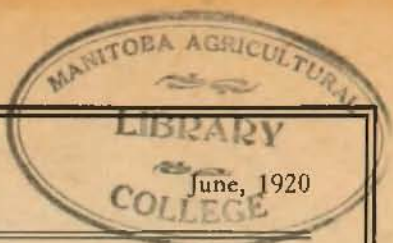


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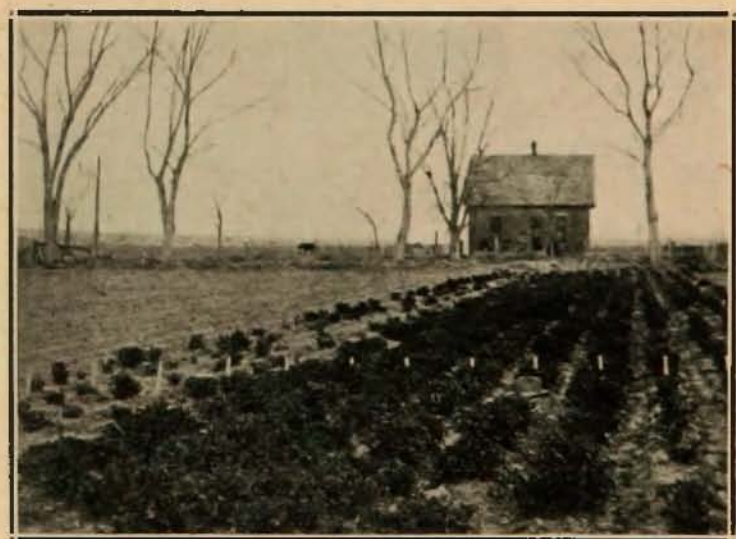


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**FACTORS THAT AFFECT
ALFALFA SEED YIELDS**

By PHILO K. BLINN



The first alfalfa nursery test. Seed was sown in 1905. The six center rows are Turkestan alfalfa. The four rows at either side are common alfalfa.

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Factors that Affect Alfalfa Seed Yields

A Progress Report

By PHILO K. BLINN

The problem of alfalfa seed production is a vital one to the farmers in Colorado. Alfalfa occupies the same important place in the farm economy of the West that red clover occupies for the farms in the East. Alfalfa has even greater importance, due to its larger forage producing capacity and its very great power as a fertility builder on western soils. Due to its fertilizing value, it plays an important role in western crop rotation.

Immense quantities of alfalfa seed are required each year to reseed new acreages, resulting from crop rotation. The production of alfalfa seed does not seem to be keeping pace with this ever increasing demand. The inability of seed production to keep pace with seed demands seems to be largely due to the uncertainty of alfalfa seed yields. With uncertain seed yields, there is not strong encouragement for farmers to attempt to produce alfalfa seed. Recently, it has seemed that alfalfa seed could be successfully produced only under the most favorable circumstances. Even then seed yields are so irregular from season to season that the irregularity constitutes a strong business limitation on alfalfa seed producing efforts.

For a number of years the Colorado Experiment Station has been endeavoring to determine the causes of uncertain alfalfa seed yields. The Experiment Station has tried to find the controlling factors in seed yield. It has tried to work out the cultural methods necessary to insure successful alfalfa seed production. These efforts have been put forth in the hope of developing a seed growing industry which would at least supply the demands of Colorado growers for good alfalfa seed. Investigations cover a period of over twelve years. It seems advisable at the present time to publish the results of these experiments and observations. The final conclusions, however, seem somewhat indefinite. A clear-cut statement of the status of the investigation may serve to clarify the problem and offer some beneficial suggestions to those engaged in producing alfalfa seed. It is hoped the results will be helpful, even though they do not give a final solution to the problem.

Investigations have been conducted chiefly on the Colorado Experiment Station farm at Rocky Ford. This farm has excellent land

and dependable water rights. It is located in one of the largest alfalfa growing districts in the state. At one time the Arkansas Valley was a very important alfalfa seed producing region. The experiments at Rocky Ford have been supplemented by co-operative tests with alfalfa seed growers in different parts of the state. Much work has been done in collaboration with the Office of Forage Crop Investigation, Bureau of Plant Industry, Washington, D. C. The field observations have covered Colorado and a portion of the alfalfa seed producing sections of Utah and Idaho. The Office of Forage Crop Investigation has furnished several lots of alfalfa seed varieties from different parts of the world which have been used in the tests and experiments.

In the preliminary canvass of the investigation, theories and beliefs were advanced by different growers and others in an attempt to explain the causes for success or failure of alfalfa to set seed. The concensus of opinion seems to be that the care of the crop, together with the ability of the grower to judge of the prevailing conditions and their effects upon the seed production are the most important factors.

A careful comparison of the results secured under actual field conditions seemed to be the most plausible method of attacking the problem. Accordingly, tests have been made and observations



A later alfalfa nursery test of different types and varieties. Notice the large stooling row in the center, a typical hardy strain. The winter killed rows at the left and one on the right of the hardy strain came from Italian strains of seed, all of which are non-hardy.



Abnormal root development of hardy plants grown from cuttings.

carried out with practical growers, in addition to the carefully planned work on the Experiment Station grounds.

In describing the progress of these investigations, it seemed best to present the matter under the topical heads which might be considered the principal factors apparently influencing alfalfa seed yields. No attempt has been made to arrange these topical heads in the order of importance because their relative importance has not been determined by the experiment.

SEED SETTING TENDENCY OF DIFFERENT VARIETIES

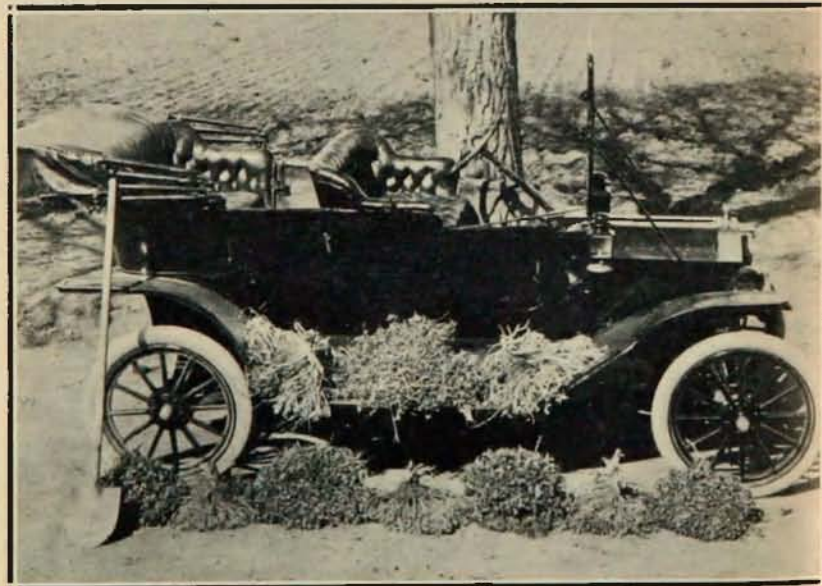
It is noticeable in every field of alfalfa left for seed that there is a great range of difference in the seed yields of different plants. This characteristic is apparent, even when all of the plants are growing under as nearly similar conditions as it is possible to impose. This fact, observed as early as 1904, led to the selection of a number of heavily seeded plants of common alfalfa, with a view of testing out plants with strong seed yielding tendencies in the hopes of developing an improved strain of alfalfa with strong seed producing power.

