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FARM DEPARTMENT.

H. M. COTTRELL, M. S. . . . . Agriculturist.

GROWING ALFALFA IN KANSAS.

ALFALFA is adapted to a wide range of soils and climate. In Kansas it will make the greatest growth on rich, well-drained bottom land where the subsoil, while not sand or gravel, is porous. It has been grown for years on the farm of the Kansas State Agricultural College on high upland, where the subsoil is stiff hard-pan and where it is 180 feet to water. The yield on this land averages more than three tons per acre per year. On better land the yield is four to six tons per acre.

Alfalfa makes the strongest growth and lives longest on rather heavy land that is well supplied with lime. On sandy soils the growth is vigorous when moisture is abundant, but during drought alfalfa suffers severely on sandy soils. It is much shorter-lived on sandy than on heavy soils, one reason probably being the lack of potash and lime. It is somewhat difficult to get a stand of alfalfa on waxy, gumbo soils, but once a stand is secured heavy crops may be expected for many years, and the growth is less affected by drought than with other soils.

The writer has traveled thousands of miles in Kansas each year for the past five years, and has found profitable crops of alfalfa growing on almost all kinds of tillable soil. He believes that at least ninety per cent of the tillable land of the entire state is adapted to the growth

of alfalfa, and that there are very few farms anywhere in the state but what have some land that will grow alfalfa profitably.

Alfalfa is a profitable crop both on bottom land and upland, and under present conditions, on the greater part of the tillable land of the state, this crop will return a greater cash income year by year than any other feed crop raised.

CONDITIONS DEMANDED BY ALFALFA.

The young alfalfa plant is one of the weakest plants grown on Kansas farms. It grows slowly, is a weak feeder, and is easily checked or killed by weeds and by unfavorable conditions of soil, weather, or treatment. Mature alfalfa is a most vigorous plant. It grows down deeply in the soil, is a vigorous feeder, and lives and yields well under many unfavorable conditions. For this reason it will pay well to give the baby alfalfa plant good care and favorable surroundings for the first year of its life.

Moisture is an absolute necessity to the growth of the young plant and it should be held in the most favorable condition for plant growth. Land for alfalfa should be in the best of tilth and carry a full supply of moisture, without being soaked. Loose soils should be packed both before seeding and during the life of the plant, while hard soils should be made mellow. Both classes of soils should be put and kept in the best condition for holding and supplying moisture to the plant. Do not seed land to alfalfa until this condition is secured, if it takes two or three years to get it.

A good seed-bed almost insures a good stand of alfalfa. The stand to be secured from seeding alfalfa largely depends upon the condition of the seed-bed. As alfalfa is a costly crop to seed, and it is expected to furnish good crops for ten or more years after seeding, it is profitable to spend much labor on the seed-bed and get it just right. The land for alfalfa should be thoroughly fined on the surface to a depth of three or four inches; below this the soil should be mellow but compact, in such a condition as to hold moisture and to bring up the greatest amount of moisture from below.

The young alfalfa plant is a very weak feeder, and must have soil that is fertile and in condition to furnish plant-food easily. After alfalfa reaches maturity it can secure abundant food from tough, hard soils. Mature alfalfa adds nitrogen to the soil in large quantities, but the young alfalfa plant must be supplied with nitrogen in an easily available form or it will not thrive and will often perish. In Kansas this supply of nitrogen is secured cheaply in two ways — by a short fallow, and by growing some legume, such as soy-beans, Canada field peas, or cow-peas, on the land before it is fitted for alfalfa. Either of

these methods will put in the surface soil sufficient nitrogen in the right form for the young plant.

Alfalfa will not grow with wet feet. The land must be well drained, either naturally or artificially. It grows best where permanent water is fifteen or more feet below the surface. With thoroughly drained soils, it sometimes thrives where the ground-water is only six to ten feet below the surface, but not often. On hundreds of farms in Kansas alfalfa is a paying crop with the permanent water 30 to 180 feet below the surface.

To insure a good stand of alfalfa, the land must be free from weeds and weed seeds at the time of seeding. The weak, young alfalfa plant is more easily killed by weeds than any other farm plant. If it is desired to sow alfalfa on land that is foul with weeds, it will pay to plant some cultivated crop for a year or two and give such cultivation as will thoroughly clean the land. The additional yield of alfalfa secured through this preparation will repay for the expense and the delay.

Prof. William P. Headden found at the Colorado Experiment Station that each ton of alfalfa hay removed from the soil fifty-one pounds of potash, forty-four pounds of lime, and eight pounds of phosphoric acid. A ton of alfalfa hay contains forty-four pounds of nitrogen. The soil must furnish these materials.

The conditions demanded by alfalfa are abundant moisture, a perfect seed-bed, fertile soil at seeding, good drainage, and no weeds. The cheapest method to secure these conditions on the farm where alfalfa is to be seeded is the method to adopt. Each farm will require slightly different treatment from neighboring farms.

CONDITIONS UNDER WHICH ALFALFA WILL FAIL.

When alfalfa is covered with water from forty-eight to seventy-two hours it dies. There is some land in Kansas on which alfalfa cannot be grown that is suited in every other way to alfalfa, except that it is subject to overflow. An overflow where the water stays on less than twelve hours seldom injures alfalfa, except from washing, but where the water stands two or three days the alfalfa will be killed. On close soils alfalfa sometimes kills out in spots, because there are low places or small depressions where water stands. On such soils, care should be taken before seeding to have such depressions treated so that the surface-water will drain from them quickly. This can usually be done with shallow open ditches or furrows. Alfalfa must not have standing water on it or it will die. Alfalfa will not grow in water-soaked soils. In swampy ground and in poorly drained soils the roots will rot and the plants die.

Alfalfa will not grow where permanent water comes too near the

surface. Under most conditions alfalfa does best where permanent water is twenty to thirty feet below the surface. In loose land it frequently does well where permanent water stands as close as ten feet to the surface, but in such cases the soil above the permanent water must be well drained. During spring rains alfalfa may thrive for a short time if the ground-water does come much closer to the surface than the distances given, but the shorter the time in which this water stays close to the surface the better it will be for the alfalfa.

Alfalfa does not grow well where the subsoil is loose gravel, unless there is a good body of good soil above the gravel.

In some places in western Kansas the ground-water is sufficiently close to the surface for good results, but between the surface-soil and permanent water is a layer of dry sand that cuts off the connection between the surface-soil and the ground-water. With such conditions alfalfa will die in time of drought. Under the same conditions cottonwood trees will die and corn will be a failure. These conditions are not common, and where they do occur one farm will often be found to have them while on adjoining farms the strata of sand is either absent or moist and alfalfa thrives. A rule that holds true, with some exceptions, in all parts of Kansas is that alfalfa land is land which will grow regularly good corn and cottonwood trees.

CROPS TO RAISE BEFORE SEEDING TO ALFALFA.

When every condition is favorable, alfalfa may be seeded on freshly turned prairie sod that has been well fined. More often alfalfa fails on sod, and does best when seeded after the land has been cropped for two or three years.

With land that has been under cultivation for many years crops must be grown that will free the land from weeds and put it in good mechanical condition. Corn and potatoes are both good crops for this purpose. On stiff, hard land, millet is a good crop to mellow up the soil, but it must be cut when the heads appear. If left until some of the seeds harden, enough will shell off to seed the ground, and volunteer millet is one of the worst weeds young alfalfa has to contend with.

Many farmers have found difficulty in securing a stand of alfalfa that followed sorghum or Kafir-corn. Both of these crops exhaust the soil of water more than other farm plants, and if the ground cannot be put in good condition and become well supplied with moisture from the surface to a good depth after sorghum or Kafir-corn has been harvested, it will be useless to seed alfalfa. Usually good conditions for alfalfa can be secured following these crops if the ground is well plowed, packed daily as it is plowed, and thoroughly harrowed as fast as packed. In Barber county this year, with scant

early rainfall, an almost perfect stand of alfalfa was secured with these methods on land which last year grew a heavy crop of sorghum.

The best crop to raise on land before seeding to alfalfa is some legume, such as Canada field peas, soy-beans, cow-peas, or clover. The legumes have the double value of putting the land in good condition and of adding nitrogen and vegetable matter to the soil in just the form needed by the young alfalfa plant. Canada field peas should be sown in March with oats, sowing two bushels of each per acre. Cut when the oats are in bloom and a heavy yield of good hay is secured. Soy-beans may be planted late in May, and will be ready to harvest in August. Both Canada field peas and soy-beans are off the ground in time for thorough preparation of the soil for fall seeding of alfalfa. Cow-peas and Red clover are especially valuable to grow the previous season, when alfalfa is to be seeded in the spring. If the land is weedy, soy-beans and cow-peas have the advantage that they may be cultivated.

Red clover is a good plant to grow before seeding to alfalfa on soils that have a hard-pan subsoil which holds water and prevents good drainage. Red clover is much more vigorous than young alfalfa, and will grow down into the hard-pan under conditions that will kill young alfalfa. After the Red clover has stood two years or more and has penetrated the hard-pan to a good depth, the ground can be prepared and seeded to alfalfa. The decaying clover roots will keep the hard subsoil open and drained, and furnish nitrogen to the alfalfa plant until it reaches full vigor, when it will yield a much larger crop than clover, live for many years, and each pound of alfalfa will be worth considerably more than an equal amount of clover.

PREPARATION OF THE SOIL.

The ground for alfalfa should be thoroughly pulverized and deeply plowed, but it must be well settled before seeding and only the surface loose. Alfalfa will usually fail if seeded on freshly plowed ground. If it is necessary to plow the ground before seeding, plow as early as possible, harrow thoroughly, making a good seed-bed, and then wait until a good rain has settled the soil before seeding.

A well-cultivated corn-field, with the stalks cut and drawn off, will give ideal conditions for seeding alfalfa. Such a field should not be plowed, but harrowed, before seeding. Wheat, oat, flax and millet stubble ground, plowed, disked and harrowed thoroughly, and allowed to settle before seeding, furnishes good conditions for alfalfa. If such ground is mellow plowing may not be necessary, and the land will need only to be disked and cross-disked.

A careful farmer and a careless renter a few years ago put in alfalfa in adjoining fields in northeastern Kansas. The farmer plowed the

land deeply and pulverized it until it was like a garden-bed. He immediately sowed alfalfa, secured a thick stand, and in a few months the alfalfa entirely died out. The renter thought it would not pay to spend much time on another man's land. His field had been in corn the previous year. He broke the stalks with a pole, sowed the seed broadcast, and covered it lightly with a harrow. He secured a good stand that was permanent. Usually a good stand cannot be secured with so little preparation, but a deep, mellow seed-bed at seeding time generally insures a failure. The more thoroughly the seed-bed is prepared the better, if it is allowed to settle before seeding.

The ground must be deeply pulverized, well settled, with a good mulch on the surface, and saturated with moisture, so as to bring up the seed quickly and force growth. If any of these conditions are lacking do not sow.

