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ALFALFA

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INTRODUCTION

Following its introduction into California from South America in 1854 alfalfa quickly gained an important place in the agriculture of the Western States. The ease with which it could be established, the longevity of the stand and the heavy yields of excellent forage made it the outstanding forage crop of that region. In the eastern part of the country, however, early attempts to grow alfalfa met with indifferent success, chiefly because the cultural requirements for successful production under humid conditions were not understood. It was several years before these requirements were determined so that little progress was made in the cultivation of the crop until comparatively recent years. During the past twenty years, however, and particularly during the past ten years, the acreage east of the Missouri River has increased at a very rapid rate, even faster than in the West. It is interesting to note just how rapid this increase has been in a few of the larger producing States in the eastern part of the country. According to census figures, Kentucky produced only 808 acres of alfalfa in 1899. In 1909 20,300 acres were grown. By 1919 this had increased 177 per cent, or to 56,216 acres. In Ohio 29,439 acres were grown in 1909 and 94,416 in 1919, an increase of 220 per cent. The Illinois figures are 18,344 acres in 1909 and 88,968 in 1919, an increase of 385 per cent. Missouri increased her acreage from 35,478 in 1909 to 151,720 in 1919, which is 327

per cent increase, and New York from 35,343 to 119,000 or 239 per cent. Other States show even a larger percentage of increase.

The total area in alfalfa in the United States in 1919, as given by the 1920 Census figures, was approximately 8,570,000 acres; nearly double the acreage of 1909, or ten years earlier. Among crops grown distinctively for forage, alfalfa ranks third in the acreage grown, and because of its higher yield—nearly double that of other forage crops—ranks second in tonnage of hay produced.

What to Expect From Alfalfa

The prospective grower of alfalfa may expect success on whatever type of soil be may have, provided the soil is put into the condition required by the crop. Of course, under the most favorable soil conditions, failure to get a stand may sometimes occur just as with clover or grass. Inoculation is not successful in every case even with the greatest care, and this results in poor growth.

The yield depends upon the fertility of the soil and how perfectly it is prepared for the crop; also, of course, upon the stand. The yield of alfalfa is less affected by drouth than that of other forage crops because of the very extensive and deep root system, and because the very rapid growth of the plants permits them to make very effective use of all available water. The ability of alfalfa to give good yields in dry seasons was well illustrated on the Station farm in 1922, one of the driest seasons ever experienced in the Bluegrass region of Kentucky. Four cuttings were obtained, giving a total yield of over six tons per acre, or one and a half tons per cutting. Such yields as this are possible, however, only on very fertile land. Three cuttings per year may nearly always be obtained in Kentucky and in most seasons four, provided the harvesting is done at the proper time. An average yield of a ton per cutting may be reasonably expected from a good stand of thrifty alfalfa. Alfalfa fields may be expected to remain productive and fairly free from

weeds for from four to six years and on especially favorable soils somewhat longer.

Cost of Preparing Land for Alfalfa

It is evident that the cost of preparing land for alfalfa will vary widely. In most cases the application of limestone will be the heaviest direct cost, amounting to from $5 to $15 per acre when no allowance is made for the expense of hauling to the farm and spreading. Where land must be tile drained, this will be the heaviest item of cost. Fertilizers, except in the central Bluegrass region, will cost from $5 to $8 per acre, and the application of manure or growing a crop to plow under are other items of cost. Not all the cost should be charged to the alfalfa, however, for succeeding crops will benefit greatly. When this expense is spread over the entire period of the crop it is not great. Tiling wet land is nearly always profitable regardless of the crops to be grown. The use of lime and phosphatic fertilizers is also necessary on a large proportion of the soils of Kentucky to bring them up to profitable productivity. Regardless, however, of future benefits, the returns from a good field of alfalfa are enough greater than from other forage crops to pay for the cost of preparation.

Soil Requirements for Alfalfa

Drainage. Alfalfa requires a well-drained soil. Good surface drainage is not sufficient, for poor underdrainage is often found where surface drainage is good. Underdrainage must be thoro and rapid. If natural drainage is poor, the land should be tile-drained. It is often possible to judge by the appearance of the subsoil whether the drainage is good. If it is white, grayish or yellowish gray, its adaptability to alfalfa is questionable, for these colors are generally an indication of poor drainage.

For alfalfa, tile drains should be laid from three to three and one-half feet deep. The distance between the lines depends upon the nature of the soil.

Dynamiting the soil is sometimes recommended as a means of drainage. The expense of this operation is so great and the

results so doubtful, that it is a safer investment to install tile drainage, which is a permanent relief from poor drainage.

