from 20 to 40 per cent greater than that of Grimm, which does not begin growth so early in spring nor continue it so late in autumn. Where cuttings for hay have to be made early in order to insure the last one's being a full crop, Grimm would probably mean one less mowing in the season. The seed yield of Grimm is likely to be less than that of common alfalfa by anywhere from 20 to 50 per cent. It is, therefore, apparent that the only virtue
Grimm alfalfa has for Utah is the higher price and more ready market for its seed.

Fig. 12.—Alfalfa seed is best cut with a self-rake grain reaper. The bunching attachment shown here is probably the next best device.

UTILIZING THE CROP

Alfalfa is utilized either by marketing directly or by disposing of it indirectly after it is consumed by animals. Animals utilize it principally as hay or pasturage, but small amounts are fed as green alfalfa, alfalfa silage, alfalfa chaff (after seed is threshed out), or prepared feeds.

MARKETING

Tho it is usually recommended that the hay be fed on the farm rather than marketed, it is sometimes advisable to sell it. The hay may be hauled to market from the field or it may be stacked and sold later either by weight or by measurement. Some growers make contracts that require the feeding of it on or near the farm in order that the manure may be available. This method of marketing overcomes most of the objections to selling hay from the farm.

The sooner Utah farmers begin to keep sufficient livestock to use a considerable part of the feed produced on the farm, the sooner will our agriculture begin to assume an aspect of permanence. This does not mean that hay may not be sold. It may be wiser to grow a little more hay than the producer expects to feed in order that in years of low hay production he shall not
have to buy at high prices. This sort of management means that in ordinary seasons, even a livestock farm may have some hay to sell. On the other hand, many stockmen prefer to buy some hay every year, even when it is high-priced. When just beginning, it is often best for a farmer to sell most of his hay, and work into livestock gradually as he gains experience.

**Measuring Hay.**—Weighing hay is much more accurate than measuring it, but when weighing is not possible, measurement is the only easy method of determining the approximate number of tons in a stack. There are three general rules for measuring hay:

1. **The quarter master’s rule**
   \[
   \left( \frac{O + W}{4} \right)^2 L = \text{No. of cubic feet}
   \]

2. **The Frye-Bruhm rule**
   \[
   \left( \frac{O - W}{2} \right) W L = \text{No. of cubic feet}
   \]

3. **The U. S. Department of Agriculture rule**
   \[
   F O W L = \text{No. of cubic feet}
   \]

   \[O = \text{overcast of stack in feet}\]
   \[W = \text{width of stack in feet}\]
   \[L = \text{length of stack in feet}\]
   \[F = \text{a fraction determined experimentally for 9 different shapes of stack. These may be divided into three groups and these again sub-divided into three other groups as follows:}\]

**Table V.—Fractions for Various Shapes of Hay Stacks**

<table>
<thead>
<tr>
<th>Shape of Stack</th>
<th>Top of Stack</th>
<th>Top of Stack</th>
<th>Top of Stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roughly Tringular in Shape</td>
<td>Medium Full</td>
<td>Full and Rounded</td>
<td></td>
</tr>
<tr>
<td>Height about (\frac{3}{4}) as great as width</td>
<td>.25</td>
<td>.28</td>
<td>.31</td>
</tr>
<tr>
<td>Height about equal to width</td>
<td>.28</td>
<td>.31</td>
<td>.34</td>
</tr>
<tr>
<td>Height about (1\frac{1}{4}) times the width</td>
<td>.31</td>
<td>.34</td>
<td>.37</td>
</tr>
</tbody>
</table>
To apply this rule the overcast or overthrow (distance straight over stack from ground to ground), width, and length (all in feet) are multiplied together and the product multiplied by the proper fraction for the shape of stack. This rule was found by the U. S. Department of Agriculture to be much more accurate than either of the other rules, which gave errors of from 1 to 20 per cent.

The number of cubic feet of alfalfa hay to the ton is usually considered to vary from 512 cubic feet just after the hay is stacked to 422 cubic feet after settling for 3 or 4 months, during which time several storms have fallen on it. The number of cubic feet in a ton is at best only an approximation. Until something better is found the following is suggested:

For stacks 1-10 days old (no heavy storms) 512 cu. ft. = 1 ton.
For stacks 20-30 days old (no heavy storms) 480 cu. ft. = 1 ton.
   Same, with at least one heavy storm, 470 cu. ft. = 1 ton.
For stacks 60-80 days old, ........................................ 440 cu. ft. = 1 ton.
For stacks over 100 days old, ........................................ 422 cu. ft. = 1 ton.

Alfalfa will vary rather widely in the number of cubic feet to the ton, but he who sells or purchases by measurement must reconcile himself to an approximation. Wild hay or fine grass is usually a little heavier than alfalfa, but coarse grass is likely to be somewhat lighter.