On clay lands to be sown in the spring, we prefer deep plowing in the fall, followed by a thorough surface preparation without plowing in the spring. Hard and waxy subsoils that hold water and prevent good drainage may be greatly improved by listing deeply late in the fall, putting the furrows close enough together to make a sharp ridge instead of a flat one, as in listing for corn. Such land will freeze through and through, the ridges will freeze and thaw each warm day during the winter, and the deep furrows allow the subsoil to be frozen to a good depth. The alternate freezing and thawing of the ridges make much plant-food available that the plant could not secure otherwise, and the freezing of the tough subsoil has a tendency to granulate it and make it porous. Often this effect will last for several years, by which time the alfalfa has attained such a vigor that the unfavorable soil does not affect it. Land listed in the fall for alfalfa should be leveled in March and, as leveled, have a good surface mulch provided to retain the moisture. This is very important on firm soils.

With either spring or fall seeding, if the land needs to be plowed, we harrow each day's plowing the day it is plowed. As soon as the surface has become dry we go over the ground with a Campbell subsurface packer. This is an implement which consists of a series of wheels mounted on a shaft. The wheels are about thirty inches in diameter and are placed six inches apart on the shaft. The rims of the wheels are sharp, so that they press and cut into the ground, and a six-foot machine is weighted to nearly a ton.

The packer leaves the soil firm at the bottom of the furrow and loose at the top. The firming of the bottom soil makes a good connection with the subsoil and puts the soil in such condition that the water in the subsoil is brought up by capillary action to the soil in which the roots grow. The loose surface-soil as left by the packer

forms a dust mulch that prevents the evaporation of moisture from the surface. We follow the surface packer with a harrow, and harrow or disk every ten days until seeding.

On loose and sandy soils the preparation of the soil is different, the need on these soils being to compact the land as much as possible. One of the best preparations for loose soils is to grow legumes for a year or two, to add vegetable matter to the soil and help hold it together and retain the moisture. The cow-pea is one of the best plants for this purpose.

In Kiowa county good stands of alfalfa followed by heavy yields have been secured on very sandy land by sowing the land to wheat. After harvest volunteer wheat and grass sprung up, and through the fall and winter these were pastured heavily, the object being to pack the soil with as much trampling as possible. Early in the spring the trash on the ground is burned, and the alfalfa drilled in without the ground being stirred with either harrow, disk, or plow. In a favorable season a good stand is secured. In an ordinary season, the fall after seeding there will be patches of alfalfa and patches of sand-burs. The entire field is again pastured through the fall and winter, in order to secure more packing. Early in the spring the trash is again burned off and the bare places again seeded to alfalfa with a drill, without the soil being stirred. In two or three years a good stand is secured all over the field. Such treatment will only succeed with very loose soils and light rainfall. On heavy soils such treatment would insure an absolute failure.

For fall seeding we disk the ground the day the crop is removed, if possible. Where the land has been in wheat or oats, we disk as soon as the crop has been shocked, running the disk around the shocks. The disking should be deep enough to form a good earth mulch. As soon as convenient after disking, if the land needs plowing, it is plowed, harrowed, and packed, as previously described, and then cultivated, disked or harrowed every ten days thereafter until seeding. The repeated cultivation keeps the surface fine, compacts the subsurface, aids in retaining moisture, promotes the formation of the nitrogen compounds so much needed by the young alfalfa, and rids the land of weeds. After each cultivation a crop of weeds starts up to be killed by the following cultivation.

The seed-bed is the most important factor in securing a stand of alfalfa. The conditions needed in a seed-bed have been fully described, and some of the methods of securing them have been given. Each farmer should treat his land in such a way as to best secure these conditions cheaply.

WHEN TO SOW.

Sow whenever the soil, moisture, seed-bed and weather are in the proper condition. Do not sow until you have all of these right, if you have to wait a year or two. Alfalfa yields crops for many years from one seeding, and several crops each year. A poor stand means a low yield every cutting every year, so long as the alfalfa stands.

In general, it may be said that fall seeding is advisable wherever the proper conditions of seed-bed, in regard to moisture and mechanical condition, can be secured in August or early September. In some years, in some sections of Kansas, the conditions for fall sowing may be secured but grasshoppers will destroy the young plants.

From the east line of Kansas westward for 120 miles, spring seeding of alfalfa fails more often than it succeeds. In 1900, in Wabaunsee county, a farmer secured a heavy stand of alfalfa from fall seeding on a field where he had tried spring seeding for four years in succession and failed. Alfalfa seeded in September, 1900, yielded its first crop of hay May, 1901.

West of a line 120 miles west of the eastern line of the state, fall seeding of alfalfa is not so certain. If conditions are right it will pay; otherwise spring seeding is best. When a good stand can be secured fall seeding has many advantages. Alfalfa may be seeded in the fall, after another crop has been taken off. The next year it will yield full crops of hay and no time is lost. Alfalfa seeded in the spring usually yields no hay until the following year, and requires mowing several times during the first summer to keep the weeds down. Alfalfa sown in the fall under proper conditions requires no attention whatever until the following spring, when a crop of hay is ready to be harvested.

It must be remembered, though, that conditions must be right or fall seeding will fail, as a vigorous growth must be secured in order to carry the alfalfa through the winter.

Alfalfa may be sown from August 15 to September 15, and, if the season is favorable, will make a vigorous growth through the fall and go through the winter in good condition. August sowing is preferable, as it gives the alfalfa a longer time in which to grow before the ground freezes.

In the winter of 1901-'02 hundreds of acres of alfalfa seeded in the fall of 1901 in Kansas died. During the three previous winters there were but few reports of winter-killing. In the same winter and spring Secretary Coburn reports that 34.5 per cent. of the entire area in the state seeded to winter wheat was plowed up or abandoned. The conditions were these: There was an extreme drought in the summer of 1901. Late in the season good rains fell, which were sufficient to supply the soil with moisture to the depth of plowing, but the subsoil

remained dry. There was little snow and rain during the winter, and continued high winds during the spring, which exhausted the moisture in the surface-soil and blew plants out of the ground. There was no reserve moisture in the subsoil to draw on. Such conditions are not frequent in a large area of the state.

In the western part of the state the best conditions in regard to moisture are found in the spring, and spring seeding is generally preferable. The seeding should be done as early as possible and avoid heavy frosts. In the northern half of the state, the first fifteen days of April is usually the best time. In the southern part of the state, seeding may be done slightly earlier. The majority of failures in spring seeding, when the ground is properly prepared are due to late sowing. With late seeding, the weeds are liable to get ahead of the young plants and the supply of moisture is less likely to be sufficient.

On land that has been cropped for several years it is easiest to get a stand with fall seeding, if proper conditions can be secured, and land seeded to alfalfa in September will ordinarily yield a good cutting of hay in May—less time than a grain crop could be produced on the same land. When old land is seeded in the spring a good stand is easily secured; as soon as hot weather comes crab-grass starts to grow, and frequently before the ground freezes has smothered the alfalfa in large spots through the entire field, and it is very difficult to reseed these without destroying what alfalfa has lived and then reseeding the whole field. Seeded in the fall on old land, alfalfa becomes so vigorous by the time crab-grass starts in the summer that it is able to overcome it.

VARIETY.

There is only one variety now on the market; that is the common alfalfa. The Turkestan has been tried here for several years, and so far has been found to make a weaker growth than common alfalfa, is less able to withstand drought, winter-killing, and weeds, and yields less. Until a better strain is introduced, Kansas farmers will have no use for it.

We have not been able to make a satisfactory trial in plats of seed from different sources, although the attempt has been made several times. From observation on our fields and on fields in many sections of the state, we think that it is probable that it is best to secure seed from the same latitude or a little north of the place where the seed is to be sown. We prefer seed grown as near the place of seeding as practicable, and a number of seedings have indicated that seed from land not irrigated will produce a better stand under unfavorable conditions than will seed from irrigated land. Plump, bright, fresh seed, from either irrigated or not-irrigated fields, will produce a good stand

under good conditions. If a beginner is doubtful about his soil being adapted to alfalfa, we recommend that he thoroughly prepare the soil along the lines indicated, and then use choice seed from land not irrigated. If good, large seed can be secured from alfalfa grown on upland, so much the better. The plants have had to withstand more unfavorable conditions than those better situated, and if they have made a strong growth they possess great vigor.

The leaves of alfalfa contain nearly four times as much protein as the stems, and, according to Prof. W. P. Headden, of the Colorado Experiment Station, the leaves form from forty to sixty per cent. of the weight of the entire plant, varying with different plants. There is a great opportunity for the seed-breeder who will breed up and furnish seed from plants yielding the greatest weight of leaves to the acre. Plants should be selected that retain their leaves well while curing.

SEED.

We recommend twenty pounds of seed per acre. With every condition favorable, experienced alfalfa-growers sometimes succeed in getting a good stand by using ten to fifteen pounds of seed per acre, but this small quantity is not generally sufficient. Where there are indications of dry weather to follow seeding or other unfavorable conditions, we sometimes use thirty pounds of seed per acre. It pays to use enough seed to secure a good stand, as alfalfa, unlike clover, never thickens and the number of plants per acre tends to continually decrease.

Good seed is the cheapest. Especial care is necessary to secure seed that is free from admixture of the seed of Russian thistle.

HOW TO SOW.

If the soil and the air are moist, the most even stand is secured by sowing the seed broadcast. Cover lightly with a harrow and then roll, unless there is danger from blowing. If the weather is dry or there is much wind, broadcast seeding is a failure. The seed germinates close to the surface of the ground, and the wind dries out the soil and kills the young plants almost as fast as they start.

Generally the best way to sow alfalfa is with a press-drill. Mix the seed with equal parts by measure of coarse corn chop, bran, or fine sawdust; drill and cross-drill, sowing half the seed each way. If either a hoe or disk drill is used, care must be taken not to get the seed too deep; about twelve times the diameter of the seed is the proper depth, if this places the seed in moist soil. The press wheels pack the moist soil closely around the seed, causing quick germination. Occasionally a heavy beating rain will fill up the drill furrows before the seed has germinated, and bury it so deeply that the young plants die before

they can get to the surface. In the fall of 1901, this Station lost twelve acres from this cause. This difficulty is not common.

Alfalfa should be sown alone. It does not want a nurse crop. Sometimes a good stand is secured when alfalfa is seeded with some other crop, but many times it fails utterly. Young alfalfa is a delicate plant, and it needs all the moisture, plant-food and sunshine available, and usually when it has to share these with another crop it dies.

TREATMENT AFTER SEEDING.

Sometimes a heavy rain will fall just after alfalfa has been seeded, and a crust will form on heavy soils that the young plants cannot penetrate. A very light harrowing or loosening of the surface with a weeder will sometimes save the stand.

On most land, spring-seeded alfalfa will need to be run over with a mower three or four times to keep the weeds down. The mower should be set high, and the weeds mowed so often that when cut and allowed to remain on the ground they will not smother the alfalfa. Some good alfalfa growers mow the alfalfa three or four times the first season when there are no weeds, as they find that the pruning of the young plants makes them more vigorous. The cut vegetation should be left on the ground to act as a mulch. If mowing has been delayed until the weed growth is heavy, it is often necessary to cut the weeds, rake, and take them off the ground, to prevent smothering of alfalfa.