The first selections were sown in the spring of 1905. At the same time there were put out tests of imported Turkestan alfalfa seed.

The plantings were made in adjacent plots, the condition of the two being as nearly uniform as possible. A few more selections were added in 1906. It so happened that the Turkestan strain proved to be so superior to the common alfalfa in both forage development and seed production that it was evident that a larger test of varieties would be desirable in order to get the best type from which selections might be made. These first selections were finally abandoned and a much larger test was started in the spring of 1907. The enlarged test comprised sixteen choice selections from heavily seeded Turkestan rows. It contained, in addition, 48 regional varieties of alfalfa from different parts of the world, furnished to us by the Office of Forage Crop Investigation, United States Department of Agriculture. This list of varieties included alfalfas from northern and southern climates, from both eastern and western hemispheres.

Each variety consisted of two square rods, sown in hills spaced twenty inches apart each way. Each hill was thinned to a single plant. The entire nursery was given, as nearly as possible, the same culture and irrigation. During the season of 1908, the whole nursery was left to produce seed.

The contrasts in results of both seed yields and forage production were very marked. The extreme southern strains of seed, such



A group of hardy plants of the extremely large crowned type. This type is extremely hardy. But, owing to its excessive stooling habit, it is undesirable for either hay or seed production in our climate.



Extra large crowns of alfalfa developed from a single seed as they appear growing in the field. These are very hardy. But, owing to their low growth, are undesirable for hay production. These types are also poor seed producers.

as those from Ecuador, Peru and Tripoli, gave evidence of having the strongest inherent seed setting tendency. These strains exhibited a small stooling, tall growing type of plant, apparently not the most desirable type for hay production. The northern grown strains of alfalfa had a heavy stooling type of crown. They produced a much branched, fine stemmed plant, which seemed well adapted for hay production. In general, the northern strains were deficient in seed production. The common strains of alfalfa from Colorado, Kansas and Utah were intermediate in type between the northern and southern strains. The seed yields and forage production were also seemingly intermediate between the northern and southern extremes. There were some plants in the common strains that seemed similar to the northern strains, while other plants seemed more like the southern varieties. There were plants which seemed to combine some of the traits of both northern and southern types. It has often seemed that good seed yields and heavy forage production were antagonistic traits. Yet numerous instances occurred where plants were found which seemed to combine these two desirable qualities in the same plant. Such plants were found in several of the best commercial strains, such as the Grimm and Baltic.

SEED SELECTION TO IMPROVE SEED YIELD

It seemed possible to produce a strain having the ability to produce a good yield of hay and at the same time a good yield of seed.

With this object in view, a number of individual plant selections were made.

After the variety test had passed the second winter, it became very evident that there were non-hardy strains of alfalfa in the test. This was evidenced by heavy winter killing in certain of the plants. The proportion of loss seemed to be correlated with the region from which the variety came. The extreme southern varieties were almost completely winter killed. The extreme northern varieties practically escaped winter loss. Further investigations revealed a relationship between the type of plant and its ability to withstand winter injury.

It was found that the plants with an **upright growing type of crown**, where the stems started out near the surface of the ground, were the plants which suffered most from winter killing. In this type of crown, the buds for the next season's growth were more or less exposed to freezing and thawing and drying out. At any rate, the type of plants with the exposed crown suffered winter losses much more extensively than the type having a more deeply submerged crown.

On the other hand, the alfalfa plants which had a **heavy stooling habit** with a **spreading crown**, the buds of which largely started beneath the surface of the soil, suffered much less from winter killing. Evidently there is a difference in plant resistance in these two types of alfalfa. But the fact that the buds of the erect type are more exposed to freezing and thawing than the buds of the heavy stooling type may have something to do with winter resistance. The northern or heavy stooling types have their buds protected by a considerable layer of soil. Hence, freezing and thawing and drying out are reduced in effect. It is probable, therefore, that a part of the hardiness is due to inherited qualities and a part to protection, due to the habit of growth.

The conclusions of these observations were published in 1911 in the Colorado Experiment Station bulletin No. 184, "Alfalfa, The Relation of Type to Hardiness."

It thus became evident that any system of seed selection to improve alfalfa must take into consideration the question of hardiness and desirable forage production, as well as good seed production. With this in view, a long series of individual plant selections of special merit have been made during the past ten years.

Over 400 specially good plants have been saved separately and tested for comparative values. Their progenies have been reselected for several generations, where the results seemed to warrant.

SUMMARY OF COMPARATIVE TESTS

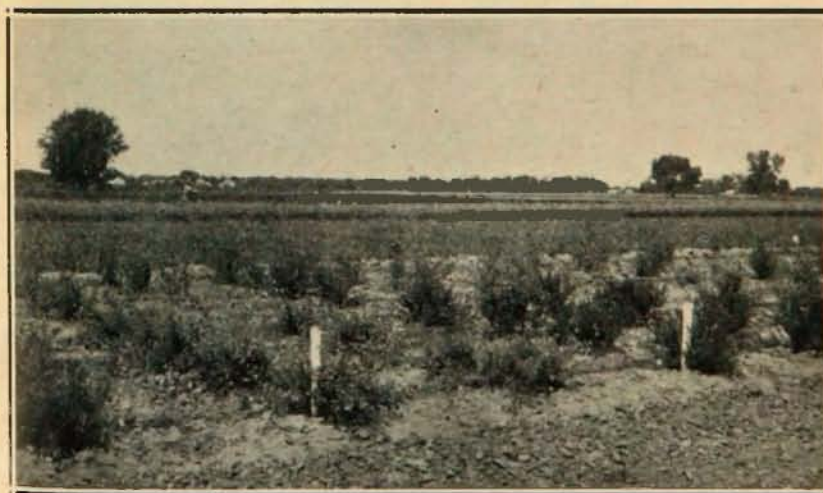
The results of these comparative tests, together with the individual plant selections, might be summarized in the following statements:

1. The **northern strains** of alfalfa have proven to be the most desirable for forage production. They are poorest in seed yields. The **southern strains** were best in seed production. The southern strains winter killed so badly as to be impractical.