A Fertile Soil is Required. Alfalfa requires a fertile soil and it will not make a satisfactory growth on poor land. Altho, under proper conditions, it has the power to obtain a large part of its nitrogen from the air thru the agency of bacteria living upon its roots, yet it takes a considerable part of its nitrogen from the soil, particularly during the early stages of growth. The crop also makes heavy drafts upon the mineral elements of plant food. According to analyses made by the Kentucky Experiment Station, four tons of alfalfa hay, not an unusual yield per acre for a season, may contain twenty-three pounds of phosphorus and 125 pounds of potassium. A corn crop of fifty bushels, including one and one-half tons of stover, requires approximately twelve pounds of phosphorus and thirty-six pounds of potassium. Thus it is evident that a soil on which alfalfa is grown should furnish large amounts of available phosphorus and potassium. While most of the soils of Kentucky contain sufficient potassium for alfalfa, nearly all those outside of the better Bluegrass soils should be liberally treated with some carrier of phosphorus. Acid phosphate, steamed bone meal and basic slag are the most effective carriers of phosphorus for alfalfa. Probably the most satisfactory method of using these fertilizers is to apply them in sufficient quantities, when the alfalfa is sown, to last for the period that the crop is expected to stand, which is usually about four years. The rate for acid phosphate and basic slag would be 800 to 1,000 pounds per acre, and for steamed bone meal about half this amount. When used in these amounts, the materials are probably best applied broadcast and disked in before breaking the ground. Very little phosphorus is lost by leaching.

If preferred, acid phosphate may be applied in smaller quantities when the alfalfa is sown, and applied annually as a top dressing of about 200 pounds per acre to be cultivated in after the first cutting.

Organic Matter. In addition to a liberal supply of the mineral elements of plant food, soils of the types found in

Kentucky should be well supplied with organic matter or humus. Organic matter contains the nitrogen of the soil, the source of part of the nitrogen used by the alfalfa crop. It increases the moisture holding capacity of the soil, reduces the rate of evaporation, facilitates the intake of water, hastens drainage, prevents baking and cracking and generally promotes the physical condition of the soil favorable to the growth of alfalfa. Furthermore, organic matter aids in rendering the mineral elements of plant food in the soil available, in addition to giving up its own plant food as it decays. A goodly supply of organic matter is a primary requirement of a productive soil.

Sweet Clover as a Preparation for Alfalfa. One of the very best means of increasing the organic matter of soils is to grow a crop of sweet clover and turn it under. A crop of 3 to 4 tons per acre of cured sweet clover is not an unusual yield, and is equal to 12 to 15 tons of average farm manure in the amount of organic matter provided. A ton of cured sweet clover contains from 40 to 50 pounds of nitrogen, representing approximately the amount taken from the air. As previously stated, a fair supply of nitrogen in the soil seems to be essential to alfalfa. It has also been shown that sweet clover is able to take large amounts of potassium from very poor soils, which becomes available to other crops upon decay of the plants. Sweet clover has a large, fleshy root system which penetrates the soil in all directions and decays readily, resulting in improved drainage, aeration and generally improved physical condition of the soil. The nitrogen-gathering bacteria of sweet clover are the same as those of alfalfa. If the sweet clover is well inoculated, it leaves the ground better inoculated for alfalfa than will any artificial inoculation applied at the time of sowing alfalfa.

The Kentucky Agricultural Experiment Station prepared for alfalfa a rather thin piece of land on the farm of the Lincoln Institute in Shelby County by growing a large crop of sweet clover and turning it under. The yield of twelve cuttings of alfalfa in four years averaged 1.65 tons of clean, field-cured hay per acre per cutting. One of the best pieces of alfalfa ever

grown on the Experiment Station farm followed a crop of sweet clover which was turned under.

If the growth is too heavy to turn under, it may be cut before the seed ripens enough to grow and allowed to lie until it is brittle, when it may be cut up with a disk harrow and turned under. Other crops, such as cowpeas, soybeans, etc., may be grown to be turned under to increase organic matter but, as stated, no other crop equals sweet clover for this purpose. It should be borne in mind that liming is as necessary for sweet clover as for alfalfa.

Farm Manure. Farm manure is an unexcelled source of organic matter, but it is not always obtainable in sufficient quantities for alfalfa. Ordinarily ten to twenty tons per acre should be used. Manure often carries large quantities of weed seeds and seeds of grasses; consequently it is not advisable to apply it as a top dressing. It should be applied before the ground is plowed. Perhaps the best plan is to grow a cultivated crop after applying the manure.

The application of manure does not take the place of phosphates. Manure is quite deficient in phosphorus and should be accompanied by the use of phosphates on the soils already specified as being deficient in phosphorus.

Limestone. In general it is useless to undertake to grow alfalfa on soils that do not contain calcium carbonate (limestone). Alfalfa requires large amounts of calcium, an element found in calcium carbonate, and probably requires it in the carbonate form. One ton of alfalfa hay contains about thirty-six pounds of calcium, against about twelve to fifteen pounds in a corn crop of fifty bushels, including the stover. An alfalfa crop of four cuttings per season may require from five to ten times as much calcium as a crop of corn grown on the same character of soil. Some Kentucky soils contain calcium carbonate naturally, such as the hilly lands of the northern part of the State where sweet clover and alfalfa thrive. Soils that contain calcium carbonate generally show outcroppings of limestone or contain fragments of limestone in or near the surface soil. Soils that do not show these characteristics are generally sour or acid.

altho they may be derived from limestone formations and may be underlaid with limestone rock. Especially is this true of soils that have been cultivated for some time. Limestone rock may be identified by the vigorous effervescence produced by hydrochloric (muriatic) acid.