Fall-seeded alfalfa needs no attention until the following May, when a crop is ready to cut for hay.

No stock of any kind should be allowed on alfalfa the first year of its growth.

HABITS OF GROWTH.

In determining the methods to use to maintain a good stand of alfalfa after one has been secured, and to get the greatest yield with the highest feeding value, it is necessary to consider the habits of growth of alfalfa.

Alfalfa sends down deep into the soil a large tap-root. From this tap-root numerous large side-roots branch out. Frequently the tap-root will divide, sometimes several times, each main branch growing downward. We have followed this tap-root to a depth of ten feet in stiff hard-pan subsoils in eight-year-old alfalfa without finding the end. The roots extend fifteen to thirty feet and more in depth, in fairly good soils. Sec. F. D. Coburn, in his book “Alfalfa,” records an instance of a mining tunnel being driven into the side of a mountain below an alfalfa field. Alfalfa roots came through the roof of the tunnel, which was 129 feet below the surface of the alfalfa field.

The young plant consists of a number of branches springing from

a central stalk. As the plant becomes older the larger of these stems thicken close to the base of the plant, and spread out along the ground nearly horizontal, the entire group of branches forming a crown. Each of the thick branches which form the crown sends up stalks. Sometimes a branch will send down a second tap-root, but with most plants this is not the case. May 28, 1902, an examination of alfalfa ready to cut showed an average of eleven full-grown stalks to each root. The least number of stalks found in this field growing from one root was two, and the greatest was thirty-nine. The field was high upland, and the stand good. The alfalfa was four years old. May 6, 1901, we found an alfalfa plant which from a single root had 312 stalks which had grown to a height of ten inches. This plant was found in a field of alfalfa growing on high upland, the subsoil a stiff hard-pan, and permanent water 180 feet below the surface.

When the upright alfalfa stems are cut in grazing or haymaking the stubble dies down to the branches which form the crown, and new branches start up from buds on the crown. When young alfalfa is grazed closely a crown cannot form, and continued cropping weakens the root, and the plant dies. If old alfalfa is closely pastured, and the branches forming the crown are eaten off, there is no way in which the plant can throw up new stems, and it dies. Moderate grazing and mowing leave the crown uninjured.

When the crown is bruised or slightly cut, as in harrowing and disking, new buds are developed, and the number of branches or stems thrown up by the plant is increased.

The depth to which alfalfa roots penetrate enables the plant to secure water when the surface-soil is suffering from drought, and puts within its reach many times the quantity of plant-food available to shallow-rooted farm plants.

The first growth in each season blossoms very irregularly, some plants bearing ripe seeds when their neighbors are just coming into bloom. The period of blossoming extends with the first growth through three weeks or more. With the second and third crops of each season blossoming is more uniform, the greater proportion of the stem coming in bloom within a few days with the third crop. As soon as the plant reaches full bloom it begins to shed its leaves, and when the first crop is left standing until the latter third of the plants have bloomed, a large part of the field will show almost bare stems. This makes it necessary to out on the first appearance of bloom for a full crop of hay. Alfalfa cut early usually makes in Kansas three crops of hay and a good growth of aftermath. Four crops of hay are not uncommon. When the alfalfa is not cut until full bloom or after, the growth for the remainder of the seasons is severely checked. This

is particularly true of the first cutting of each season. For this reason, when our best alfalfa-growers want seed they prefer to cut the first two crops of the season for hay and save seed from the third crop. The yield of seed from the third crop is greater on account of the more uniform blossoming and ripening. The vigor of the plant is promoted if a good growth of aftermath is allowed to remain on the ground through the winter without cutting or pasturing.

Cutting acts as a tonic to alfalfa. Whenever alfalfa does not thrive, cut it. This applies throughout the life of the plant, from the time it first becomes high enough to cut with a mower and through all the years of its life. Whenever alfalfa begins to bloom, cut it, no matter how short, unless seed is desired. In time of prolonged drought alfalfa will sometimes begin to bloom when only five or six inches high. Cut it as soon as the first blooms appear, if it is so short that the hay cannot be raked and has to be left to waste on the ground. The vigor of growth and the yield of the crops that follow require this. When alfalfa is cut and fed green it is usually cut before any blossoms appear. When this is done a much greater total growth for the season is secured than when the cutting is delayed until the blooms appear. It is not practical to cure for hay when cut before any bloom appears.

When it is given reasonable care, alfalfa may be expected to furnish full crops for at least ten years. Under the best conditions of growth and care, alfalfa will live and yield well for 20 to 150 years.

DISKING.

Our first experience in disking alfalfa was in 1898. A field had been seeded to alfalfa in the dry year of 1894 and a poor stand secured. In 1897 this alfalfa was heavily pastured by hogs. The hogs were taken off early in the fall, and a heavy growth of crab-grass came up. The crab-grass was so thick, and the stand of alfalfa so thin, that it was not worth keeping.

Late in March, 1898, this field was harrowed with a disk harrow, the disks sharp, and set at as great an angle as possible. It was immediately cross-disked, with the disks set the same way. The ground was thoroughly pulverized and the alfalfa apparently destroyed. It soon started, branched out thickly, and we made three good cuttings from that field that summer.

In 1900 we went a step further in disking alfalfa. The season was very dry at Manhattan, the rainfall in June being 1.19 inches, in July 4.51 inches, and in August 2.84 inches. Two fields of alfalfa, two years old, were disked.

One field was disked March 28, the first cutting for hay made May 31, disked June 6, the second cutting for hay made June 25, disked June 27, the third cutting of alfalfa made August 13, and the alfalfa disked for the fourth time August 20. The last cutting of alfalfa was

made September 13. This shows four diskings and four cuttings of alfalfa on upland in a dry year. Another field of alfalfa was disked and cross-disked March 27. The first cutting of alfalfa was made June 4 and the second disking June 6. Through July and the early part of August the alfalfa was cut from day to day and fed green to dairy cows, to help out dried-up pastures. August 20 the field was disked, and October 3 the last cutting of alfalfa was made.

The alfalfa in both fields made fine late fall growth and went into the winter in good condition.

The stand of alfalfa on both fields disked in 1900 was good. A harrow with sharp 16-inch disks was used, the disks being set at a slight angle, just sufficient to turn the soil over, and the harrow was weighted to make the disks split the alfalfa crowns to a depth of two inches. The disking split the alfalfa roots, and this made them throw out many new shoots. The disking made an earth mulch over the field, and prevented the evaporation of water, so rapid in a dry time from an alfalfa field just after being cut. The disks were set so that they barely turned the soil over, and, running at a depth of two inches, they turned the roots of the crab-grass and weeds up to the sun, which killed them. These disked fields were clean and free from crab-grass in the fall.

In 1901 we made a trial of disking one-year-old alfalfa and secured good results. In disking alfalfa at this age the disks must be set more nearly straight than with older plants. The disks must be set so that they will not cut the tap-roots and the harrow can be weighted to make it cut two inches in depth.

Disking has the same good effect on alfalfa that cultivation has on corn. We recommend that every year the alfalfa be disked early in the spring. We would prefer to have it disked in the spring before growth has started, but in 1901 we disked alfalfa when six inches high, without injuring the plants. Disk immediately after each cutting throughout the season, no matter how often the alfalfa is cut. The disking will make the crowns throw out many new shoots, will form an earth mulch over the land, preventing loss of water from the soil, and will kill weeds and crab-grass. In dry, hot weather alfalfa should be disked the same day the hay is removed, if possible, as a week's exposure of the soil to sun and winds without disking may cause the evaporation of an inch of moisture.

If the stand of alfalfa is fair to good, set the disks at the least angle at which they will turn the soil over, and weight the disk harrow to make it cut into the crowns to a depth of two inches. If the alfalfa is old, and the growth of crab-grass thick, set the disks at as great an angle as possible, and if this does not tear the soil and alfalfa roots pretty thoroughly, cross-disk with the disks set the same as for the

first harrowing. A disk harrow will not hurt an old alfalfa root, and will usually do it much good.

When disking, the ground should be stirred and pulverized sufficiently to form a good earth mulch two to three inches thick. In midsummer, on hard, dry soils, it may be necessary to disk and cross-disk to secure this result. On loose, sandy soils, a light disking, or even harrowing with a smoothing harrow, may produce this mulch.

As stated under the previous heading, whenever alfalfa does not thrive, cut it. Immediately after cutting the alfalfa, disk it, and disk it thoroughly. If the succeeding growth is not healthy, cut and disk again, and repeat these operations until a thrifty condition is secured. Unless alfalfa is hopelessly injured from some cause, this treatment will put it in good shape.

WHEN TO CUT ALFALFA FOR HAY.

Alfalfa should be cut when not more than one-tenth of the plants have come in bloom. Cut at this early stage, the yield of hay for the season will be much greater than if the alfalfa is cut near maturity, and every pound of hay secured will be worth more for feed.

We cut a strip through a field of alfalfa when one-tenth was in bloom; another strip was cut after full bloom had passed. The strip cut early was nearly ready to cut the second time when that cut after full bloom was being harvested the first time. The strip cut early grew vigorously through the season and made three cuttings and a good aftermath. The strip cut after full bloom gave a low yield the first cutting, and did not grow sufficiently to yield a good second cutting. Early cutting invigorates the plant.

The late cutting of the first crop seems to injure the plant more than at any other time, and we have found it profitable to cut alfalfa the first time as soon as one-tenth was in bloom, even though the weather was bad and we knew that the crop would spoil in curing. The increased yield from succeeding cuttings over that out late much more than makes up for the loss of the first crop.

Successful clover-growers the first time they try alfalfa often ruin the stand, so that it has to be plowed up, by waiting to cut until it reaches the stage at which clover is usually cut.

The great value of alfalfa is the large amount of protein it contains, that material in feed that is absolutely necessary for the formation of blood, lean meat, and milk. The higher the protein in alfalfa, the more valuable the crop. The chemical department of this Station found the effect of cutting alfalfa at different stages as follows:

	Protein
One-tenth in bloom	18.5 percent.
One half in bloom	17.2 "
In full bloom	14.4 "

The Colorado Experiment Station found the effect of cutting alfalfa as follows:

	Protein.
Coming in bloom	18.5 per cent.
Half in bloom	14.6 "
In full bloom	12.9 "

The Utah Experiment Station for five years cut alfalfa at different stages of maturity and fed the crop in producing beef. The average production per year per acre was as follows:

	Hay.	Beef.
In first bloom	5.35 tons.	706 lbs.
In full bloom	4.90 "	562 "
Half blooms fallen	4.55 "	490 "

These experiments made in three states — Kansas, Colorado, and Utah — prove that alfalfa cut in the first bloom will give the greatest yield and feeding value.

HOW TO CURE ALFALFA.