2. The **Baltic and Grimm strains** of alfalfa have proven to be most desirable for Colorado conditions. In hay production, they have been about equal in all of our tests. The Grimm alfalfa is thought to be a little more hardy and is somewhat heavier stooling. It is thus finer stemmed. The Baltic has proven to be less susceptible to the bacterial stem blight than other strains of alfalfa. The Baltic has been somewhat better in seed yield than the Grimm. These two strains resemble each other so closely that there is little choice between them.

3. The selection of plants for **high seed yield** has resulted in locating some phenomenally high yielding plants. Selection has produced some specially large stooling crowns. But the high seed yields and large crowns did not occur upon the same plants or strains.

4. The selection of **desirable forage types** has improved uniformity in some strains. This improvement has been sufficient to produce a better quality of hay, while at the same time increasing



A view of the alfalfa nursery, showing the variation in types of plants from different seed sources.



A different view of an alfalfa nursery, showing the variation in the development of alfalfa plants. The small plots are grown from seed from an individual source. Differences can be seen in the progenies, as each plot represents a progeny.

hay yields to a certain extent. But the largest crowns did not produce the highest yields. Crowns were found that would occupy over four square feet of ground. Such crowns were developed from a single seed. These extra large crowns produce enormous numbers of stems. But the stems are usually fine and short. Consequently, the large crowns do not usually make maximum hay yields.

5. The selections for high seed yields located a number of plants that produce as high as eight ounces of clean seed per plant. But the progenies grown from these high seed yielding plants in the subsequent generations have not produced uniformly high seed yielding plants. There is some evidence of a slightly better seed setting tendency. But it seems apparent that the heavy seed yields which are often found with individual plants are not entirely due to strong inherent seed setting qualities. Evidently there are other factors, local or inherent, which favor or retard the setting of seed. Hence, seed selection alone does not seem an adequate solution of the problem.

IRRIGATION AND MOISTURE REQUIREMENTS FOR ALFALFA SEED YIELDS

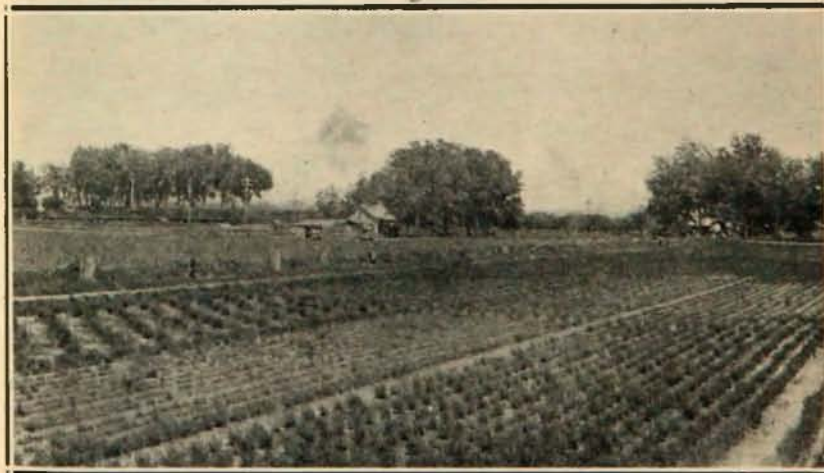
The proper amount of soil moisture required for the best yields of alfalfa seed has long been regarded as one of the first essential conditions for the successful production of alfalfa seed.

It is a well established fact that plenty of soil moisture is necessary for maximum yields of alfalfa hay. But it has also been well established that an over-abundance of moisture is not conducive to good seed production. The best seed yields seem to be secured where the moisture in the soil is somewhat limited or possibly limited at certain stages of the crop's development. But just what the moisture requirements for alfalfa seed production are has not been fully determined.

Soil moisture is extremely variable. The grower has a very limited opportunity for regulating the amount of moisture available to the crop. There are three ways in which a grower can partly control soil moisture for his alfalfa seed crop:

1. **By selecting a field properly located** in relation to irrigation and flood water, with a soil of suitable type for retaining and giving up soil moisture.
2. **By applying water** by such methods that the soil will not be over soaked.
3. **By using types of cultivation** which will regulate soil moisture to some extent.

At the beginning of the investigation, it seemed probable that a careful canvass of all methods followed by successful alfalfa seed growers would reveal a satisfactory solution of the soil moisture problem. But after a long observational study of the question under field conditions, it is clear that the solution of the problem is complex and difficult. A few growers have found fairly successful



A view of the alfalfa nursery, where the alfalfa was given different field spacing to test the effect of different spacings on seed production.



A close-up view of the alfalfa nursery experiment upon the effect of space on seed production.

methods. These growers are producing alfalfa seed by following the methods that have been worked out empirically for their particular farm conditions. But invariably they admit that the same plan does not always succeed. Neither does the same plan succeed under different soil conditions. The different ideas of the most successful alfalfa seed growers in regard to supplying irrigation have very few points in common. Hence, any specific rule formulated for regulating the water supply is usually subject to numerous qualifying conditions.

The most **conclusive results** from field observations might be summarized in the following statements:

1. The moisture condition in the soil which seems to produce the best alfalfa seed yields appears to be a somewhat **limited water supply**. The supply must be limited so that there will be a somewhat retarded growth of forage. Yet there must be sufficient moisture for the plant to function properly during the blooming period and while the seeds are forming and maturing.

2. Excessive moisture in the soil seems to stimulate a heavy growth of forage at the expense of seed production. A **heavy rain or an over soaking irrigation at about the blooming period is usually fatal** to a high seed yield. The increased moisture induces a new growth of stems and seems to exert an abortive influence on the flowers in bloom.

3. A favorable soil and moisture condition for alfalfa seed production seems to be a **sandy to sandy loam bottomland** with a water table about six to eight feet below the surface. Under such conditions, after the alfalfa is once started, the water will rise by capillarity, thus supplying the plants without irrigation with sufficient water for good seed development. Such conditions are frequently very successful for producing good alfalfa seed yield. Sometimes a light irrigation is required in addition in order to insure seed yields. Whether or not the irrigation is required depends on soil and climatic conditions.

4. **Heavy adobe soils** that are rather impervious to moisture produce desirable alfalfa seed yields where the moisture can be supplied at the proper time and in the proper amounts. Applying water at the proper time and in proper amounts requires experience with different types of heavy soil. Some growers have reported instances where five or six irrigations were necessary to produce a successful crop of alfalfa seed on heavy adobe soil.

5. **Deep, loamy soils** that are well adapted for prolific hay yields are not, as a rule, suitable for alfalfa seed production. When an attempt is made to control moisture, the seed yields are usually uncertain and irregular.

6. Under strictly **dry land conditions** without irrigation or natural sub-irrigation from an underground water table, alfalfa seed production is usually a flat failure, with the climatic conditions common to Colorado upland dry farming. On very favorable soils, with a rainfall of 18 to 20 inches, fairly good results in seed production have been secured.