There are some tests which a careful man can make that will give some indication of the condition of the soil as regards calcium carbonate. One is the litmus-paper test, which is made as follows: A moist clod of soil is broken open, a folded strip of blue litmus-paper (which may be obtained from druggists) is inserted and the pieces of soil are pressed firmly together. The paper is allowed to remain in contact with the soil for ten minutes and is then removed and dried. If it is red or pink on drying it indicates an acid condition of the soil and therefore an absence of calcium carbonate. Care should be taken not to let the fingers touch the paper or the soil at the place of insertion. It is doubtful if this test is of much value unless made by a person of experience.

A test that will show the presence of calcium carbonate in the soil is carried out in the following manner: In a ball of moist soil, make a shallow depression and pour into it some strong hydrochloric acid. If calcium carbonate is present, there will be an effervescence. It will not be vigorous unless there is a large amount of calcium carbonate in the soil.

By using these two tests in a careful manner, one may gain some idea as to the necessity for applying lime.

Ground limestone is recommended* in preference to any other form of lime, altho burnt lime may be used with good results. A sufficient application for alfalfa, on most soils, is four tons per acre of ground limestone, or two tons of burnt lime. It is best to apply the material on the plowed ground and disk it in thoroly, altho when used in large quantities it may be applied and disked in before the ground is broken.

It cannot be too strongly emphasized that alfalfa is nearly always a failure on soils that do not contain lime.

*For a fuller discussion of the use of lime in different forms, see Extension Circular No. 59, College of Agriculture, University of Kentucky.

In one liming test on the Experiment Station farm at Lexington, the soil of which is only very slightly acid, the following yields were obtained from nine cuttings in three years:

Unlimed soil	4.9 tons hay per acre
2 tons ground limestone per acre	8.4 tons hay per acre
4 tons ground limestone per acre	9.7 tons hay per acre
6 tons ground limestone per acre	9.4 tons hay per acre

The hay on the unlimed areas always contained a large proportion of weeds and grass and at the end of the three-year period the alfalfa had practically disappeared. The alfalfa on the limed ground was quite free from weeds, due to the heavier growth of alfalfa which kept them choked down.

Seeding Practices

It is not difficult to get a stand of alfalfa. The seeds germinate quickly and under favorable conditions the plants grow rapidly. They will not stand competition with weeds and summer grasses successfully, however, until well established, and the failure to control weeds is perhaps responsible for as many failures as any other single cause except the lack of lime. Young clover and the various meadow and pasture grasses are just as easily injured by weeds as alfalfa, but the former usually are seeded with small grains which hold the weeds in check until the clover or grass is established. This method of seeding alfalfa has not proved very satisfactory, however, especially seeding in the spring on fall-sown grains. Seeding alone on a specially prepared seed bed is generally recommended, but if thus seeded in the spring weeds may prove very troublesome. Crabgrass and foxtail are especially troublesome in Kentucky and in some seasons will practically destroy the stand.

Advantages of Summer Seeding. Because of the danger of weed injury when alfalfa is sown in the spring, summer seeding is usually advocated for humid regions. Almost perfect weed control may be secured by summer seeding, and it is undoubtedly the safest practis. Summer seeding has advantages other than weed control to recommend it. Spring sown afalfa often pro-

duces little hay the first year and the returns from the land are small. In summer seeding the land can be used during the early part of the season for small grains or for growing an early maturing cultivated crop such as potatoes or tobacco. There is usually more time to prepare the land thoroly in the summer than in the spring because other work is not so pushing. Probably summer seeding offers the best opportunity to obtain thoro inoculation of the plants. The Experiment Station recommends summer seeding in Kentucky, especially for the inexperienced grower, or wherever the assurance of a successful stand is the chief consideration.

Seeding With a Nurse Crop. It is the common experience of growers that alfalfa planted on land that has previously been in alfalfa thrives better than the first seeding. This is undoubtedly due to the perfect inoculation of the sol. A crop of sweet clover will also give perfect inoculation. It seems quite probable that the unsatisfactory results from seeding alfalfa with a nurse crop may be due to a large extent to poor inoculation. Alfalfa grows faster than clover and roots deeper. It should therefore tolerate a nurse crop fully as well as clover, provided the soil is well inoculated. As a matter of fact, a great deal of the alfalfa grown in Kentucky is seeded with a nurse crop. This is the common practis in the limestone hill lands of North Central Kentucky, where more than 50 per cent of the crop of the State is grown. Alfalfa and sweet clover have been extensively grown there for a number of years and the soils, as a rule, are well inoculated. At the Experiment Station a very good stand of alfalfa has been obtained by sowing in wheat on land where alfalfa had been previously grown. The economy of this method of seeding justifies the experienced grower in giving it a thoro trial on soil known to be well inoculated. Fall-sown grains make much better companion crops in this State than spring-sown grains for clover, and undoubtedly this is true of alfalfa. Winter barley is decidedly the best nurse crop and wheat the next best. Rye is good if pastured rather heavily in the spring. If spring oats are used, they should be planted

at about half the usual rate and cut for hay in the milk stage. Spring barley is regarded as much better than oats, particularly the beardless spring barley. Spring-sown grains do not control weeds nearly as well as winter grains, however, and this is an important point, as already explained.