FEEDING

Of all forages grown in the United States, alfalfa produces the greatest feed value for each acre. In Table VI are shown the comparative acre-yields of feeding constituents produced by the principal forages.

The total yield of dry-matter for alfalfa exceeds that of other common forage crops, being about double that of clover or timothy, and a half greater than that of corn. The same ratio holds for the total yield of carbohydrates and fat, but the high oil content of corn grain places it about equal to alfalfa in total
net energy. However, energy supply is only part of the function of forage: the tissue-building properties must also be considered.

*Table VI.*—Returns for an Acre of Alfalfa and Other Common Forage Crops. (Average for United States, 1899-1909)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acre-yield (pounds)</th>
<th>Dry-matter (pounds)</th>
<th>Digestible Crude Protein (pounds)</th>
<th>Digestible Carbohydrates and Fat (pounds)</th>
<th>Net Energy (Thermals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>5,040</td>
<td>4,632</td>
<td>529</td>
<td>2,143</td>
<td>1,734</td>
</tr>
<tr>
<td>Clover hay</td>
<td>2,580</td>
<td>2,185</td>
<td>183</td>
<td>1,080</td>
<td>896</td>
</tr>
<tr>
<td>Timothy hay</td>
<td>2,440</td>
<td>2,118</td>
<td>68</td>
<td>1,106</td>
<td>819</td>
</tr>
<tr>
<td>Corn (ears and Stover)</td>
<td>3,440</td>
<td>2,604</td>
<td>140</td>
<td>2,110</td>
<td>1,762</td>
</tr>
</tbody>
</table>

1Henry and Morrison, Feeds and Feeding, p. 224.

The digestible crude protein which is taken as a measure of the tissue-building substance is about three times as great for alfalfa as for clover, four times as great as for corn, and seven times as great as for timothy. The percentage of ash is also highest in alfalfa.

Not only does alfalfa yield more feed value to the acre, but it is also richer pound for pound than most common roughages. This is shown in *Table VII* where alfalfa hay is compared with seven common hays, and with wheat bran and oats.

*Table VII.*—Percentage Composition of Alfalfa Hay, Leaves, and Stalks, and of Seven Other Forages, Wheat, Bran, and Oats (Dry Basis)

<table>
<thead>
<tr>
<th>Hay</th>
<th>Ash</th>
<th>Crude Protein</th>
<th>Carbohydrates</th>
<th>Fat</th>
<th>Digestibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fiber</td>
<td>Nitrogen-Free Extract</td>
<td></td>
</tr>
<tr>
<td>Timothy</td>
<td>5.5</td>
<td>7.0</td>
<td>33.8</td>
<td>50.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Orchard-grass</td>
<td>7.8</td>
<td>8.9</td>
<td>34.3</td>
<td>45.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Salt-grass</td>
<td>13.3</td>
<td>8.6</td>
<td>32.2</td>
<td>43.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Wheat Hay</td>
<td>7.0</td>
<td>6.7</td>
<td>26.9</td>
<td>57.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Red Clover</td>
<td>8.2</td>
<td>14.7</td>
<td>29.3</td>
<td>44.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Alsike Clover</td>
<td>9.5</td>
<td>14.6</td>
<td>29.3</td>
<td>43.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>5.7</td>
<td>3.4</td>
<td>40.8</td>
<td>48.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Alfalfa stalks</td>
<td>6.5</td>
<td>8.2</td>
<td>50.6</td>
<td>33.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>9.4</td>
<td>16.3</td>
<td>31.0</td>
<td>40.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Alfalfa leaves</td>
<td>12.8</td>
<td>22.4</td>
<td>14.2</td>
<td>45.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>7.0</td>
<td>17.8</td>
<td>10.6</td>
<td>59.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Oats</td>
<td>3.8</td>
<td>13.7</td>
<td>12.0</td>
<td>65.6</td>
<td>4.8</td>
</tr>
</tbody>
</table>
It is apparent that alfalfa exceeds other hays in value and is approximately 80 per cent as valuable as wheat bran or oats, the leaves being equal to them but the stalks much less so. The leaves of alfalfa comprise about 40 per cent of the total weight. Table VII shows that they are much richer in protein than the stalks; consequently, great care should be taken to preserve them.

Carroll1 of the Utah Station found that for dairy cows there was no material difference in the feeding value of hay made from the first, second, or third cutting.

Alfalfa hay is so extremely palatable that animals tend to gorge themselves on it, particularly horses. Owners of driving horses have also felt that alfalfa was too laxative, causing the horses to be "washy." It seems also to cause a rumbling noise when animals not used to being driven are made to trot or gallop. On these accounts grass hay and grain, with only a little alfalfa, is used for such horses. The real remedy seems to be to feed alfalfa in mixed rations and to limit the quantity eaten by horses.