The leaves of alfalfa contain nearly four times as much protein as the stems, a ton of dried alfalfa leaves containing as much protein as 2800 pounds of bran. Every effort, then, should be made to cure the alfalfa in such a way as to save all the leaves possible. The method of curing will vary with the condition of the crop, ground, and weather. When alfalfa has made a slow growth, and at the time of cutting the ground and the weather are dry, there is no difficulty in curing. Often, under these conditions, it is safe to rake within a few hours after mowing, and stack a few hours after the alfalfa has been put in the windrows. When alfalfa has made a rapid growth, and is rank and succulent, and the weather and ground are damp, the problem of curing is a difficult one. It is easy to dry the leaves, but the stems will contain much moisture after the leaves are too dry. Alfalfa hay should become so dry before stacking that when a handful of stems are twisted together no water can be squeezed out. The most practical way to accomplish this, and at the same time save the leaves, is the plan to adopt, and this will vary with different seasons and places.

There is usually no difficulty in curing any but the first crop. When the conditions for curing the first crop are unfavorable, we have usually found the most practicable methods to be to cut the alfalfa early in the morning, after the dew is off, allow it to barely wilt in the swath, then rake, and before night put in narrow, tall cocks. After the dew is off the next morning and the surface of the ground has become dry, we open these cocks carefully, so as not to shatter off the leaves. If the weather is favorable the hay may be stacked in the afternoon; if not, we recock carefully, and repeat treatment until the hay is properly cured.

Some alfalfa-growers, in stacking the first cutting of alfalfa, put alfalfa and dry straw or prairie hay in alternate layers; this is a satisfactory way if the dry material is available. Others use ten to fifteen pounds of salt or air-slaked lime to each ton of hay, sprinkling the salt or lime so as to cover as much of each load as possible. Experiments made at this Station indicate that considerably less gains are made by cattle when salt is mixed with the feed. A trial of lime on alfalfa, made at this Station, showed little effect.

SPONTANEOUS COMBUSTION OF ALFALFA.

This subject has been treated fully in Bulletin No. 109 of this Station, and will be treated briefly here.

There were many instances during the summer of 1901 of alfalfa hay becoming so hot that it took fire by spontaneous combustion and was destroyed. A single instance will give an idea of the conditions under which this took place.

J. L. McCormick, Zeandale, Kan., had alfalfa hay on rich bottom land. It made a rank growth, and was cut late in May, when the first blooms appeared. It lay in the swath about one and a half days, when it was put in windrows with a side-delivery rake. After curing in the windrows one to two days the alfalfa was gathered on wagons with a hay-loader, and placed in a stack with a stacker. The stack was built thirty feet wide, thirty feet high, and of sufficient length to hold 150 tons. Two months and a half after stacking fire broke out. The stack settled badly in the middle, and two or three weeks before fire broke out several loads; from the second cutting of alfalfa were placed on the top of the stack, to fill out where settling had taken place. At that time the stack was quite hot and the smell of heating alfalfa was strong, but no danger was anticipated. The hay kept getting hotter, and it was decided to take the stack down and save as much hay as possible. One end was taken off safely. After the top of the stack near the middle had been taken off for several feet, the hay was so hot that men could no longer stay on the stack. A few minutes afterward smoke burst out at the ground all along the stack. Men cut two feet into the side of the stack, and a blaze started. This was kept smothered with water until fifty tons of hay had been taken away, when the fire could not longer be controlled, and what hay remained was burned.

All cases of spontaneous combustion of alfalfa hay that have come to our notice have occurred with the first cutting. Early spring growth of alfalfa in an ordinary season is rank. The alfalfa was cut either in May or early in June, and at this time of the year the weather is such that it is difficult to thoroughly cure the alfalfa without getting it wet. Usually there is considerable damp weather and

little wind after the first cutting is put in the mow or stack, and this hinders further drying. With later cuttings the growth is not so rank and succulent, and the weather is dryer, and there is often wind. This makes curing easy.

At this Station we have not had alfalfa heat sufficiently to take fire, but we have it become so hot that, as a matter of safety, we took it out of the barn several weeks after putting it in the mow and stacked it out of-doors. We have had so much trouble with the first crop heating, that for the past four years we have stacked it outdoors and put the other cuttings in the barn. We have cured the first cutting as carefully as we knew how, keeping it several days in cocks, putting covers on the cocks at night, and opening the cocks during the daytime; and with all these precautions, if there came a week or more of wet, "muggy" weather in July or August, the alfalfa hay would become hot. If the weather stayed dry, no heating took place. The College barn is of stone, and is well ventilated at the roof above the mows. In all cases of spontaneous combustion given in this bulletin the alfalfa was handled as little as possible, and was turned but little. This resulted in the leaves becoming dry, while the stalks contained considerable moisture. Where weather conditions were favorable, this moisture in the stems was sufficient to promote fermentation, and in the cases given the fermentation generated sufficient heat to start a fire. Usually alfalfa will not get hot enough to do this, and the heating causes little damage. It is quite common to find alfalfa hay from the first cutting that is brown or black from the heating, and the cattle eat it with relish.

LOSSES IN CURING.

Prof. William P. Headden found, at the Colorado Experiment Station, that in an average alfalfa plant the stems amounted to forty to fifty per cent. of the weight of the plant, while with very leafy, small-stemmed plants the leaves sometimes form more than sixty per cent. of the entire weight. The leaves were readily lost if the hay was not handled carefully. He concluded from his experience and observation that the minimum loss from the falling off of the leaves and stems in careful haymaking amounts to from fifteen to twenty per cent.; and, in cases where the conditions have been unfavorable, as much as sixty or even sixty-six per cent. of the entire dry crop is lost. Stated in another way, with the best of conditions for making alfalfa hay, and with great care, for every ton of hay taken off the field, at least 350 pounds of leaves and stems are left scattered on the ground. With unfavorable conditions and careless handling, for every ton of hay taken off the field, 3000, and in very bad cases as much as 3800, pounds are left and lost.

A study of these facts will induce the careful haymaker to use all possible skill in curing alfalfa, and they show that it will be profitable to expend more than the usual amount of labor in saving the leaves.

THEORY OF MAKING ALFALFA HAY.

In making alfalfa hay all the leaves possible must be saved, as they are worth, pound for pound, nearly four times as much as the stems, and to avoid heating and spontaneous combustion the hay must become so dry before stacking that when a handful of stems is tightly twisted together no moisture can be squeezed out.

After the alfalfa has been mown, the leaves, so long as they remain alive, pump moisture out of the stems and exhale it through their pores into the air. After the leaves become dead, the only way moisture can escape from the sterns is by evaporation, and this is a slow process unless the weather is hot and the air dry.

When newly cut alfalfa is spread out directly to the hot sun the leaves are quickly dried and killed, and their help in exhausting the water from the stems is lost. When this is done the leaves may become so dry in a short time that they may easily be crumpled to powder, and the outside of the stems will appear dry, while on the inside the stems are almost as full of moisture as when cut.

Alfalfa should be cured as rapidly as possible and handled as little as possible, because the great loss in curing comes from the shattering off of the leaves and delicate stems. The longer the leaves can be kept alive the more quickly the alfalfa will cure. The less the leaves are exposed to the sunlight and the more the stems are exposed to the air, the quicker the hay will be cured. The best method of doing this will vary with the conditions of temperature, dryness of air, and amount of wind. The digestible food materials in alfalfa hay are more easily dissolved out and lost by leaching from rains than those from most hay plants. Repeated wetting and drying from showers not only cause this loss from washing, but bring on fermentation, and with it additional loss.

STORING.

Correspondents frequently inquire as to whether it is best to store alfalfa hay in small stacks or mows of twenty to thirty tons each, or in quantities of 150 tons or more. Many think that the danger from heating and spontaneous combustion is greater when large quantities are stored in one body. We have investigated this matter to a considerable extent, and cannot find any evidence of greater danger in the larger stacks.

Where alfalfa is stored in stacks without protection, the greater the quantity in the stack the less the proportion that is exposed to the

surface to be injured by weathering. With the improved haying machinery now in general use in the state, stacks thirty feet in height are cheaply made, and if the hay has been properly cured it will keep with less loss in such stacks than it will in those of less height. The feeding value of the alfalfa is easily reduced by rains, and in most parts of the state it will pay to protect the top of the stack after it is completed with some kind of a covering.

TOP-DRESSING.

Each winter, while the ground is frozen, we cover the College alfalfa fields with a good top-dressing of manure. Usually the manure is taken directly from the stables or feed-lots without rotting. We spread from fifteen to thirty tons per acre, and are careful to spread it thinly and evenly. This is best done with a manure-spreader, but can be done by hand if care is taken.

The manure is used on the alfalfa fields not so much on account of the fertilizing effect, though this is profitable, as for its effect in holding moisture in the soil. The College fields are upland, with heavy soil and a hard-pan subsoil. In one of the fields permanent water is 180 feet below the surface. The fields suffer from lack of moisture if high winds blow in the spring and in times of drought. The rainfall is sufficient every year for large crops of alfalfa if it could be saved in the soil for the plants. The top-dressing of manure greatly helps in this saving.

Prof. F. H. King found, at the Wisconsin Experiment Station, that in the spring, manured ground contained on an average 34.4 tons more water per acre in the first three feet than did unmanured ground, and in a dry season seventy-two tons more water. The loss of water from evaporation in unmanured ground was one ton per day greater than from manured soil. And he also found that the manure in the surface-soil brought up the deeper soil-water to where it could be used by the plants. In another case, wetting the surface of sand with water leached from manure reduced the evaporation one-half.

It was a study of Professor King's experiments that led us to top-dress alfalfa, and the top-dressing has proved satisfactory in every respect. The manure spread on the surface does not dry out the soil as it sometimes does when plowed under, the crowns of the alfalfa prevent it from being washed out of the field, the rain and snow dissolve the plant-food and carry it into the soil, and the leachings of the manure prevent evaporation of moisture from the soil. Where the manure is spread thinly a large portion of it decays, and becomes a part of the soil itself. The rest acts as a mulch.

In the spring we disk the land, and this covers up the manure that

has not rotted, and we are not troubled with the manure being raked up in the hay.

When alfalfa is seeded in the fall, and a heavy top-dressing put on when the ground is frozen, the top-dressing will delay the thawing out of the land in the spring, will check alternate freezing and thawing, and in these ways will be a help in protecting the young plants from heaving and from blowing.

THE TUBERCLE.

An examination of the finer roots of a thrifty alfalfa plant will show little tubercles, about the size of a pin-head, attached to the roots. These tubercles are swellings or enlargements made on the roots by bacteria. These bacteria exist in the soil, and when they come in contact with a hair root attach themselves to it, and, wounding the root, make it form a tubercle in which they make their home. These bacteria take the free nitrogen of the air and combine it into forms available for plant-food.

Nitrogen is one of the most-needed elements of plant-food. The reduced yield from our long-cultivated fields comes largely from a lack in the soil of nitrogen in a form which our field plants can use. Four-fifths of the air is pure nitrogen. But ordinary plants can make no use of it. The bacteria that cause and live in the tubercles on alfalfa roots take this nitrogen from the air and put it in such a condition that the alfalfa can use it. This enables the alfalfa to make a vigorous growth, containing a large amount of protein, a compound of nitrogen, and when the roots decay the nitrogen in them supplied by the tubercle-forming bacteria enriches the soil.