It is probably true also that the inability of alfalfa sown alone in the spring to compete with weeds is due to imperfect inoculation. When well inoculated and on favorable soil young alfalfa plants grow very rapidly and a thick stand holds weeds in check quite successfully. At the Experiment Station, early trials of seeding alone in the spring were not very successful. These were made on land that had never been in alfalfa before. In 1921 a field that had been in alfalfa a few years previously was sown in this way. A perfect stand was secured and the plants grew so fast that a fair cutting of hay was obtained in early July. Weeds gave practically no trouble, and a second cutting of hay was obtained in August.

Preparation of the Seed Bed

Summer Seeding. Success in summer seeding necessitates a very carefully prepared seed bed. It should be well pulverized and firm and should contain sufficient moisture to insure prompt germination of the seed and rapid growth of the young plants. In order to obtain these conditions the seed bed should be prepared as far in advance of the time of seeding as possible.

Small grain stubble should be broken in early July or as soon as the grain crop can be removed. If early threshing is not possible, the grain should be removed so that preparation of the land will not be delayed. The ground should be plowed if at all possible, even if hard and dry, because it is then in condition to absorb and hold all rainfall. Disking thoroly before plowing is advisable when the ground is dry. The disk and drag should follow the plow closely to break up the clods before they become dry and hard. If possible the preparation of the seed bed should be completed at once by further disking and rolling. Frequently small clods cannot be pulverized until moistened by a shower, but thoro working after plowing will

bring these to the surface where even a light shower will soften them up so that they can be easily pulverized. After the seed bed is prepared, the surface should be stirred lightly with a harrow whenever it becomes crusted or whenever weeds appear. Deep stirrings which tend to loosen up the soil should be avoided.

If clover sod is to be plowed for alfalfa, the breaking ought to be done as soon as the hay crop is removed. It is not advisable to sow alfalfa on grass sods, especially bluegrass sod. A cultivated crop should intervene. Where alfalfa follows a cultivated crop such as potatoes or tobacco, little preparation is necessary for seeding provided few weeds are present. In fact, deep stirring is not advisable. A light disking followed by the drag to level the ground and the roller to firm it will usually put it in the proper condition. If weedy, a thoro disking may be necessary, but in such cases the land should be rolled two or three times to firm the surface. In seeding in tobacco stubble it is best to cut the tobacco stalks; unless this is done a vigorous crop of suckers may spring up and injure the alfalfa.

The most ideal conditions for summer seeding are obtained when land is broken in the spring and harrowed and disked thruout the summer to keep down weeds and keep the surface loose. By following this practis one is assured of a good moisture supply at seeding time and in addition the plant food which becomes available during the summer insures a vigorous fall growth of the plants. As no returns are secured from the land for a year, however, this practis is rather expensive.

Preparation for Spring Seeding. For spring seeding without a nurse crop, fall plowing is very desirable and should be practist where soils are not subject to washing. Fall plowed land should be worked only enough to level it and break up the larger clods. In the spring a light disking followed with the drag is usually sufficient to put it into good condition for seeding. Spring plowing should be done early and the seed bed prepared at once, but weeds will be less troublesome if seeding is deferred for a few weeks and the land harrowed whenever weeds appear.

An extensive alfalfa grower of this State has had excellent results from spring seeding according to the following methods: The field intended for alfalfa is prepared in the fall and sown to rye. Early in the spring the land is disked until a large proportion of the rye is destroyed. Then the alfalfa is sown. Enough rye is left to keep down weeds, but not to injure the alfalfa.

Subsoiling for Alfalfa

Subsoiling is frequently recommended for alfalfa. However, this practis is of doubtful value on soils adapted to alfalfa, for the crop requires a porous subsoil that will permit ready drainage. The Experiment Station made a test of various methods of subsoiling for alfalfa, the results of which are given below. The total yield for eight cuttings in three years is given:

Ordinary plowing, about 7 inches	7.8 tons per acre
Dynamiting and ordinary plowing	7.9 tons per acre
Deep tilling machine, about 16 inches	7.5 tons per acre
Ordinary subsoiling, about 16 inches	8.9 tons per acre

There is good reason to believe that a large part of the increase apparent for subsoiling was due to better ground where the subsoiled plat happened to lie.

Date of Seeding

In Kentucky the most favorable time for summer seeding is from August 10 to 20. If sown much earlier, weeds may give trouble, while if sown later the plants may not make sufficient root growth to prevent heaving out during the winter. However, in most seasons alfalfa sown by September 1 will winter successfully, especially if the soil conditions and season are favorable for a rapid fall growth. In the southern part of the State there is little risk in sowing as late as September 1.

Favorable moisture conditions are very essential for success in summer seeding and this emphasizes the importance of early preparation of the seed bed, in order that a good supply of moisture may be stored up in the soil. Even when the seed bed contains considerable moisture, however, the surface may be

quite dry and to get the seeds in moist soil they must be covered deeper than is desirable. There is always danger when seed is covered very deep that a hard, beating rain may pack the ground so hard that a poor stand may result. The use of a heavy roller before seeding will bring the moisture closer to the surface and permit shallower covering of the seed. However, the most favorable condition for seeding obtains after a rain, and it usually pays to wait as long as is safe in an effort to secure this condition.