These rather indefinite conclusions have been drawn from the field observations. In order to get more definite results on the specific question, "What are the moisture requirements for alfalfa seed production," several experiments have been tried by applying different amounts of water at different times on alfalfa produced for seed.

The first experiment was tried on a uniform field of alfalfa that had been sown in rows. The soil was uniform. The field of alfalfa had been developed from a single selection. This made all conditions as nearly uniform as one could reasonably expect under field conditions.

Fifty rows in the field were divided into five sections of ten rows each. The first section was left unirrigated. The second section had irrigation water run in small furrows. The water ran about twenty minutes. The third section had the water running in

the rows about one hour. The fourth section had the water running about two hours. The fifth and last section had the water running thru the rows about five hours. These different irrigations provided a large range in the amount of water applied to the different sections.

In this experiment there was practically no difference in seed formation between any of the five sections. The unirrigated section seemed to be equally as good as the others. The only difference noticed between these five different applications of water was that the section where the water ran five hours gave a **slightly higher yield in forage** than the unirrigated section.

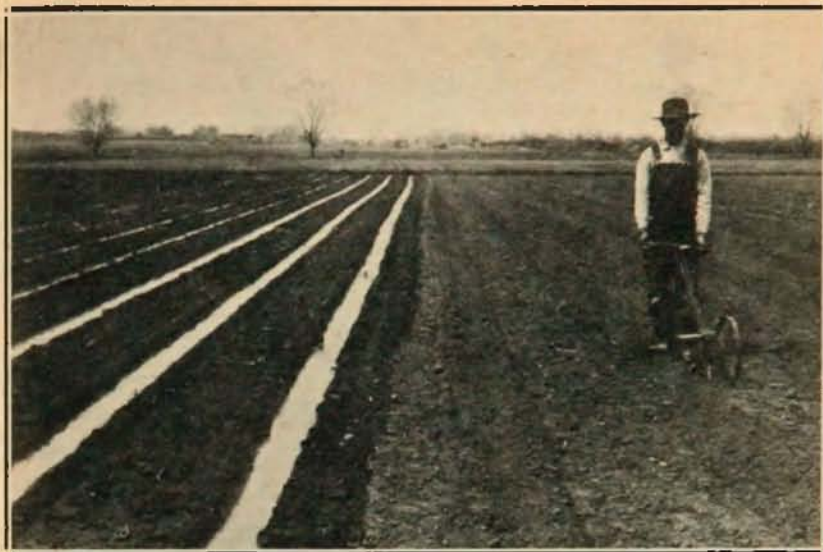
These results apparently indicated that all the plants might be receiving subsoil water. Investigation with the soil auger proved that moisture was rising by capillarity from an underground water table which was 12 feet below the surface.

Two other similar tests have been conducted on the Experiment Station at Rocky Ford. Several different comparative moisture tests were made by alfalfa seed growers. The results of these experiments have not shown any consistent relation between alfalfa seed setting and any limit in the amount of moisture applied to the alfalfa crop.

In general, a limited amount of water seems better for the production of alfalfa seed than a larger amount. But it sometimes



A field of dry land alfalfa planted in rows for seed production. While this field is on dry land, it receives some water from an underground water table approximately 8 feet below the surface.



One method of laying off a field with irrigation for the rows where alfalfa is to be seeded in rows. The same method may be used to seed alfalfa in narrow beds. The ground is soaked by running water in the irrigation furrows.

happens that alfalfa plants growing on ditch banks, where the soils are continuously wet, will give good sets of seed. Such contradictory evidence is hard to explain. But it seems that climatic conditions and a number of undetermined factors have more to do with the question of successful seed setting than any particular amount of water.

Another observation in this connection which is difficult to explain can be found almost any year in almost any field left for seed. Frequently in such fields one portion will fail to receive enough moisture on account of the ground being too high or the water not being run long enough in spots. Near such spots, portions of ground will be found frequently where the soil becomes too wet on account of the ground being at a lower level. Such low levels will collect the water until the soil becomes so wet that the alfalfa will grow too rank for seed production, while the dry spots will not have water enough to produce seed yields.

It would seem that between these two extremes, there should be a zone where the moisture supply would be just right for successful seed production. But such a zone is seldom found.

This would indicate that seed setting in alfalfa is not dependent solely on any definite amount of soil moisture. Consequently, there must be other very important factors influencing seed production.

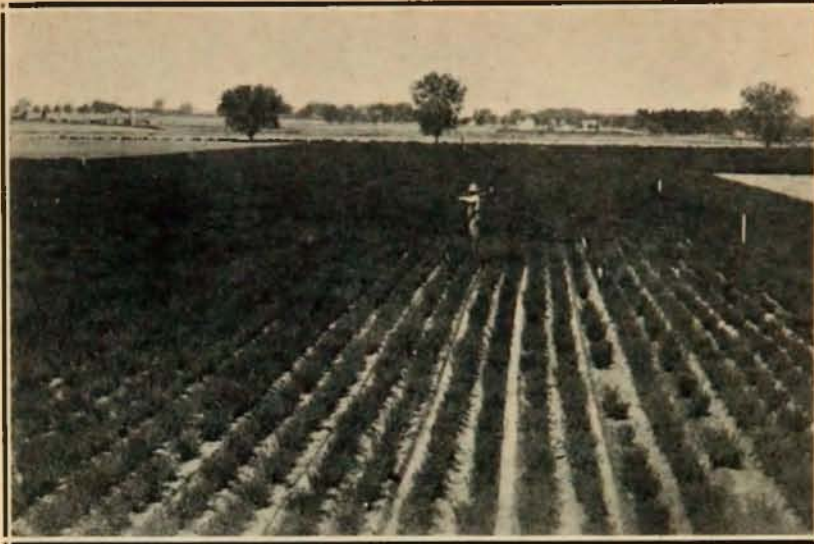
But the efforts to determine the role of soil moisture in seed production did not end with the above experiments. An experiment was planned to control all the water available to the plants by cutting off a possible subsoil supply.

To carry out this experiment, 24 cement lined soil pits were constructed, each four feet long by two feet wide by four feet deep. The pits were dug oval shaped. The walls and bottom were plastered with cement and made water tight by several coatings of cement. The soil from each pit was replaced. As soon as the soil was well settled, two alfalfa plants were transplanted into each pit. These transplanted plants had all been propagated by crown cuttings from two large stooled Grimm alfalfa plants. Thus, the plants in the separate pits each had the same inheritance, the same inherent seed setting tendencies, because they were parts of the same original mother plant.

The plan was to get the plants established in each soil pot under as uniform conditions as possible for the first season. Then, during the second season, it was proposed to supply a series of different amounts of water to the different soil pots. The plan was carried out on two series or in duplicate sets, according to the following tabular arrangement. The first application was made April 25, 1916, at the time the plants began to show the first signs of a need of water. The plants in all the soil pots were very nearly uniform in size.