It was also held that excess nitrogen in the alfalfa endangered the kidneys due to inflammation caused by heavy excretion of nitrogen. McCampbell2 experimented with artillery horses driven frequently at a trot or gallop. One lot was fed alfalfa hay and a little grain, and two other lots prairie or timothy hay and 16 per cent more grain. The horses fed alfalfa gained 25 pounds each during the trial and showed good wind and endurance whereas those fed on timothy or prairie hay lost weight in spite of extra grain. Urination was not excessive in the alfalfa-fed lot.

Similar results from other places confirm the high feed value of alfalfa for work horses. At Illinois3, work horses fed alfalfa hay did hard work and maintained their weight on 20 per cent less grain than when fed timothy hay. The Utah Station4 kept horses on straight alfalfa for nearly 12 years without troubles of any sort.

Cattle likewise thrive on alfalfa. Beef cattle5 being fattened on corn gave greater gains and better finish when alfalfa hay was fed than when timothy, millet, or sorghum furnished the roughage. Hogs following the steers also made better gains in the alfalfa-fed lots.

For dairy cows alfalfa is ranked highest among the hays on

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1 Utah Station Bul. 126.
2 Kansas Station Bul. 186.
3 Illinois Station Bul. 150.
4 Utah Station Bul. 77.
5 Missouri Station Bul. 76.
account of its palatability and its high content of good quality protein and ash, the lime being markedly high. These substances are important, since lime and protein are found in high percentages in milk. Where corn silage is a common feed, then a crop high in protein and lime is necessary to balance the ration. This purpose is well served by alfalfa or clover, which is probably the most economic source of these substances for farm livestock.

Experiments at New Jersey\(^1\) and Illinois\(^2\) show that about one-half the concentrates in a ration for dairy cows may be substituted by the cheaper alfalfa hay without materially decreasing the production of milk or butter-fat. However, a complete substitution of concentrates by alfalfa hay caused a decrease of about 20 per cent. Where high production for individual cows is not essential to profit and where alfalfa hay is relatively cheap as compared with concentrates, it may be that the ration could with profit be restricted to alfalfa hay. Usually, however, a little grain is desirable.

Hogs make greater gains on alfalfa and corn than on corn alone. Brood sows wintered on alfalfa produced large, healthy litters. Even for fattening hogs, a little alfalfa in the ration makes cheaper gains than where it is not used. Sheep also make greater gains with some alfalfa or clover hay in the ration. The use of alfalfa hay aids poultry men to produce cheaper eggs.

The high palatability of well-cured alfalfa hay encourages animals to eat it in large quantities. This is a decided advantage with dairy cows, tho not with horses as already explained.

### PASTURING

Throughout the alfalfa-producing region of the United States, it is general practice to permit animals to graze over the alfalfa fields after the hay has been removed. Some fields are used entirely for pasture without being mowed at all. The problems of pasturing alfalfa have to do (1) with the welfare of the fields and (2) with the welfare of the animals.

In humid regions pasturing tends to kill the plants. In arid and semi-arid regions, where growth is vigorous, no serious injury to alfalfa fields from moderate grazing has been observed. Continued extremely close pasturing, particularly by sheep but sometimes by horses or hogs, may cause the stand to become thin. Trampling by animals in wet weather, especially on land that is heavy or naturally somewhat wet, is likely to injure the field. Animals tend to congregate—the cattle to paw

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\(^1\) New Jersey Station Bul. 190.
\(^2\) Illinois Station Bul. 146.
up dust and the horses to roll. This must be expected unless a shed or some sort of shade is provided. Fields should go un-grazed for a few days after being irrigated.

Horses do so well on alfalfa pasture that the only precaution necessary is to change from dry feed to green pasture gradually. Large fields furnish opportunity for desirable exercise. Many horses do moderate work with no other feed than night pasturage on alfalfa and a little grain at noon. Ordinarily, however, green alfalfa is too bulky and too laxative to form a major part of the ration for horses doing heavy work or much traveling.

Hogs and poultry make splendid use of growing alfalfa. Green feed rich in protein assists in egg production and in growth. Young pigs do particularly well on green alfalfa. It is counted advisable to have several small pastures for hogs and to move the animals about, thereby permitting the mowing of dry, coarse stems. This practice also enables the hogs, after the first few weeks of early spring, to be kept on the more mature alfalfa. If pastured during the period of budding and early blooming, the feed is of better quality, and the acre-yield for the season higher. Pasturing very young growth is not wise because the feed value is low and new growth does not start at once. A large proportion of the hogs on alfalfa pasturage are not fed grain; yet to make a satisfactory growth they require from 1 to 2 pounds of grain daily for each 100 pounds live weight.