Probably early April is the most favorable time for spring seeding, but any time from March 15 to May 1 should give good results. After May 1 moisture conditions are likely to be unsatisfactory for seeding, and weeds particularly troublesome.

In seeding with a fall-sown nurse crop, it is best to sow by April 1 or before the grain crop has gotten a very vigorous start. Just how much cold young alfalfa plants will stand has not been definitely determined, but probably as much as clover. Until this is known, it is not advisable to seed earlier than March 15.

Method of Seeding

The use of a clover-seed drill will give the best distribution of seed and, unless the seed bed is very loose, the most uniform covering of the seed. Because all the seed is covered and to a uniform depth, somewhat less seed is required than where the covering is done with a harrow. Where it has rained since the ground was last stirred, it is necessary to precede the drill with a light drag harrow in order that the seed may be well covered. It may also be well to follow the harrow with a roller before seeding. As stated, the seed should not be covered any deeper than moisture conditions require and in no case should they be covered more than one and a half inches deep.

When the seed is sown broadcast a more even stand can be secured by sowing half the seed in one direction and the other half in cross direction. A smoothing or drag harrow is the best implement for covering the seed. The use of a roller, especially a smooth one, after seeding is not advisable unless the ground is very dry. A heavy rain on rolled ground is likely to produce

a thick crust thru which the plants cannot make their way. If rolling is absolutely necessary, less crusting will occur in case of rain if a "cultipacker" or corrugated roller of some kind is used instead of a smooth one.

In seeding alfalfa with a nurse crop, the relatively late seeding recommended makes it advisable to cover the seed. Either the clover seed drill may be used or the seed sown broadcast and covered with the harrow.

Fall-sown alfalfa should not be clipped or pastured under any circumstances as all the growth is needed for winter protection.

Rate of Seeding. The rate of seeding generally practist in Kentucky is from fifteen to twenty pounds per acre. Under especially favorable conditions a good stand can be obtained by sowing even less seed, but it scarcely pays to economize on seed, for a thick stand of plants is a great help in keeping down weeds.

Varieties and Strains of Alfalfa

Alfalfa seed cannot be produced satisfactorily in humid regions and practically all the seed used in this country comes from the semi-arid regions of the West. Some is imported, chiefly from Turkestan. Probably most of the seed sold in Kentucky comes from Kansas and is of the common variety. In recent years the hardy varieties of alfalfa such as Grimm, Cossack, Baltic, etc., have attracted much attention in this country, particularly in the Northwestern States where, because of the severe winters, great cold resistance is essential. These hardy varieties belong to the group known as variegated alfalfas or sand Lucerne, and are crosses between the common alfalfa and the hardy yellow flowered sickle alfalfa which grows wild thruout northern Europe and Siberia. It is, of course, the latter which gives the variegated alfalfas their hardiness. The value of these hardy strains for regions where great winter hardiness is essential has been fully demonstrated. In Kentucky, however, temperatures seldom if ever get low enough to kill the common variety of alfalfa and unless the hardy strains are superior to the common in other respects than hardiness, the growers of

this State are not justified in paying the high price asked for seeds of these varieties. The Experiment Station has compared several of the hardy strains with the common for the past two years, but the data so far do not permit drawing definite conclusions. The winters have been mild and none of the varieties has suffered even the slightest winter injury. In 1921 a heavy freeze occurred on March 29, following a long period of unseasonably warm weather during which alfalfa had made a large and vigorous growth. The temperature fell to 23° F., damaging vegetation quite seriously. The common alfalfa was injured very badly and growth checked. The hardy strains suffered little and made a very good first cutting of hay. The hardy strains also gave a better second cutting and a good part of the season was required for the common varieties to recover from this freeze. There is no doubt that the hardy strains will yield more when heavy freezes occur after alfalfa has started its spring growth, but such freezes do not often occur.

A few years ago some plots of Grimm and common alfalfa were sown for observation on fairly wet land where winter heaving of clover and alfalfa is severe in many years. This was true in 1918. The plants of the common variety heaved considerably more than those of the Grimm. It is probable that on land where heaving is severe, one of the hardy strains of alfalfa will pay.

The writers are inclined to believe that Grimm and Cossack have been slightly freer from leaf spot than the common, and less injured during wet periods. The difference is slight, however.

The hardy varieties are not as upright in growth as the common and have weaker stems; consequently on rich land the stems tangle worse.

The yields of Grimm, the most extensively grown of the hardy strains, and common alfalfa on the Station farm for the past two years, 1921-1922, were as follows:

	1921	1922
	Lbs. Per Acre.	Lbs. Per Acre.
Common	6,105	12,975
Grimm	6,962	12,955

Three cuttings were made in 1921 and four in 1922. The Grimm outyielded the common very decidedly in 1921, due to the injury to the common from freezing, already mentioned. The common contained much crabgrass and weeds in 1921, while the Grimm was very clean, so that the figures do not show the real superiority of the Grimm. In 1922, on the other hand, the common gave just a little larger total yield than the Grimm. The Station does not feel justified in making recommendations concerning the hardy alfalfas as yet, but it is suggested that growers plant most of their crop with the common variety and try an acre or so of Grimm.