A field of Baltic alfalfa planted in rows with a view to seed production. On the right are shown rows of alfalfa alternating with rows of grain. The grain was planted with the idea of reducing the amount of water which the alfalfa would receive, in the hopes that it would increase seed production. The results were entirely unsatisfactory.



Irrigating alfalfa in rows. In this test, the irrigation water was allowed to soak into the soil for different lengths of time in an attempt to determine the proper moisture conditions for best seed production.

Table of Amounts of Water Applied in Series A and B—Soil Pots

Plants in soil pot No. 1	received	1 quart of water every 30 days
Plants in soil pot No. 2	received	1 quart of water every 20 days
Plants in soil pot No. 3	received	1 quart of water every 10 days
Plants in soil pot No. 4	received	4 quarts of water every 30 days
Plants in soil pot No. 5	received	4 quarts of water every 20 days
Plants in soil pot No. 6	received	4 quarts of water every 10 days
Plants in soil pot No. 7	received	8 quarts of water every 30 days
Plants in soil pot No. 8	received	8 quarts of water every 20 days
Plants in soil pot No. 9	received	8 quarts of water every 10 days
Plants in soil pot No. 10	received	12 quarts of water every 30 days
Plants in soil pot No. 11	received	12 quarts of water every 20 days
Plants in soil pot No. 12	received	12 quarts of water every 10 days

In addition to the water applied, each soil pot received the normal precipitation for the season. This proved to be an insufficient amount to affect the experiment.

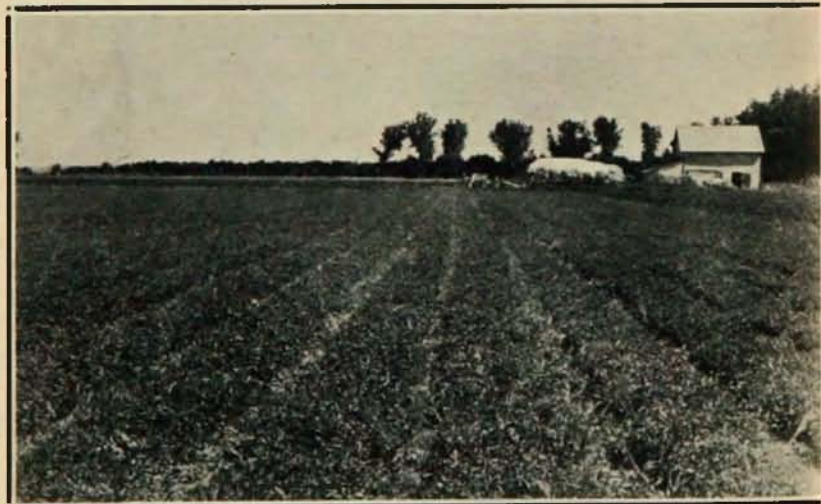
The different quantities of water applied to the different plants resulted in a forage development about in proportion to the relative amounts of water applied. The lightest application of one quart every thirty days was just about sufficient to keep the plants alive. As the amount of water applied was increased, the forage growth was increased. The heaviest application of twelve quarts every ten days produced practically a normal sized alfalfa plant. But the

effect on seed production could not be detected as all of the plants seemed to set seed in about the same manner. The amount of seed set was in about the same ratio as the size of the plant. The experiment did not show that alfalfa seed yields could be controlled by the application of any definite amount of water.

An effort was made to repeat the experiment the following season. But for some reason the plants in the different soil pots developed great irregularity in growth. It is possible the irregular, abnormal growth was due to differences in root growth, the results of irregular settling of the soil in the pots.

During the season of 1919 several plants in these pots were supplied with excessive amounts of water. The soil was nearly saturated every week or ten days. In spite of the fact that all other alfalfa seed tests on the Experiment Station failed under field conditions in the season of 1919, the plants in the cement pots which received the heavy application of water all set seed fairly well.

The failure of the alfalfa seed under field conditions was thot to be due to abnormally wet conditions during the spring and summer months. Yet the plants growing in the open cement pots, which received the same precipitation and in addition heavy applications of irrigation water, were not apparently reduced in seed production by the excessive water. Again this seems to indicate that there are



A field of alfalfa sown in thick drill rows. Seeding was done with an ordinary seeder, getting results much the same as would be had by using a drill having the hoes spaced 7 or 8 inches. In this method of seeding, furrows for irrigation are spaced every three feet. This makes it possible to control the irrigation water so as to get the alfalfa as small an irrigation or make it as wet as is desired.



The most common method of irrigating alfalfa by flooding from field laterals. This method is not well adapted for seed production. On soils suitable for this method of irrigation, it is well adapted for hay production.

other factors influencing seed setting besides any definite moisture supply.

The most practical conclusions to draw from the investigation on the effect of different supplies of moisture might be summed up in the statement, "alfalfa intended for seed production should be supplied with the minimum amount of moisture that will insure a medium growth of forage and provide an adequate supply of water to insure the maturity of the seed." To accomplish this, the grower must become familiar with his farm soil conditions. He must learn how to handle his soils so as to control the moisture.

CULTURAL CARE AND METHODS TO INSURE SEED PRODUCTION

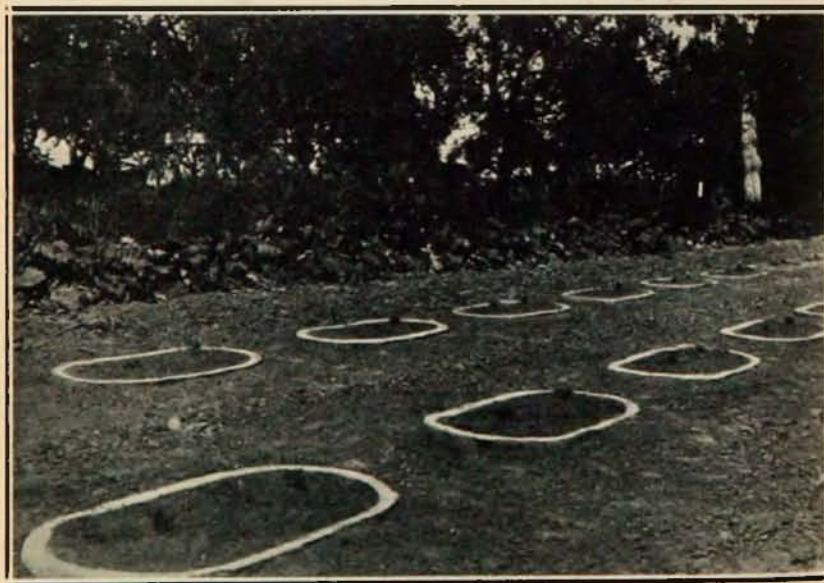
Many successful alfalfa seed crops have been attributed to the plan of pasturing the alfalfa with livestock late in the spring. The argument advanced was that the first growth which usually starts in the spring is exhausted by being pastured off. It is that that the growth that follows when the grazing livestock is removed, about the middle of May, will be somewhat dwarfed and thus more inclined to set seed. Many successful crops of alfalfa seed would seem to warrant this conclusion. However, the investigations on this point are not conclusive. Experiments have been carried on several years where the first growth of alfalfa have been clipped off in the spring. Various plans of grazing have been tried out in comparison. The

tests have been duplicated for several seasons. The results do not show that grazing off the first growth will stop alfalfa seed failure. Some seasons the first crop growth will set best with seed. In other seasons, the second growth seems to be more favorable. These varying results are attributed to varying climatic conditions.