Cattle and sheep do well on alfalfa pasturage, but there is always danger of bloat, caused by fermentation of fresh alfalfa which packs tightly and forms heavy masses in the paunch. Dew on the leaves seems to increase danger of bloat. Experienced men think it wise to feed animals well before turning them on alfalfa and to leave them constantly on the pasture. If some dry feed such as hay or straw, is accessible, the animals will eat at this occasionally, thereby reducing but not eliminating danger of bloat and scours. It is also maintained that water should be available at all times, or at frequent, short intervals. Finally, there are a few animals that bloat easily. These probably ought not to be pastured on alfalfa; conversely, some animals seem to have no trouble under almost any conditions.

Soiling, or the feeding of freshly cut alfalfa, is not a general practice on account of the great amount of labor required. Dairy cattle, especially, will do well on such feed. Bloating danger is also materially decreased, but not entirely eliminated, at least for susceptible animals. Many farmers feed freshly mown alfalfa or tether the animals along the edge of alfalfa fields, for a few days or a few weeks just preceding haying time if
their supply of hay is short. In Europe where man labor is cheap, both soiling and tethering is a general practice. Where this is done, alfalfa is a favorite crop on account of its early, rapid, and almost continuous growth.

By-products of the alfalfa seed industry are also valuable feeds. Alfalfa straw, or chaff as it is usually called, makes good feed for stock merely being wintered, or as a part ration for producing animals. The animals seem to like it, unless it has been badly spoiled by wet weather.

Dusty, moldy, and spoiled hay may be fed to non-producing animals. Its palatability is increased and its feeding value supplemented by being chopped fine, mixed with ground grain, and sprinkled with hot water in which has been dissolved a little molasses. These manufactured feeds are valuable, tho often the price is too high in proportion to feeding value. Shrunken and discolored alfalfa seed may be utilized in these prepared feeds, but such screenings should not be so used if they contain many weed seeds. The seed of most weeds pass uninjured thru the alimentary tracts of ordinary farm animals.

SUMMARY

Alfalfa has been cultivated from ancient times. It is at present widely grown in almost all arid or semi-arid regions that are inhabited by civilized people. It is also grown in, or else is spreading to, those parts of the humid region where the soils are deep, well-drained, and rich in lime.

In regions of excessive winter cold, variegated strains such as Grimm, Baltic, and Canadian Variegated, are preferred on account of their ability to resist great winter cold. In regions of moderate winter cold or where the ground is snow-covered in cold weather, common alfalfa is better on account of its earlier growth, higher yield of hay, and more prolific seed production. In the regions of mildest winters, Peruvian alfalfa is a favorite on account of its more rapid and more nearly continuous growth.

Best results are obtained by sowing bright, mature seed free from weed seed on a fine, well-firmed seed-bed. Most seeding is done in spring with or without a nurse crop. Late summer sowing, after the removal of some early crop such as grain, early potatoes, peas, beans or certain truck crops, has given equally as good if not better results except where shading seems beneficial. After young alfalfa begins growth, it should not be clipped frequently or close unless this is necessary on account of weeds.

After the second season alfalfa fields should be harrowed in
fall or spring to control weeds. Weevil are best controlled by spraying with a solution of 2 pounds lead arsenate powder (4 or 5 of the paste) in 100 gallons of water applied to an acre.

Irrigation water should be applied in 3 to 5 heavy applications on loams or clay loams, but in 4 to 10 frequent, light applications on porous soils. Large streams should be used, and on porous soils the head-ditches should be close together. Where water is scarce, fall, winter, and early spring irrigation may be practiced, and water thereby stored in the soil.

Since young fields yield more and better hay, alfalfa should not ordinarily be allowed to get more than four to seven years of age. The practice of allowing alfalfa to remain 12 to 15 years is unwise as the yield and quality of hay are both greatly decreased by weeds. Ordinarily, 5 years is long enough.

The greatest acre-yields for a season and the best quality of hay are secured when alfalfa is cut at the time of early bloom, raked at once, and cocked green. In no case should enough drying in the swath be tolerated to permit the leaves to become brittle, because they are then easily broken off and lost. When hay is stacked out of doors, the stacks should be built with firm, rounded middles that are kept higher than the sides from the first load to the last.

Seed growing is a specialized industry, being confined chiefly to a dozen or so spots scattered widely over the country, but all west of the humid region. Clean fields are primarily essential to clean seed. Dodder, which greatly reduces the price of alfalfa seed, can be eliminated by sowing clean seed and by cultivating frequently. Fields ought not to be too long devoted solely to seed production.

Alfalfa is a splendid feed either as hay or pasture. With cattle and sheep, however, bloating needs to be guarded against by feeding the animals before putting them on green alfalfa and by leaving them thereafter continuously on it. Water should also be accessible. With hogs, good practice calls for pastures divided into small lots alternately used. Alfalfa yields most when pastured in the budding period, because the next growth then begins at once. Very young growth contains too much water to have high feeding value.

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