There are various so-called regional strains of common alfalfa seed. It is generally believed that seed from Dakota, Wyoming, or other regions with extremely cold winters will produce alfalfa of greater hardiness than seed from a section having a milder climate. To what extent this is true has not been definitely proved. It is worth noting that the March freeze of 1921 injured the alfalfa grown from Dakota seed less than the common alfalfa. Of course Kansas seed is sufficiently winter hardy for Kentucky.

Turkestan alfalfa has proved decidedly inferior to the common variety in the eastern part of the United States and care should be taken not to get seed of this variety.

Inoculation

For its best growth, alfalfa must bear the nitrogen-gathering bacteria upon its roots. If grown without inoculation the crop draws upon the soil for its nitrogen and depletes it of this element the same as does a non-leguminous crop. Hopkins* has shown that alfalfa which did not bear the nitrogen-gathering bacteria not only made a smaller yield, but contained a smaller percentage of nitrogen.

The presence of these organisms is indicated by small nodules upon the roots. Care is necessary in looking for them, for if the plant is pulled up, the nodules may be stripped off. The proper way to make the examination is to take up a plant

*Ill. Exp. Sta. Bull. No. 76.

with a spade, leaving the soil adhering to its roots. The soil should be then carefully removed by hand or, still better, the plant thus removed may be placed in water to soften the soil, which is then washed from the roots. The nodules are about the size of a pinhead or a little larger, and appear when the alfalfa is from 3 to 4 weeks old.

Inoculation may be effected by using laboratory cultures, and treating the seed according to directions always furnished with the culture. Inoculation may also be effected by taking soil from an alfalfa or sweet clover patch known to be inoculated and scattering it at the rate of 200 to 400 pounds per acre and immediately harrowing it in. After alfalfa has come up it may be inoculated with soil scattered just before a rain, but this plan is not recommended unless the attempt to inoculate at seeding time has failed.

Another method of inoculation is to sprinkle inoculated soil over the slightly moistened seed, using about two quarts of soil per bushel of seed. The aim is to get as much of the soil as possible to stick to the seed and perhaps slightly better results may be secured by using a glue solution to wet the seeds instead of water. The solution is made by dissolving a pound of carpenter's glue in two gallons of water. The inoculated soil should be dried in the shade and put thru a sieve; a piece of window screen wire will answer. If just enough water is used and the soil is dry, the inoculated seed may be sown at once. This is probably better than drying completely as in the latter case some of the soil will drop off the seeds. In using the glue solution, some of the seeds stick together and must be rubbed apart with the hands or by putting thru a screen.

Some recent experiments at the Minnesota Experiment Station indicate that the commercial cultures are more effective than the use of small amounts of soil as indicated above. It was found that mixing dry inoculated soil with the seed in amounts equal in weight to the seed and sowing the mixture gave good inoculation. The use of a clover seed drill would be necessary in following this practis.

The value of a preceding crop of sweet clover for inoculating the soil has already been pointed out. Sowing some alfalfa or sweet clover seed with preceding crops of red clover or grass is an excellent method of inoculating soil for alfalfa.

Cutting and Curing Alfalfa

Time to Cut. The time for cutting is best determined by the apearance of new shoots at the crown of the plant and not by the appearance of bloom. Cutting should not be delayed after the new growth appears, as the delay not only injures the succeeding crop, but it may also prevent the cutting of an additional crop at the end of the season. If clipping is necessary to keep down weeds the first season, the rule may be disregarded, but under ordinary circumstances it is a safe one to follow.

General Practis in Curing. The same general practises apply in curing alfalfa as in curing any other kind of hay. Alfalfa, like clover, must be handled more carefully than the grasses to prevent the loss of leaves and bleaching by the sun. The leaves of alfalfa are thin, and when the hay is fully exposed to the sun on a hot day, they become dry and brittle long before the stems become dry. In this condition they break at the slightest touch and a large proportion is lost when the hay is raked or otherwise handled. As the leaves are the most nutritious part of alfalfa hay and constitute a considerable proportion of the total weight, the loss is serious.

It is seldom possible to prevent the leaves of alfalfa becoming dry before the stems are cured or to avoid bleaching the hay when curing is done entirely in the swath. Occasionally, however, in fairly cool or partly cloudy weather and especially when a light breeze is stirring, the hay can be dried out evenly if tedded or stirred once or twice a few hours after cutting. The last cutting of alfalfa comes in late September in this State and the opportunity to make good hay by curing in the swath is better than for any other cutting. Even when alfalfa can be cured successfully in the swath, it is necessary to rake it into windrows as soon as cured or it will quickly become so dry that it cannot be handled without loss. Curing in the swath is

the most rapid method, but as much labor is required as in windrow curing.