The **effect of cultivation** on seed production has also been the subject of investigation. Tests of different degrees of cultivation have been tried out on fields of alfalfa grown in rows, where a portion was left uncultivated, a portion cultivated lightly, and a third portion cultivated deeply. So far as seed production was concerned, no difference could be seen whether the soil was cultivated or not. Cultivation seems to aid in conserving moisture. But cultivation leaves a loose surface soil, which is seriously objectionable in an alfalfa seed field. The loose soil and gravel is likely to be picked up with the crop when the crop is harvested. Loose soil and gravel mixed with the seed is difficult to separate. It often damages the alfalfa huller in thrashing.

THE EFFECT OF SPACE OCCUPIED BY THE PLANTS ON SEED PRODUCTION

It is generally conceded by alfalfa seed growers that a thin stand of alfalfa gives the best results in seed production. A thick stand



A close-up view of the cement pots used to test out the effect of different applications of water on seed yields.



A view of the series of cement pots used to test the effect of different amounts of water applied on seed yields. This view was taken the second year of the tests.

limits the bloom to the tips of the plants, while a thin stand exposes a larger proportion of the plant to light and air, thus permitting a greater amount of bloom on the scattered branches. The greater amount of bloom on the thin stand enables a heavier seed yield to be produced if other conditions are right.

Space effect in its influence on alfalfa seed production has been under investigation in a series of experiments. The alfalfa was planted in rows spaced at different distances. The plants in the row were thinned out to different row spacings. The space allotted to each plant ranged from 18 to 20 square inches to as many square feet. The results from these experiments indicated that a thin stand is necessary. But it was also evident that lack of space was not the general cause of failure of alfalfa to produce seed. Where plants were given practically unlimited space, there were still approximately the same percentage of plants which failed to produce seed. It has been observed that plants which grow in large, open spaces will sometimes produce seed prolifically, especially on the stems which lie close to the ground. Often the other branches of the plants are not especially well set with seed. There is some doubt whether space is primarily the cause of this extra good seed setting near the ground. (This observation will be referred to

again under the topic of "The Influence of Temperature on Seed Yields.")

The conclusion on the studies of space effect is that a **uniform, thin stand** is desirable for best results in alfalfa seed production. The stand must be thin enough to give the plants a maximum opportunity to bloom as fully as possible.

GROWING ALFALFA IN ROWS FOR SEED PRODUCTION

Many growers have sown alfalfa in rows, expecting to cultivate. The object in sowing in rows was to secure a uniform, thin stand for seed production. This method of seeding has been highly successful in securing a uniform, thin stand of plants. But it has not succeeded in solving the seed problem.

There are some very serious objections to handling alfalfa in rows, especially if the rows are widely spaced. The chief difficulty is encountered in handling the crop with farm machinery, if the rows are thirty to forty inches apart. The soil between the rows will become low as it is washed out by rain or irrigation or blown out and drifted into the crowns. These causes leave the field rough and uneven. On such land it is very difficult to harvest a crop. The outer branches from the row will lie over on the ground,



A field of Grimm alfalfa seeded in 20-inch rows. On this field the tests on cultivation, root pruning and top clipping were carried out.



A comparison of both crown development and habit of growth of northern and southern types of alfalfa at the end of the first season's growth. The southern type is on the left, the northern at the right.

making mowing difficult. If cultivation is neglected, a field of alfalfa in wide rows will become a veritable weed patch.

The principal arguments in favor of seeding alfalfa in rows are to secure a **uniform, thin stand** and provide a means of **regulating irrigation** in furrows between the rows. If the rows are not too far apart, the plan succeeds fairly well. In rows twenty inches apart, the stems will interlock and support themselves so that the crop may be harvested fairly well. But even with twenty-inch rows, the ground may be somewhat rough.

A more suitable method for seeding alfalfa so as to regulate the application of irrigation is to sow the seed in closely spaced rows or drills, say six to eight inches apart. At intervals of about every

thirty inches or so an open space may be left for an irrigation furrow. This is equivalent to seeding in narrow beds with a crease or small irrigation furrow between the beds. The plan lends itself either to hay or seed production. The seeding may be made light or heavy as desired. For seed production, **one to three pounds** of good seed should furnish a stand of plants sufficient for highest seed yields. **Eight to ten pounds** would be better adapted for hay production.

THE RELATION OF BEES AND OTHER INSECTS TO ALFALFA SEED YIELDS

There is a theory that alfalfa seed yields are dependent on the presence of bees or other insects. This seems to be based on old textbooks, which teach that the fertilization of alfalfa flowers is dependent on the "tripping" by bees of the flower mechanism that envelops stamens and pistil.



A typical plant of the southern or non-hardy type of alfalfa.



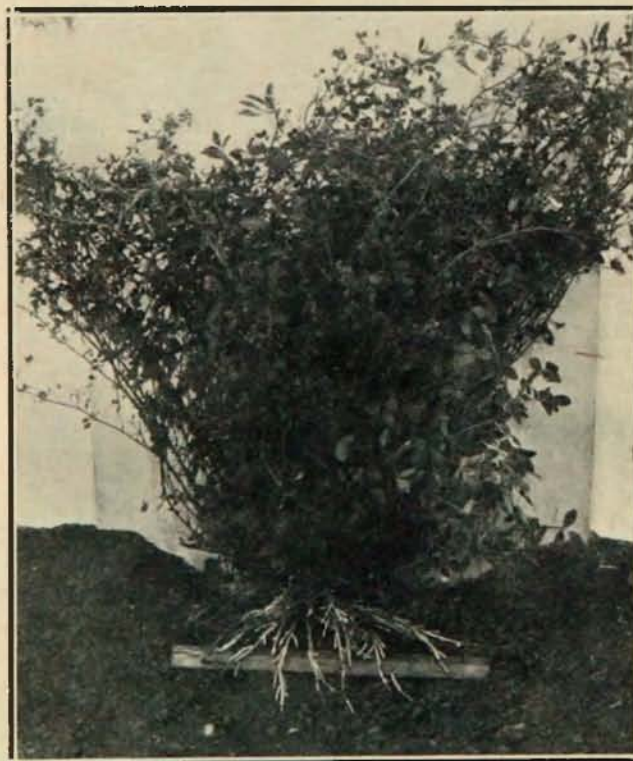
A typical plant of the common alfalfa.