With the help of these tubercles, alfalfa can yield heavy crops and leave the soil richer in nitrogen than it was before the alfalfa was grown, as this addition of plant-food comes entirely from the air. Where no tubercles form on the roots, the alfalfa does not add to the fertility of the soil, but simply gets it growth from food already in the soil, leaving it poorer.

THE TUBERCLE AND YIELD.

We have frequent reports from correspondents in sections of southern Kansas and Oklahoma that a good stand of alfalfa is easily secured, but that good yields are produced for only a year or two, when the plants gradually dwindle and dry. One of our students, W. L. English, examined a number of these fields where the alfalfa was dwindling away, and was unable to find a single tubercle on the roots in any of the fields. He found one field of alfalfa of several years' growth growing vigorously, and found the roots well supplied with tubercles.

This suggests that, when alfalfa is seeded in a section where it has

not previously been grown, it may be profitable to inoculate the soil at the time of seeding, rather than wait for the slow spread of the bacteria by natural means.

In 1898 George L. Clothier, then Assistant Botanist of this Station, examined alfalfa fields from Manhattan west to the Colorado line, and found tubercles in sixty-three out of sixty-eight fields investigated. We have not found an alfalfa field without tubercles in this section of the state, and have therefore been unable to test the effect of their absence on the growth of alfalfa.

RESEEDING.

J. W. Robison, El Dorado, Kan., a large alfalfa-grower, has found that it is much easier to get a good stand of alfalfa on ground where alfalfa has previously been grown than it is on land that has never been in alfalfa. In sections where little alfalfa has been grown, it is frequently easy to secure a good stand, and the first year good yields are secured. The alfalfa then begins to weaken, and either makes a short, feeble growth or dies out in patches. Mr. Robison says that, when this is the case, if the ground is plowed after the alfalfa has been grown two or three years, and immediately reseeded, a good stand is easily secured, and the alfalfa grows vigorously for years. The probable explanation of the fact is, that the ground where alfalfa has never been grown is poorly supplied with the root-tubercle bacteria, and as a consequence the plants are weak and short-lived. At the same time, as long as the alfalfa plants live, the bacteria continue to multiply, especially on the few plants that are vigorous. When the dying alfalfa is plowed up and the ground thoroughly pulverized for reseeding, the operation of pulverizing distributes these bacteria throughout the entire surface-soil, furnishing an abundant supply for the plants from the reseeding.

H. D. Watson, Kearney, Neb., has 2500 acres in alfalfa. It yields well, and a large part is growing on what was called the arid plains, where, until Mr. Watson started alfalfa-growing, the farmers thought they had proved that cultivated plants would not grow. Mr. Watson obtains the same marked beneficial results from a second seeding as does Mr. Robison, but he prefers to grow a crop of wheat or corn between the two seedings, as he gets a heavy yield from the land enriched by alfalfa, and the time between the two seedings allows for a more thorough rotting of the alfalfa roots.

We urge the use of the methods of Mr. Robison and Mr. Watson on hard, stubborn soil, where alfalfa has either not been grown or has not made a vigorous growth. In hard or waxy subsoils, the roots at the first seeding of alfalfa have a hard time to work their way down, and may not be able to penetrate more than five or six feet before they

become exhausted and feeble or die outright. The soil may be so compact that the plants get drowned out. If, when the plants show signs of this exhaustion, the ground is plowed the roots will decay. This will let air into the subsoil, where it can act to break up the soil, and the decayed roots will add vegetable mold to the subsoil and make it more mellow. The alfalfa should be sown again on this land. The plants from the second sowing will find the ground prepared for them to the depth which the roots from the first seeding penetrated. By the time these plants have reached subsoil that has been untouched they will have reached an age and vigor that will enable them to further extend their growth and to yield well.

FERTILIZING VALUE.

The way in which alfalfa takes plant-food from the air by means of its tubercles and adds it to the soil has been fully explained under the heading "The Tubercle." The increase in the yield of following crops caused by alfalfa is great. Lord Skully's agent, Mr. Powers, reported to us that he had made a test of the fertilizing effect of alfalfa in Marion county, Kansas. Alfalfa was grown for three years and was then plowed up and the land sowed to wheat. The first crop (1900) yielded forty bushels of wheat per acre: the second crop (1901) yielded forty-one bushels per acre. Adjoining fields with the same character of soil, that had not been in alfalfa, yielded twelve to fifteen bushels of wheat per acre.

Prof. B. C. Buffum, at the Wyoming Experiment Station, selected an area of land and seeded one-half of it to alfalfa. The alfalfa was allowed to grow on this land for five years. The other half of the area was cropped with grain crops and potatoes in a rotation for the same five years. At the end of this time the entire area was plowed up and planted to field crops. The yield of wheat on the alfalfa land was sixty per cent. greater than on the other, and the grain weighed more per pushel.

The yield of oats was forty-eight per cent. greater on the alfalfa land; the grain stood a foot and a half higher, and the heads were two inches longer. The yield of marketable potatoes was increased sixty-two per cent. on the alfalfa land; the potatoes averaged larger in size. The yields per acre were as follows:

	Alfalfa land.	Other land.
Wheat	30 bushels.	18 bushels.
Oats	78 "	37 "
Potatoes	81 "	52 "

The increased yield of crops on land on which alfalfa has grown does not come alone from the addition of plant-food to the soil which alfalfa makes. In many soils the mechanical improvement made by

alfalfa has a greater influence in increasing the yield. Alfalfa roots are large and abundant, and they penetrate deeply. When alfalfa is plowed these roots decay, adding vegetable matter to the soil, and providing a passage for the air to go down to the subsoil and loosen it. On stiff clay lands this addition of the vegetable matter mellows the soil; on sandy lands it helps bind the soil particles together. On both classes of soil the addition of decayed vegetable mold increases the power of soil to absorb and retain moisture and makes a better tilth.

ALFALFA IN CROP ROTATION.

When Kansas soil was first broken, it was thought by many to be inexhaustible. Farmers are beginning to notice the weakening in fertility on old lands, and our best farmers are rotating crops, with the thought of improving their soil. Alfalfa is one of the best soil enrichers we have, but after a stand is once secured good crops should be yielded for at least ten years. There is no field crop raised in Kansas that, year by year, will yield as great a net cash income per acre as alfalfa, and for this reason the grower cannot afford to plow up a good stand, even for the sake of securing a good rotation of crops.

We would recommend that, where a rotation of crops is desired, and this should be on most Kansas farms, alfalfa should be allowed to stand ten years, and that the rest of the cultivated land of the farm be put in such short rotation as will be found to be the most profitable in the section where the farm is located. Cow-peas, soy-beans and Canada field peas are good crops to be used in short rotations for enriching the soil, and a crop of any one of these can usually be grown between regular crops as a catch-crop without losing a single cropping of the regular crops.

THICKENING OF STAND.

When a poor stand of alfalfa is secured it is very difficult to reseed the bare spots. The number of alfalfa plants on the alfalfa field is always the greatest when the plants first start, and the numbers continue to decrease through the life of the stand. A stand of alfalfa is not thickened by self-seeding, as is the case with Red clover. The number of stems to a root may be largely increased by disking, but not the number of roots.

There are two difficulties in the way of reseeding the bare spots in an alfalfa field. Whenever the ground is moist alfalfa seed may be sown on these bare spots, and the young plants will come up thickly. If the spots are small the old alfalfa plants shade the young growth, and take moisture from them, and in a short time the young plants die. With large bare spots these difficulties do not prevent the growth of

the young plants, but the young plants, being so much more tender than the older growth, are entirely destroyed by grasshoppers and other insects, which seem to come in all directions for quite a distance.

Each year for five years we have tried to thicken the stand in alfalfa fields by reseeding the bare spots, and every trial has been a failure, unless the spots were sufficiently large to be worth plowing and seeding as on a large area. We have made these trials in both spring and fall.

A few farmers in various sections of the state have reported success under favorable conditions in thickening the stand by reseeding the bare spots in the spring and keeping them mown down close for two or three months, treating the old alfalfa as though it were weeds. We have not tried this method at this Station. The moral is plain. Prepare the ground so thoroughly and take such care in seeding that a good stand will be secured from the first seeding, and then protect a good stand when you get it.

PROLONGING THE LIFE OF ALFALFA.

Alfalfa does not reach full growth and maturity until at least three years after seeding. Often it takes a longer time. Alfalfa should be treated as a baby until it reaches maturity and full vigor.

Until it reaches full growth, alfalfa should not be pastured by any kind of farm animals. Pasturing young alfalfa does not always cause serious damage, but it always injures the stand to some extent, and sometimes entirely destroys it. This is a frequent cause of failure with alfalfa. In an eastern county in Kansas where not much alfalfa is grown, because farmers think it will not thrive, a farmer seeded alfalfa in April. Two months later he wrote us that he had a perfect stand, there was not a bare spot in the field, and the plants were from eight to ten inches high. He had just turned a large number of hogs and pigs into the field and he would like to have us tell him whether the alfalfa would hurt the pigs or not. The almost certain destruction of alfalfa under such circumstances usually convinces the grower that alfalfa is not adapted to his farm.

A small area is often sown to alfalfa, and, after it has a year's growth, the fence is changed and it is thrown into a large pasture. When the pasture grass becomes dry in midsummer, the alfalfa is still green, and the entire herd feed on it until it is eaten close to the ground and the soil tramped hard. This shortens the life of the plant, if it does not end it summarily.

Alfalfa may be pastured severely after it reaches maturity, so long as the crowns are not injured, but, to prolong its life, do not pasture while young.

Cutting each crop when the first blooms appear invigorates alfalfa

and adds much to its length of life. Disking helps the plant, conserves moisture for it, and keeps in check its weed enemies. Top-dressing adds to the supply of moisture and food. Alfalfa should have a good growth of foliage when the ground freezes, and if pastured close to the ground or mowed just before the ground freezes its life will be shortened.

Alfalfa is, first of all, a hay plant, and all the methods of protecting and invigorating it that have been suggested will profitably increase the yield of hay while prolonging the life of the plant.

PLANT ENEMIES.

The worst enemy of alfalfa in Kansas, plant or animal, is crab-grass. When this grass secures a foothold in an alfalfa field, no matter if it is a small one, it spreads rapidly, if unchecked, and in time will ruin the stand. Where alfalfa and crab-grass start together in the same field, it is usually impossible to keep the crab-grass in check, as the young alfalfa will be destroyed by any treatment that will eradicate the crab-grass. The best treatment, under such conditions, is to plow the ground, put in some crop that requires cultivation, and thoroughly clean the land of crab-grass before reseeding to alfalfa.

When crab-grass does not get started in an alfalfa field until the alfalfa is two years old, the grass can be kept down by disking, so that it will do but little injury. The alfalfa should be disked early in the spring, and after each cutting, as described under the head of "Disking."