Under ordinary weather conditions the premature drying of the leaves can be prevented only when the curing process is completed in windrows or shocks. If hay is raked into windrows after partially curing in the swath, but before any of the leaves have become dry, a large proportion of the hay will be protected from the direct rays of the sun, and the curing will take place evenly by the transpiration of water from the leaves. In good haying weather, this is probably the most practical way of curing alfalfa, especially when a large crop must be handled with a minimum amount of labor. While not producing quite as good hay as shock curing, because more of the hay is exposed to the sun, yet a very good quality of hay can be obtained and the work can be done more rapidly and considerably cheaper than by shocking.

The ideal method of handling alfalfa is to complete the curing in shocks; in fact, the very highest quality of hay can be made only in this manner. Shock-cured alfalfa develops a flavor and aroma that can be secured by no other method of curing, the loss of leaves is reduced to a minimum and the natural green color of the hay can be retained. In addition, shocking alfalfa hay is about the only practical way of preventing serious loss when rains occur during hay harvest. If the hay is carefully shocked when partially cured, the shocks will shed water quite satisfactorily and the hay will be but slightly damaged, unless heavy or prolonged rains occur. By using canvas hay caps almost perfect protection from rain may be obtained.

The time of day when alfalfa is cut has so little influence upon the quality of the cured hay, if ineed any at all, that it may be disregarded. Wet hay is rather difficult to mow, however, and from the standpoint of convenience it may be desirable to let the dew dry off before starting the mower.

In order to prevent damage by rain the hay should be put into the shock, rick or barn as soon as possible. The curing can be hastened considerably by tedding the hay once or twice before

it has dried much or by stirring it in some other way. As already stated, to cure hay completely in the swath, stirring is very necessary. The tedder should never be used after the leaves have become dry. Hay cures more rapidly in the swath than in the windrow and where curing is completed in the windrow the alfalfa should not be raked up any sooner than is necessary to keep the leaves alive. Where curing is to be finished in shocks, however, the hay should not be allowed to become too dry before shocking or the shock will not turn water well.

Alfalfa will dry out more rapidly in tall, slender shocks than in shocks of large circumference. To secure protection from rain, a'falfa shocks must be kept well built up and packed down in the center so that in settling they will shed water well. Each forkful of hay should be put down so that the stems will be straight instead of being doubled up and mashed down. After finishing the shock the sides should be raked downward so that water falling on the shock may be directed outward.

Completion of Curing. Alfalfa cured in the swath or windrow is dry enough to put into barn or stack if the stems will break when a small handful is twisted several times. This is not a good test for shock hay, however, for it is generally tough and pliable. Shock hay is sufficiently cured when no moisture shows on a tightly twisted wisp drawn from the center of the shock. Alfalfa should, of course, be cured enough to keep, but over-cured hay loses in palatability; furthermore, it does not handle or fork well and is especially difficult to stack.

Opening Shocks. When alfalfa is cured in the shock, especially if put in rather green, it settles down so solidly that the water which is transpired from the leaves cannot readily escape. It collects on the surface of the hay and the hay is said to be "sweating." Unless they stand for several days it is generally necessary to open alfalfa shocks a few hours before hauling in, to permit this moisture to escape. The hay need not be scattered much, just enough to allow the air to penetrate freely.

Treatment of Wet Alfalfa. When alfalfa hay gets wet, ample time should be allowed for the surface of the hay to dry

before handling or stirring it. Where the hay is in windrows and the rain has been heavy, it will usually be necessary to open up the windrows slightly to dry out the hay near the bottom. This should not be done until the hay on the top of the windrows has dried. If the hay is in shocks, it should be handled the same way. Unless the water has penetrated the shocks deeply, however, the hay will usually dry without opening the shock at all. If wet hay is dried without getting much sun it will lose little of its color, but if scattered so that the sun strikes it fairly, nearly all the green color will be lost.

Baling from Windrow or Shock. Much alfalfa is now baled from the shock and some from the window. The economy of such a practis is very great where alfalfa is produced for market. In order that it may not spoil, alfalfa baled from the field must be perfectly cured, more so than is necessary for putting into the barn or stack. If baled when even slightly wet from rain or dew, it is certain to spoil. The bales should not be packed closely together in storing, the safest plan being to place the bales on edge a few inches apart and to place the next layer crosswise of these. It is hardly safe to attempt baling from the field when the ground is damp, or in cloudy, damp weather.

Curing Alfalfa on Trucks. The great difficulty of curing alfalfa and other kinds of hay in unfavorable weather has led to the extensive use of hay-curing trucks in some sections of the South. It is possible that their use would be profitable in Kentucky when it is desired to produce high-grade market hay. The curing truck is essentially a hay-rack mounted on an A-shaped frame, to the rear of which is attached a pair of low wheels. These trucks are moved by means of two-horse teams and a two-wheeled running gear. From 1,500 to 2,000 pounds of hay that has been cured enough to be shocked is loaded on the truck and carefully covered with a tarpaulin. The curing takes place in the same way as in the shock but, of course, the protection from rain damage is almost perfect.

Care of the Alfalfa Field

If the ground on which alfalfa is grown is free from weeds and grasses, it will need very little care after the stand is estab-

lished, but such fields are exceptional. Crab-grass and foxtail generally appear toward the latter part of the season. In case weeds and grasses appear, the ground should be harrowed immediately after cutting the alfalfa. The best implement to use for this purpose is the spring-tooth harrow or one of the special alfalfa cultivators. No injury will be done the alfalfa by harrowing. If weeds and grasses are to be controlled, cultivation should be given at the first opportunity after their appearance.