An experiment was conducted to determine to what extent alfalfa seed failures were due to bees and other insects. A number of alfalfa plants were protected with screen cages before the blooming time. These plants were compared in seed yields with similar plants which were given the same care except that they were not covered with screens. The results were that some of the plants under screens set well with seed. Some did not. This was also true of the plants not covered. The experiment was repeated two years in succession, with practically the same results. That is, **there was no clear evidence that bees or other insects were essential to alfalfa seed production.** It is possible, under field conditions, bees may have an influence in slightly assisting fertilization of alfalfa bloom. However, the covered experiments showed that fertilization could take place without the insects and did so take place.

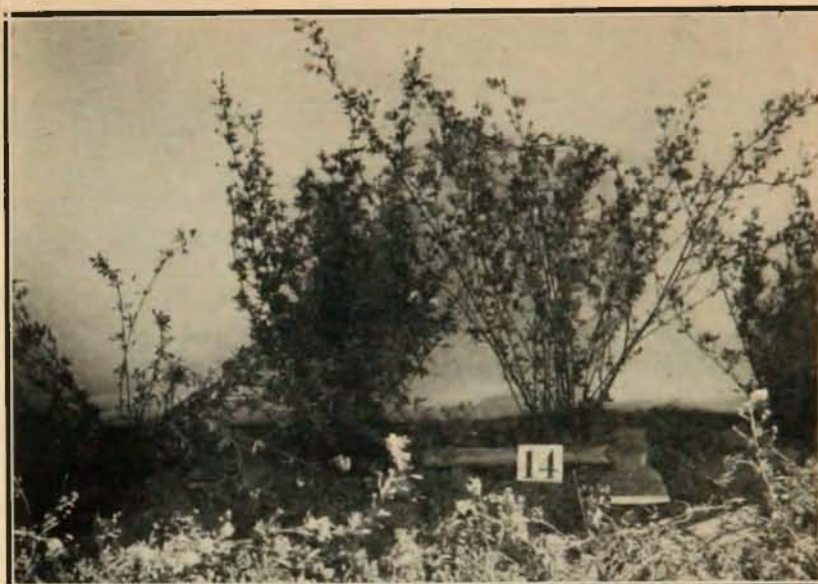
An experiment was carried on to determine the effect of artificial "tripping" of flowers. The branches of a number of selected plants

were divided. The flowers on half of each plant were "tripped" by hand. The other half of the flowers of each plant were unmolested. The results here were very similar to the results under the covering of screens. Some produced seed and some did not. There was practically no difference in seed yields resulting from hand "tripping" of the flowers. Observations have been carefully made to try and determine if the flowers on plants that were prolifically setting were any more likely to be "tripped" than flowers which were failing to set seed. While some plants seemed to have more "tripped" flowers than others, it could not be seen that the "tripped" flowers were more inclined to set seed. Many flowers were observed which did not "trip." They remained untripped until the bloom withered. Yet many such flowers did set seed. There is a possibility, of course, that the "tripping" may have occurred when the bloom began to wither.

The presence of large numbers of the small insect known as



A very good typical representative of the northern or hardy type of alfalfa.



There is a very wide range in type of plants grown from common commercial seed. The plants shown are typical variations obtained from the planting of common commercial seed.

“thrips” has been regarded by some as an important factor in causing alfalfa seed failures. Careful examination of flowers on plants that were setting seed successfully showed that the thrips were as abundant on such flowers as on blooms where no seed or little seed was setting.

From these investigations, it seems probable that **some of the injury to alfalfa bloom is due to the thrips**. There is some injury from other insects. But it is hardly possible that these injuries are the **prime** cause of seed failure. This conclusion is reached because many of the worst injured blooms set fairly well with seed.

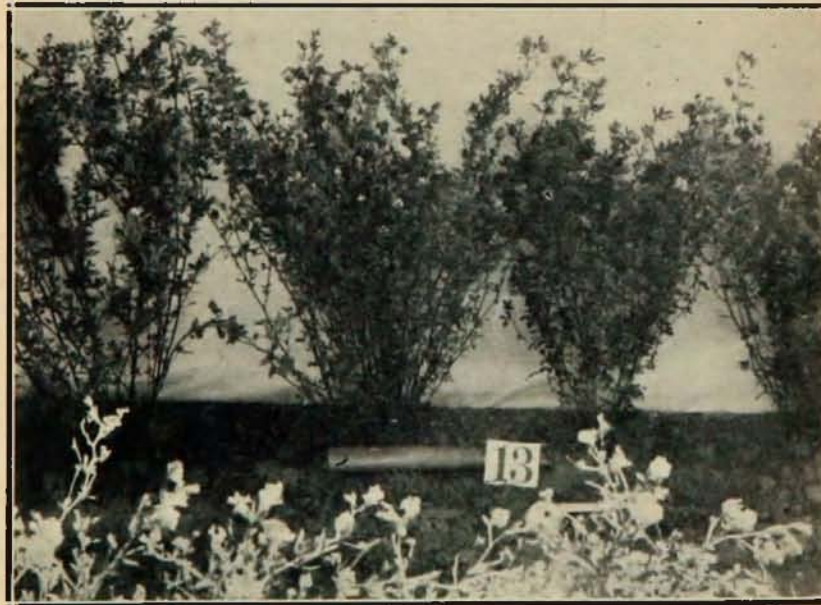
In seasons of severe alfalfa seed failure, it is usually possible to find a few plants which set seed perfectly, even where the surrounding plants in the field are a dismal failure. Such results in the midst of failure is the paradox in the alfalfa seed problem. It is difficult to harmonize these results with any theory of insect activities in relation to alfalfa seed setting. **If** beneficial insects are essential to fertilization of the alfalfa flowers, it would not seem possible that a few plants would be well fertilized, while the mass of adjacent plants were not. On the other hand, if injuries were responsible for seed failures, it would seem incredible that some plants would escape injury entirely, that their flowers should become well fertilized,

when the surrounding plants would fail completely on account of insect injury.

CLIMATIC CONDITIONS, HEAT AND ITS RELATION TO SEED YIELDS

As previously mentioned, it has been observed frequently that alfalfa branches which bend over and lie closely to the bare ground sometimes set heavily with seed, when the balance of the same plant sets poorly. These branches close to the ground are not only exposed to hot sunlight, but are also exposed to radiated heat from the soil below. A notable instance of this kind occurred on the Experiment Station Farm at Rocky Ford in the fall of 1919,

An irrigation ditch that had not been used all summer had a row of alfalfa growing on its north bank. The ditch had been cleaned out with a ditching "A." This made a dry, sandy, sloping bank next to the alfalfa row. The lower branches from this row dropped over into the ditch. These branches thruout the length of the ditch (about 300 feet) all set heavily with seed. The branches nearest the ground were best filled with seed. The balance of the branches of the plants in the row was practically barren of seed.