On lands that have been in cultivation for many years, fall seeding is the most practicable method of securing a good stand of alfalfa before crab-grass becomes troublesome, and on such lands fall seeding should be practiced wherever the right conditions for it can be secured. Sometimes the growth of crab-grass is so thick as to prevent the disk-harrow from doing good work in the spring disking. When this is the case, the old crab-grass can be burned, if a time is selected after a rain, when the grass is dry but the surface of the ground is wet.

Dodder is a parasitic enemy of alfalfa that in some fields in Kansas seriously reduces the yield, but this enemy is found but on a small proportion of the alfalfa of the state. Dodder is a small, vine-like plant, which encircles the alfalfa and feeds on it through small suckers that pierce the stem of the alfalfa. It produces a mass of yellowish, wiry stems that, when cured, look like a bunch of fine excelsior stained reddish-yellow. Dodder starts from seed sown with alfalfa seed. As soon as the stem appears above ground and attaches itself to an alfalfa plant the root of the dodder dies, and all the nourishment is taken from the alfalfa. Alfalfa affected by dodder usually lives, but makes a sickly, weak growth and a light yield.

The best method of avoiding injury from dodder is to sow the best quality of alfalfa seed only, and this will not have dodder seed mixed with it. When dodder has been found to have secured a good start in an alfalfa field, the spot should immediately be mowed before it seeds, and burned. Straw scattered over the place will assist in burning, and, if the ground is damp, the fire will not injure the alfalfa roots. When a field has become badly affected with dodder, the only remedy is to plow up the alfalfa and put the land in cultivated crops for a few years.

ANIMAL ENEMIES.

The animal enemies that destroy alfalfa in Kansas are, taken in the order of greatest destructiveness, the gopher, grasshopper, prairie-dog, and web-worm. The methods of combating these can be treated here only briefly, as the subject is handled by other departments of this Station. The most destructive animal in alfalfa fields is the pocket-gopher. It occurs in all parts of the state, and is constantly increasing in numbers. The time is now here when alfalfa-growers will have to plan as a part of the yearly expense of raising alfalfa the killing of gophers. Prof. D. E. Lantz, of this Station, after an extensive investigation in 1901, estimated that, in that year, the gophers destroyed one-tenth of the entire product of the alfalfa fields of Kansas.

The most practicable method of destroying the gopher is by poison. Professor Lantz, in Press Bulletin 109 of this Station, describes the method of poisoning, as follows:

"They are very fond of common potatoes, sweet potatoes, apples, raisins, and prunes. The presence of strychnine, arsenic or other poisons does not seem to deter them from eating the food, but if the poison is sweetened they seem to eat it more readily. In summer it may be desirable to sweeten the poison, but in the fall and early spring it does not seem worth while to do this. The poisoned food being introduced to the burrows below the surface, there is no danger of poisoning stock. It might be well, however, not to let swine run in the alfalfa fields for a time after the poison has been put out.

"The following method of introducing the poison is recommended: Cut the potatoes, or other food, into pieces not more than three-fourths of an inch in diameter. Cut a slit in each piece with the point of a knife blade; insert a little sulphate of strychnine—as much as half the bulk of a grain of wheat, will answer the purpose. The moisture from the potato will cause the poison to adhere to the blade of the knife.

"Having prepared the bait in sufficient quantity, go to the field armed with a round, sharp-pointed implement an inch or an inch and one-half in diameter, and of sufficient length. The tools were made by a blacksmith for the writer. One is a shovel handle and the other a spade handle, and each is shod with a conical iron point. A bar is attached about fifteen inches from the point, to enable the operator

to use the foot in pressing it into the soil. These tools have proved to be quite serviceable. With one of them, it is only necessary to find the runway of the gopher. The handle is sufficiently thick to make a hole large enough to permit one to drop the poisoned potato directly into the burrow. The operator then passes on to the next place, leaving the hole open. No digging with a spade or other hard labor is necessary. An experienced person can distribute poison to many acres of the alfalfa in a day, and, if the proper care is taken to rightly distribute the bait, it will not be necessary to go over the ground a second time.

"Some experience is required to enable one to find the burrows quickly. It is best to insert the food as near as possible to the freshest mounds of earth thrown up by the animals. Two or three pieces of potato at that place are worth many scattered in other parts of the runway. The operator should avoid the larger mounds and those that are not freshly made."

We have practiced on the College farm the method recommended by Professor Lantz for destroying the gopher, and for five years have found it satisfactory and practical.

The grasshopper is quite destructive of alfalfa, in some sections of the state, and in most fields keeps the edges of the fields eaten down. The grasshopper lays its eggs in a sac, in the firm ground, just below the surface. Late disking in the fall or early disking in the spring exposes these sacs to destruction by weather and birds, and greatly reduces the hatch. The most practical way of destroying the grasshoppers after they are hatched is with turkeys. A turkey to the acre will keep the grasshoppers reduced in numbers to a minimum, unless the alfalfa field is a small one surrounded by fields of grass, when a greater number of turkeys will be needed. The conditions of climate which favor the growth of alfalfa are also suited to the needs of the turkey. When there is danger from wolves a portable house can be built, and moved from field to field, and the turkeys shut in at night. Turkeys that run on alfalfa and chase grasshoppers all summer make a good growth, and in the fall are tough and wiry, with enormous appetites. They can be closely confined and fed heavily on corn, and will fatten rapidly and make delicious, tender flesh. Turkey-raising is well worth adopting by the Kansas farmer who wants larger yields of alfalfa.

The prairie-dog is a serious pest in alfalfa fields in some sections of the state. The best methods of destroying the prairie-dog are given by Prof. D. E. Lantz, of this Station, in Press Bulletin 108, and are as follows:

"A tablespoonful of carbon bisulphide placed upon some absorbent material, as cotton, dry horse manure, or a piece of corn-cob, and rolled down the prairie-dog burrows, is effective in killing the ani-

mals. It is best to immediately cover the hole with a sod, and stamp down firmly.

"I found by experiment that four parts of gasolene, mixed with one part of carbon bisulphide, is about as effective as the carbon bisulphide alone, and is not nearly as expensive. The mixture is used in the same manner as carbon bisulphide alone, but a somewhat larger dose is needed.

"STRYCHNINE POISONING. *Formula No. 1.* — Dissolve one and one-half ounces of strychnia sulphate in a quart of hot water. Add a quart of syrup — molasses, sorghum, or thick sugar and water — and a teaspoonful of oil of anise. Thoroughly heat and mix the liquid. While hot, pour it over a bushel of clean wheat, and mix completely. Then stir in two or more pounds of fine corn-meal. The quantity of corn-meal needed will depend upon the amount of extra moisture present. There should be enough to wet every grain of wheat, and no more. Care should be taken that there is no leakage from the vessel in which the wheat is mixed.

"Let the poisoned grain stand over night, and distribute it in the early morning of a bright day. Use a tablespoonful of wheat to each hole occupied by prairie-dogs, putting it near the mouth of the burrow in two or three little bunches. Do not put out the poison in very cold or stormy weather. It will keep for a considerable time, and is much more effective after a cold period, as the animals are then hungry, and eat the grain readily. A bushel of wheat should poison 1000 to 1200 holes.

"An excellent substitute for the oil of anise in the above formula can be made by soaking two ounces of green coffee berries in the whites of three eggs. Let this stand for about twelve hours, and use the liquid instead of the anise oil.

"*Formula No. 2.* — Through the efforts of Hon. S. E. Cave, of Lockport, Kan., the College has purchased the state right on a preparation patented by Mr. D. W. Staples, of Quanah, Tex. I have tested it in the field and found it entirely satisfactory. The inventor claims for it that it has the advantage of being effective *at any season*. The simple preparation of strychnine given in formula No. 1 is not successful while green food is plentiful.

"Formula No. 2 is protected by letters patent, and cannot be used *outside of Kansas* without securing the right of the inventor. We have purchased the right of its use for all citizens of the state. As this bulletin circulates outside of Kansas, the formula is not here given, but it will be sent to any resident of Kansas upon application."

In the past five years we have had two attacks of the web-worm in alfalfa fields. In each case we have mowed the alfalfa as soon as the work of the web-worm was noticed, removed the hay from the land, and immediately double-disked the land, stirring it thoroughly. We had no further damage during the season. Whether the treatment was the means of stopping the damage or not, we do not know. Such treatment is always good for the alfalfa, at any rate.

COMPOSITION OF ALFALFA.

The following table, compiled from Bulletin 103, issued by the chemical department of this Station, shows the per cent. of digestible matter found in various feeds. The percentage is calculated on the material in the condition it would be found when fed:

	Protein.	Carbo-hydrates.	Fat.
Alfalfa hay, cut ten per cent. in bloom	13.24	39.26	0.89
Alfalfa hay, cut half in bloom	11.90	40.26	0.39
Alfalfa hay, cut in full bloom	10.43	43.17	0.69
Red clover hay	6.58	35.35	1.66
Timothy hay	2.89	43.72	1.43
Prairie hay	0.61	46.90	1.97
Corn fodder	1.98	33.16	0.57
Kafir-corn fodder	3.22	48.72	1.15
Wheat bran	12.01	41.23	2.87

The digestibility of alfalfa hay, prairie hay and Kafir-corn fodder was determined in feeding experiments made at this Station by the chemical department.

This table shows that in protein, the most valuable part of our feeds, alfalfa hay cut when one-tenth in bloom is worth ten per cent. more than bran. In other words, a ton of good Kansas alfalfa hay will supply as much of the material needed to make growth of lean meat, milk and blood as 2200 pounds of wheat bran. The reader can easily make comparisons with other feeds. Kansas alfalfa can be raised, cut and cured and put in the feed racks on the average farm for two dollars per ton. The large yield has already been shown in this bulletin. A consideration of the yield, the composition and the cheapness of alfalfa should be a strong inducement to Kansas farmers to increase their acreage, and handle their seedings of alfalfa in such a way as to secure the largest yield and prolong the life of the plants.

GROWING FOR SEED.

The third cutting of the season of alfalfa ripens the seed more evenly than the earlier cuttings, and comes at a time favorable for handling. The third cutting weakens the vitality of the plant less than earlier cuttings, and allows for a sufficient time for a late fall growth to protect the plants through winter.

In seasons of drought, the second cutting may be left to seed, if there is danger that there will not be enough moisture to mature the third cutting. Under no conditions should the first cutting of alfalfa be allowed to seed, if it is desired to maintain a stand of alfalfa on the land.

The alfalfa should be cut when the greater proportion of the seeds are hard, but not sufficiently ripe to shell. The cut alfalfa should be

cured like the hay, with as little handling as possible, and then stacked. Many of our correspondents have an impression that alfalfa for seed should be rotted after being cut. The reverse is exactly what is needed. The alfalfa a should be well cured and thoroughly dry when put in the stack, or there is damage from heating, and stack-heating seriously injures the vitality of the seed. The straw left after the seed has been thrashed from the alfalfa is a fairly good rough feed, although not nearly equal to alfalfa cut at the proper time for hay.