If the above-named implements are not available, the disk harrow may be used, but the harrow should be set so that it will not injure the crowns. The idea, once prevalent, that splitting the crowns was beneficial by causing greater branching has no foundation. If the disk is used, it should be followed with a sharp spike-tooth harrow.

The profitable life of an alfalfa stand varies, but usually in Kentucky it is not advisable to try to keep a stand more than four or five years. This is especially true in the Bluegrass region, where bluegrass frequently takes the field in this time.

Rotations Including Alfalfa

Probably no attempt should be made to introduce alfalfa into a rotation until one has learned on a small scale how to grow the crop successfully.

A practical rotation is four years of alfalfa followed by corn two years, with heavy manuring for the corn crop. The cultivation of the corn serves to rid the ground of weeds and grasses. Where alfalfa is grown on a small scale, potatoes, tobacco or some truck crops may be used instead of corn.

Another good way to bring alfalfa into a cropping system is to have one field more than the regular rotation requires and keep it in alfalfa while the regular rotation is being run on the other fields. For example, if a four-year rotation is being run, a fifth field lies in alfalfa, while a complete turn of the rotation is made on the other four fields. Then the alfalfa field is plowed up and brought into the rotation and field No. 1, previously employed in the rotation, is used for alfalfa, while a complete

turn of the rotation is made on fields No. 2 to No. 5. In this way each field is brought into alfalfa in its turn.

It is perhaps best, under Kentucky conditions, to keep a good alfalfa stand as long as possible, and then introduce two years of cultivated crops for cleaning the ground, after which it may be reseeded to alfalfa.

Feeding Value of Alfalfa

Alfalfa hay is palatable and is highly prized on account of its high protein content. The following table made up of figures taken from Henry and Morrison's "Feeds and Feeding" gives the protein content of a number of feeds:

	Lbs. crude protein per 100 lbs. feed.	Lbs. digestible protein per 100 lbs. feed.
Alfalfa	14.9	10.6
Wheat bran	16.0	12.5
Red clover	13.1	7.6
Alsike clover hay	12.8	7.9
Sweet clover hay	14.5	10.9
Soybean hay	16.0	11.7
Cowpea hay	19.3	13.1
Timothy hay	6.2	3.0
Redtop hay	7.4	4.6
Orchard-grass hay	7.9	4.7
Corn stover	5.7	2.1
Corn, grain	10.1	7.5
Soybean seed	36.5	30.7
Cowpea seed	23.6	19.4

Alfalfa and Soil Improvement

Alfalfa is a good crop for improving the soil, provided the manure made by feeding it is returned to the soil. Soils that are already in a fair state of fertility will not be materially improved by growing and removing alfalfa without the return of manure. This is well illustrated by results obtained on the Kentucky Experiment Station farm. A piece of land containing limed and unlimed sections was in alfalfa for three years, during which nine crops of hay were cut on the limed section, totaling approximately nine tons per acre, while the unlimed section

yielded a total for the period of less than five tons per acre, fully 50 per cent of which was weeds and grasses, the alfalfa finally failing. After the third year the field was plowed up and planted to corn, without any manure having been returned. The yield of corn on the limed land, following the good alfalfa, was fifty-seven bushels per acre, while following the poor alfalfa on the unlimed land it was sixty-four bushels per acre. No legume crop will greatly improve soils unless it is turned back to the soil or the manure made from it is returned. Further evidence of this fact might be cited if it were necessary. The reason is that legume crops do not get all their nitrogen from the air, but take a considerable part of it from the soil. The richer the soil is in nitrogen, the more the legume takes from it. Furthermore, the nitrogen gathered from the air is not all stored up in the soil and the roots of the plant, as is so often believed, but it is distributed thruout the entire plant. Since the larger part of the plant is above ground and is removed for hay, it follows that there can be but little gain of nitrogen when neither the crop nor the manure made from it is returned. In addition, the legume crops make heavy drafts upon the mineral plant-food elements which can be returned only thru returning the plants and manure, or by purchasing them in mineral form. However, when alfalfa is fed and the manure produced from it is returned to the soil, large gains in nitrogen may be made.

Pasturing Alfalfa

In this State alfalfa is so likely to be seriously injured by pasturing that it cannot be regarded as a very profitable pasture crop for most animals. Sheep, in particular, because they eat it off very closely, are likely to greatly injure alfalfa. Hogs, however, injure it much less if they are prevented from rooting by putting rings in their noses. Since alfalfa yields so much good forage for hogs, it has become quite popular with hog raisers in some sections. In pasturing alfalfa stock should be taken off occasionally and the alfalfa allowed to make considerable growth. This will strengthen the plants. Where all the old alfalfa is not eaten off, the pasture should be mowed over,

as this encourages the growth of new shoots. Stock should always be taken off an alfalfa field in time to permit the plants to make a fair growth for winter protection. It is not advisable to pasture alfalfa until it has been established for at least two years.