Plants developed from a single mother plant, thus producing a selected strain showing great uniformity in their development and habits of growth. The above plants all came from one selected strain.



A contrast in seed setting ability on plants grown under exactly the same conditions. The plant at the right is heavily set with seed, that at the left almost devoid of seed.

It was clearly evident that the cause for this good seed setting was entirely local. The effect was limited to the branches that hung over into the ditch. The ditch was perfectly dry. It seemed evident that heat was the important influence peculiar to these branches in the ditch. The only two factors which were different for the branches out of the ditch and the branches in the ditch were heat and light. The free circulation of air would be somewhat obstructed by the bank and surrounding vegetation. The dry, sandy soil would reflect both heat and light. The air and branches in the ditch would become very warm during the heat of the day. This instance was the **first practical evidence of the effect of some one cause as a prime factor in prolific seed production** which has occurred in the past 16 years in which alfalfa seed production has been under investigation.

The effect of this observation may not be easy to analyze. But it is evident that there is some physiological relationship between the effects of heat or heat and light and the efficient fertilization of alfalfa flowers, which is equivalent to saying that there must be some relationship of heat and light and the proper functioning of the processes of reproduction. It at least gives a clue for further investigations. Climatic conditions are evidently the most potent

influences affecting seed production. But as these are beyond the control of man, it is apparent that seed production must be achieved by adapting the alfalfa or alfalfa growing conditions to meet the climatic conditions. This line seems to offer the most feasible promise in future investigations of the alfalfa seed problems.

SOIL FERTILITY AND ITS EFFECT ON ALFALFA SEED PRODUCTION

Investigation of the effects of different fertilizers on alfalfa seed production has been omitted or overlooked, probably because of the many successful seed yields under conditions where no special soil fertility was provided.

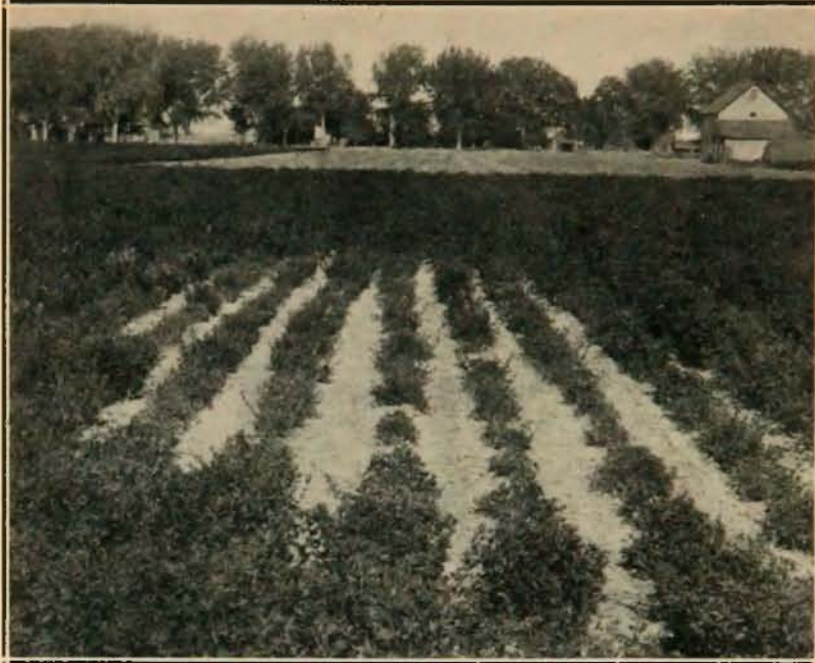
If a record of alfalfa seed yields in the Arkansas Valley could be reviewed, it would be noted that 600 to 900 pounds per acre were not uncommon yields about 25 years ago. The soils of the Arkansas Valley were nearly virgin at that time. The soils at that time were more or less deficient in nitrates and organic matter.

In recent years, alfalfa seed yields have greatly fallen off, so that 180 to 250 pounds per acre is regarded as a fair seed yield.

There are two general farm conditions that have undoubtedly



A field of alfalfa seeded in rows. It is easy to see the dry spots. Around these dry spots there was a range of moisture, varying from too dry for production up to too wet, yet there was no apparent evidence of a zone of good seed setting anywhere between these two ranges.



A close-up view of a dry spot. In the center of the spot conditions were too dry for seed production or hay production. Between the center of the spot and the edge, there was no zone of seed setting, altho there was a zone of difference in the moisture content, varying quite uniformly from the driest of the center to the wettest of the outer edge.

changed: 1. With the general practice of irrigation, the water table has risen on the old irrigated lands. 2. Soil nitrates have increased in the soils to a considerable extent.

It is now well established that much of the soil in the Arkansas Valley is rather overcharged with nitrates. These nitrates are evidently developed in some soils and carried to others by irrigation waters. This fact has aroused a suspicion that an excess of nitrates may be partly responsible for decreased alfalfa seed yields. In fact, there are strong evidences that this is the case. For the past two years, alfalfa on the experimental plats has failed to bloom normally. There was hardly any bloom at all. The soil in these plats is know to be strong in nitrates. Alfalfa, in its seed setting traits, seems to behave much as plants overfed with nitrates. This suggests that the physiological effect of different fertilizers be made a line of future investigation.

SUMMARY

1. There is a difference in the inherent seed setting tendency of different strains of alfalfa. The southern strains seem to be strongest

in this respect. But the southern strains are not adapted to our climatic conditions. They are not sufficiently hardy.

2. Seed selection for prolific seed yield improves the ability of the selected stocks to produce seed yields. But the improvement is not sufficient to solve the problem.

3. The amount of moisture for alfalfa seed production should be regulated to such an amount that a minimum amount of forage growth results and still have water enough to fill and mature the seed. This virtually amounts to what might be called a medium quantity.

4. Pasturing off the first growth late in the spring has apparently stimulated good seed yields. Good seed yields seem to be coupled with such an arrangement of the irrigation system as to regulate the amount of water and hold it close to a minimum requirement. Apparently this is best done by having small irrigation furrows about every thirty inches and thus irrigate by the furrow method.

5. A thin stand of plants is necessary for the best seed production results. A uniform stand is essential. A plant to every one or two square feet is about right if the stand is uniform.

6. There are serious objections to growing alfalfa in rows. The most serious objection is the difficulty in handling the crop with machinery.

7. There is very little evidence that bees are essential to alfalfa seed yields.

8. Dry climatic conditions with high temperatures seem to be among the most essential requirements for successful alfalfa seed production.

9. The effect of fertilizers or nutritive substances on alfalfa seed production has not been investigated. There are indications which point to soil nitrates in excessive quantities as a serious cause of poor seed yields in many irrigated regions.