Prof. S. J. Hunter, of the Kansas University, Lawrence, found that alfalfa pods taken where the blossoms had been fertilized by bees had an average of 5.58 seeds in a pod; the seeds were plump, pods numerous in a cluster, and had several spirals. Alfalfa pods taken where the alfalfa could not be fertilized by bees had an average of 3.35 seeds in a pod; seeds in at least one-third of the pods were small and shriveled; the pods were few in a cluster, and were short, with but few spirals.

The per cent. of increase from the work of the bees was 66 2/3.

CAUSES FOR FAILURE.

The failures in alfalfa-growing in eastern Kansas have chiefly come where methods suitable for western Kansas have been adopted, and successes have followed where entirely different methods have been used. In eastern Kansas, owing to many years' cultivation and a good rainfall, the land is weedy. The usual experience is as follows: Ground thoroughly prepared in the spring, seed immediately put in, a good stand, and rapid early growth; in September, a field with some alfalfa and a perfect stand of crab-grass or foxtail; next spring, no alfalfa, or only half a stand. This experience is usually repeated two or three times, and alfalfa, not paying, is dropped.

As a rule, we have found that successful alfalfa-growers in eastern Kansas have started to prepare the ground a year before sowing the seed. They plant the land intended for alfalfa in corn or some cultivated crop. They cultivate thoroughly and keep the land free from weeds. When the land has been made clean and put in good tilth, the successful alfalfa-grower in eastern Kansas has put on it a crop in the spring that he could get off early, and has then thoroughly prepared the land and seeded it in the early fall.

Another common cause of failure with alfalfa in eastern Kansas is late cutting. The successful clover-grower usually destroys his first seedings of alfalfa by late cutting.

Poorly prepared soil, loose soil at the time of seeding, seeding with a nurse crop, early and excessive pasturing and allowing the weeds to get ahead of new seeding are other causes of failure.

The writer attended six farmers' institutes in one county in southeastern Kansas in 1899. He found no alfalfa growing in the county, and strongly urged the farmers to raise it. They were almost unanimous in declaring it could not be grown in their section of the state, although very few trials had been made. In 1901 the writer again attended a farmers' institute in the same county, and found that the farmers insisted as strongly as ever that alfalfa could not be grown in their county. After a large number had expressed themselves very emphatically, stating that they knew and had proved that alfalfa could not be grown in their section, Mr. M. O'Brien, of Liberty, stepped forward and said that he had been induced to make a trial of alfalfa as a result of the writer's talk in 1899, and in 1901, without irrigation, he had made five cuttings of alfalfa, the season being the most unfavorable in many years. The five cuttings aggregated fourteen feet and two inches in length, and the yield averaged seven and three-fourths tons per acre. The yield of the cuttings was as follows: First, May 11, two and one-half tons; second, June 24, two tons; third, July 21, one ton; fourth, August 27, one and a half tons; fifth, October 19, three-fourths ton. A photograph of the five cuttings is given, through the courtesy of Secretary Coburn, of the Kansas State Board of Agriculture. Mr. O'Brien's experience can be duplicated on almost every farm in eastern Kansas.

The failures to grow alfalfa in western Kansas have come largely from two causes: Lack of moisture and proper condition of seed-bed at time of seed, and depredations of animal enemies, particularly grasshoppers, gophers, and prairie dogs. Full instructions for combating the animal enemies of alfalfa have already been given in this bulletin. Common sense and patience are necessary to secure the right condition of seed-bed. Alfalfa should not be seeded until this has been secured. We have seen several cases where good yields of alfalfa have been secured on high upland in western Kansas. A slight depression on the high prairie was selected and carefully prepared. Then furrows were run in various directions through the adjoining buffalo-grass sod to bring the surplus rainfall to this land. In one case it required two years in which to secure enough moisture to make a prefect seed-bed. When this was secured, alfalfa was seeded, it was protected from grasshoppers, and good yields were the result. Alfalfa is easily raised on the bottom lands and in the draws in every county in western Kansas, and there are few quarter-sections of upland but what have some low spot on which alfalfa can be profitably grown.

Alfalfa is adapted to a wide range of soils and climates. Secretary F. D. Coburn, in his book "Alfalfa," shows that it is a profitable crop

in at least twenty-one states and territories; that it grows under the widely different conditions of California and Delaware, Washington and New Jersey, Idaho and Louisiana, Montana and Georgia; that in New Jersey the annual yield is equal to six tons of bran, in Montana it is found thriving and yielding well sixteen years after seeding, and in Louisiana it yields six cuttings a year. Is it not, then foolish for any Kansas farmer to think that alfalfa will not thrive on his farm?

FEEDING VALUE.

The feeding value of alfalfa can be only barely mentioned here, as a separate bulletin is required to properly treat the subject. On the Kansas Agricultural College farm, during the winter of 1901–'02, we were obliged to feed our young stock alfalfa hay only, as no other roughage could be obtained at a reasonable cost. Our two- and three-year-old pure-bred heifers were fed alfalfa hay only, without any grain whatever, from September 2, 1901, to April 4, 1902 — 214 days — and made an average daily gain of one and two-tenths pounds per head. The largest gains and the best condition of the heifers was secured when twenty-three pounds of hay per head were fed daily. This shows that alfalfa hay furnished a maintenance ration through the winter months, and, in addition, a gain of 104 pounds for each ton fed. These cattle ran loose in a lot fenced with wire, and had a board shed open on the south for shelter. The heifers at the close of feeding were in such condition of flesh and hair that visiting Eastern feeders were sure that oil-meal had been fed.

At this Station, pigs were pastured through the summer on alfalfa with a light feeding of corn. After deducting the probable gain from the corn, the gain per acre from the alfalfa pasture was 776 pounds of pork. One lot of fattening hogs were fed all the grain they would eat; another lot all the grain and dry alfalfa hay they would eat. The lot having the hay made a gain of 868 pounds of pork per ton of alfalfa hay. Alfalfa should form part of the daily ration of every growing pig and of all stock hogs. Hundreds of brood sows were carried through the past winter on alfalfa hay, without grain, and had large litters. It pays, though, to feed some grain.

With scrub cows fed alfalfa hay and Kafir-corn grain, at ordinary prices for feed, butter-fat was produced at a cost for feed of seven cents per pound. On the College farm, young cattle are wintered on alfalfa hay and corn-fodder, Kafir-corn fodder, and sorghum fodder, and make through the winter a good growth without grain.

A dairyman near Manhattan cut alfalfa and fed it green twice daily to his cows. Ten cows were fed all they would eat, and gave good

yields of milk through the summer without other feed. They consumed the alfalfa that grew on four square rods less than two acres.

A stockman in Rice county, Kansas, made a gain of five pounds per day per head on steers for forty-seven days with alfalfa hay and corn. In ordinary feeding, 1000 pounds of grain are required to put 100 pounds of gain on a fattening steer. With alfalfa hay and cornmeal, at this Station, fattening steers made 100 pounds of gain for each 718 pounds of grain.

Alfalfa makes good pasturage for horses. Horseman report a gain of six pounds a day per head on horses pastured on alfalfa and given a light ration of corn or kafir-corn. Pure-bred Percheron mares were recently inspected by the writer that had been fed alfalfa hay in winter and given alfalfa pasture in summer for twelve years. They were in almost show condition, and had been and were regular breeders.

Alfalfa hay is one of the best feeds for sheep that is grown, and both green and dry alfalfa are valuable feeds for poultry. Alfalfa leaves are especially valuable to color the yolk of the egg in winter.

On account of its effect on the skin and hair, alfalfa is one of the best feeds for cattle being fitted for the show ring.

CLOSING SUGGESTION.

This bulletin completes the work of the writer for the Kansas Experiment Station, and he leaves to take up work in another state. The writer has lived twenty-one years in Kansas, and during this time has made a careful study of crop-production and of stock-feeding under all our conditions of soil and climate and changes in seasons. As a result of this study, he would urge on every farmer in the state to raise more alfalfa. Alfalfa sold or fed will return a greater net cash income per acre, year by year, than any other field crop. Land seeded to alfalfa will rent for more than for any other purpose. Large landowners can secure a greater cash income from their investments by seeding their land to alfalfa before leasing it than in any other way, and the land will constantly increase in fertility and improve in condition so long as the alfalfa is allowed to remain, while, with ordinary systems of cropping, rented land tends to constantly depreciate in fertility, condition, and value.

The Kansas farmer needs to raise more alfalfa for his land's sake. Alfalfa gives him heavy yields secured from soil many feet below that reached by other crops, and leaves the surface-soil richer, in better tilth, and ready to yield much more abundantly when planted to other crops.

Alfalfa is an absolute necessity in Kansas for the cheapest production of beef, pork, mutton, and milk, and for securing the cheapest rapid growth of colts, young cattle, sheep, and pigs. It can profitably

form the greater part of the feed of mature horses, cattle, sheep and swine that are kept for breeding purposes, and is a cheap and good feed for poultry. It supplies the food elements lacking in most of our other field plants, and, when fed with them, makes a balanced ration.

A thorough effort should be made by every Kansas farmer to grow it if he does not already have it on his farm. Alfalfa is of such great value as a feed, and its yield is so high, and it yields well for so long a period after a good stand is secured, that it will pay the Kansas farmer who is without it to carefully study every requirement of the plant, and then attempt to secure these conditions, and seed largely. If the first attempt fails, try again and again, if necessary, and final success will well repay for all expenditure. To the Kansas farmer who already has alfalfa, we would say, RAISE MORE.

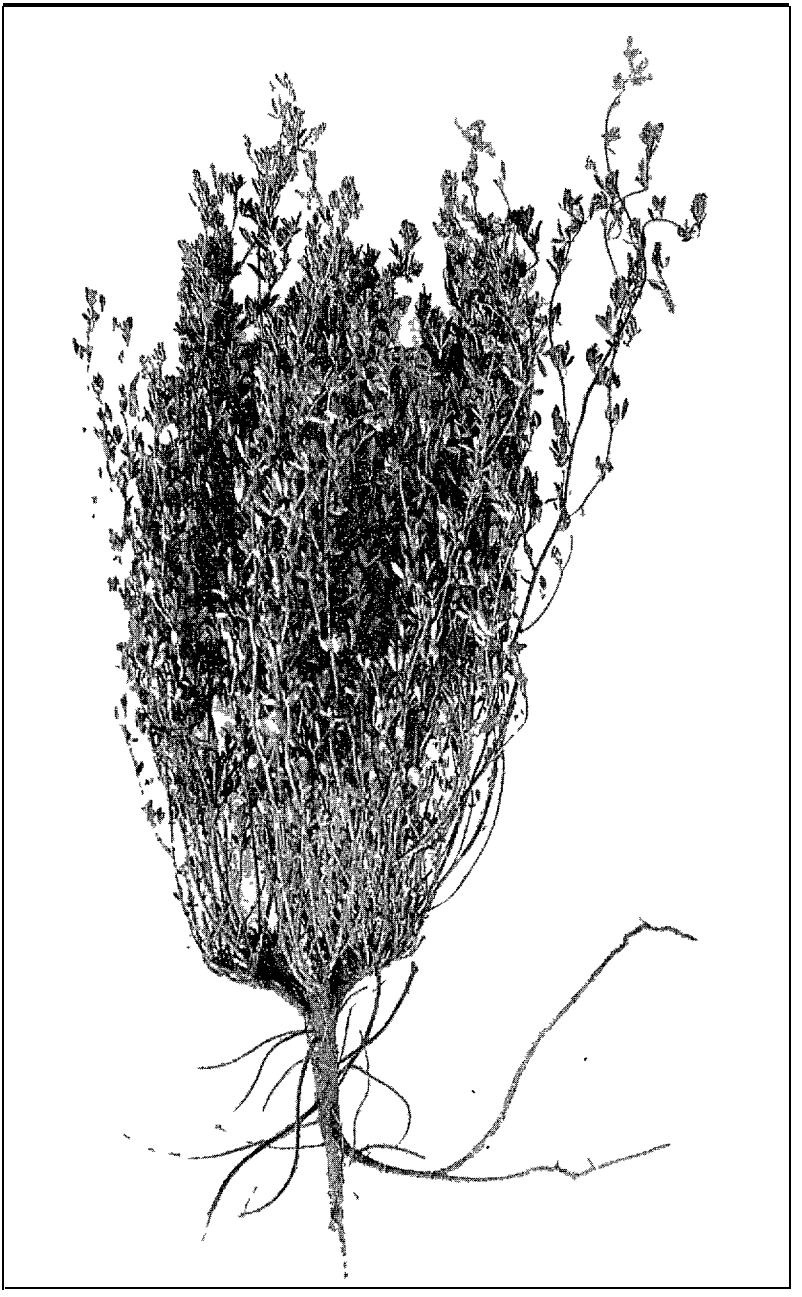

FIG. 1. Alfalfa plant on upland, four years old; seventy stalks from one root. Height of plant, thirty-six inches. Shows effect of disk-harrow in splitting crown. Taken May 28.

FIG. 2. Alfalfa plant having 312 stalks from one root. Taken May 6; growing in high upland, stiff hard-pan subsoil, 180 feet to water. Plant ten inches high; eight years old.

FIG. 3. Crown of plant shown in fig. 2. Stalks removed, to show branching of crown.

FIG. 4. Crown and root of alfalfa. The plant was seven years old, and grew on upland. It had 104 stalks from the one root.

FIG. 5. Alfalfa crown split by the disk-harrow. Roots photographed May 28, 1902. Alfalfa disked four times in 1900, four times in 1901, and once in 1902. Harrowed with smoothing harrow once in 1900 and once in 1901. The root on the right belongs to the plant shown in fig. 1.

FIG. 6. Alfalfa blossom, enlarged.

FIG. 7. Alfalfa stem and blossom.

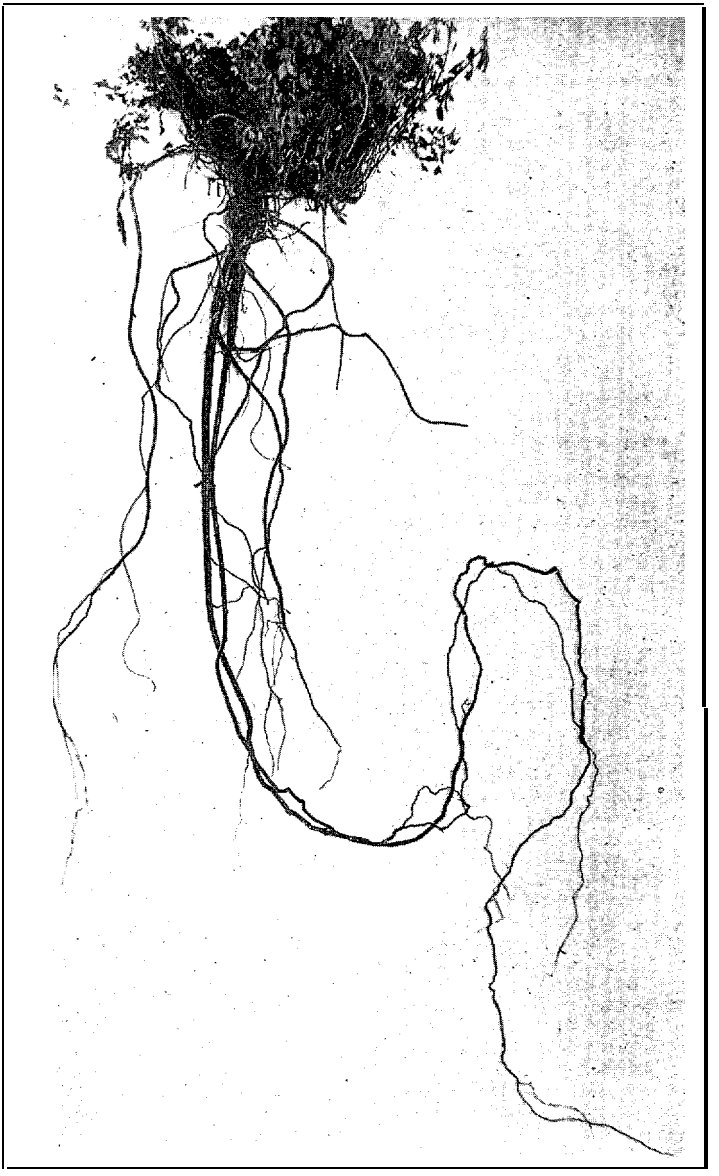

FIG. 8. Alfalfa plant, taken June 11. Root nine feet and nine inches in length; 150 stalks. This plant was nine years old, and grew in high upland having a stiff hard-pan subsoil; water 180 feet below the surface. In digging, after the first foot of soil was taken away, a pick had to be used the entire depth.

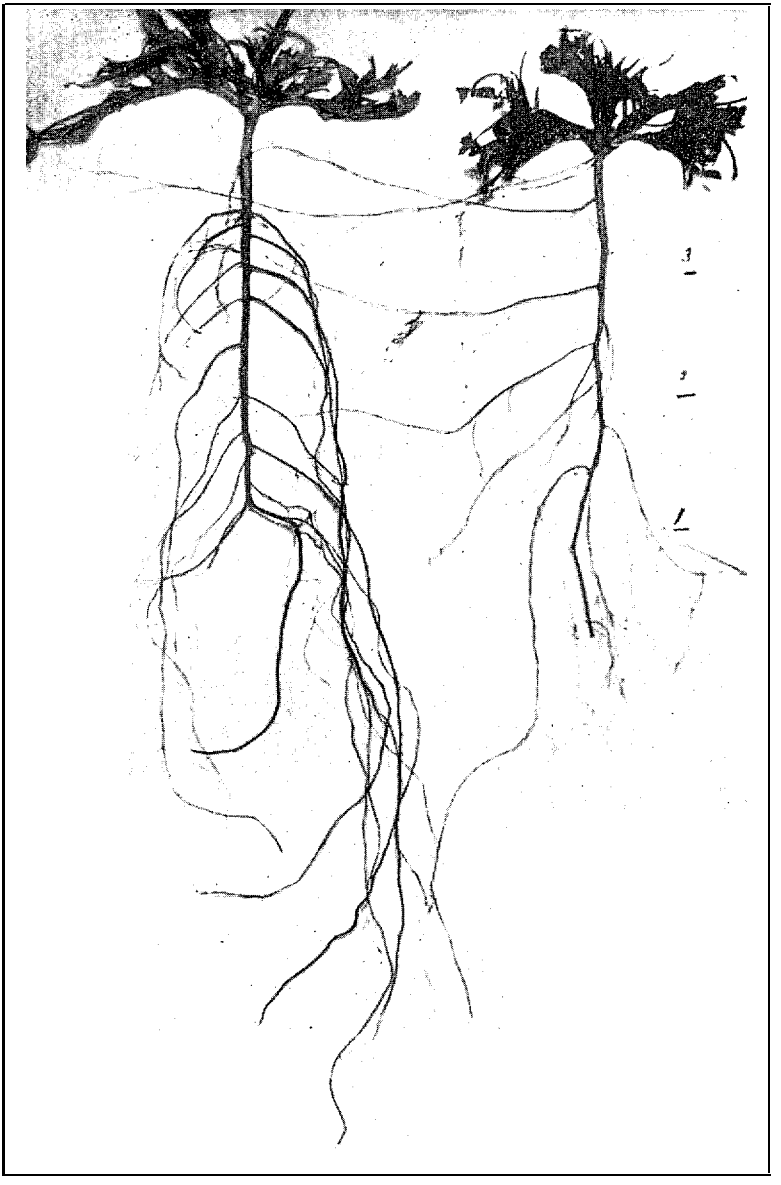

FIG. 9. Alfalfa plant, grown on upland. Seeded September, 1901; plants dug April, 1902.

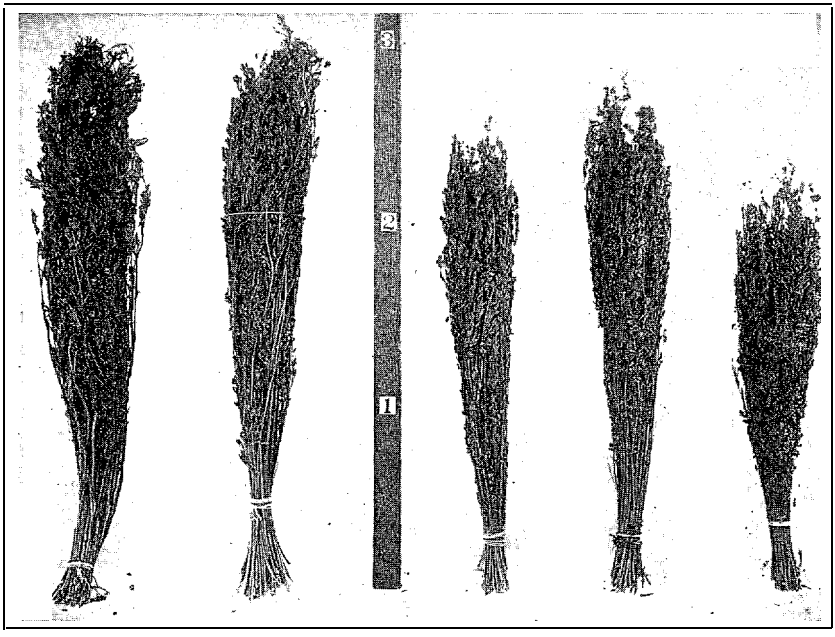

FIG. 10. Photograph from samples of five cuttings of alfalfa grown in 1901, without irrigation, by Mr. M. O'Brien, Liberty, Kan., the season being the most unfavorable in years. The five cuttings aggregated fourteen feet and two inches in height, and the average yield was seven and three-fourths tons per acre. Mr. O'Brien's neighbors were certain that alfalfa would not grow in their section of Kansas.