ALFALFA SEED PRODUCTION IN MILLARD COUNTY, UTAH

AS RELATED TO SOIL TYPE

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Alfalfa has a wide range of adaptability as a forage plant, but the areas in which it will produce seed successfully are extremely limited. These sections are confined almost exclusively to the arid or semi-arid regions of the world. In all other areas it is primarily a question of seasonal fitness. The extreme localization may be further emphasized by the fact that within the highest-producing counties there are appreciable areas of land not suitable for seed production.

Western Millard County (1) has probably approximated more nearly than any other section of the United States the ideal climatic and soil conditions necessary for alfalfa-seed production.

This area lies within the eastern boundary of the Great Basin in what is known as the Sevier Desert. It is typically desert, with an annual rainfall of approximately 3 inches. The mid-summer season is usually hot and dry with little or no rainfall and clear, sunny days. The nights are crisp and cool. The wind movement is usually high during spring and summer. Strong southerly winds often blow for days at a time, affecting the water content of the irrigated soils.

The soils were developed under arid conditions. They are rather low in content of organic matter and in alkali concentration run from free to more than 1 per cent. Most of the soils have an unfavorable structure, baking and cracking after the application of water.

(1) The area designated as Western Millard County is in the main that area described in the U. S. Department of Agriculture Soil Survey Report of the Delta Area, Utah (1919).
Western Millard County is the oldest seed-producing section in the entire United States, and until 1928 it was the most consistent seed-producing area in the United States. Since 1928, however, there has been a rapid decrease in the amount of seed produced. The average annual production for several years previous to 1928 was in the neighborhood of 5,500,000 pounds. The total production for the area in 1932 was approximately 165,000 pounds. The cause for this rapid decline in seed production is not known.

There are good and bad seed years, but even the most observant grower has been unable to explain this difference. All he knows is that in some seasons seed set quickly and abundantly in all parts of the section, irrespective of treatment; in other years, the bloom fell, although the treatment, apparently, was the same as given in other years. Some attribute these "off" years to hot, dry winds at flowering time, others to periods of cloudy weather, and still others to the work of insects. There is great diversity of opinion among those who have actually been engaged in seed production for a great many years.

REVIEW OF LITERATURE

Alfalfa seed is an extremely uncertain crop, even under the most ideal conditions. Dwyer (5), working in New South Wales, states: "A wide field is open to investigators to determine the factors -- such as climate, soil conditions, insects, and variations in the seeding ability -- which govern seed production."

Some writers seem to agree that climate in general is the limiting factor for seed production (1, 3).

Production of seed in any one locality over a long period of years, no doubt, is due in a large measure to the favorable climate possessed
by any particular locality. It is equally true that weather may be the major factor affecting the annual yield and may be the chief cause of so-called "good-seed years" or "poor-seed years." However, it is difficult to believe that climate and weather are the major factors causing continuous seed failures in the Millard area during recent years. Climate itself has not materially changed during this period, certain seasons having been as ideal for the setting of seed as to any previous to 1928. Other factors must be investigated as to the cause of these failures.

The proper amount of soil moisture has long been regarded as one of the first essential conditions for the successful production of alfalfa seed. When the soil is so dry that little vegetative growth is made, the plants produce few flowers and cannot be good seed producers (7). The failure to secure a properly balanced supply of soil and atmospheric moisture is the real cause of alfalfa flowers refusing to set seed (7,8). Engelbert (6), found that stripping of the flowers in the blooming period was due to failure to fertilize and was caused either by extreme moisture or by extreme heat with frequent high, dry winds. Blinn (2), working at the Colorado Station, found the moisture condition in the soil which apparently produces the best alfalfa-seed yield is a somewhat limited water-supply; this water-supply, however, must be sufficient for the plant to function properly during the blooming period and at the time the seeds are forming. From replies received to a questionnaire sent out to growers of alfalfa-seed in 1920, Tirmette (10) reports: "If there is any one thing that growers are agreed upon, it is that severe fluctuations in the moisture content of the soil is bad for the seed crop."

**ALFALFA-SEED PRODUCTION AS RELATED TO SOIL TYPE**

Generally speaking, the soil types indicated in this paper are based

It is often remarked by seed growers that some farms are better producers than others, regardless of methods used in production. In order to determine whether this is true, crop-production data were obtained from individual farmers, from seed house, and from threshing machine records. Data, covering an 8-year period, were obtained for more than 100 farms. After grouping the soils into classes or types, according to the Delta Area Soil Survey, it was found that some soil types have been more consistent seed producers than have others (Table I). It is evident from the data presented in Table I that the finer-textured clays have not been as consistent producers as have the medium-textured soils. Likewise, soils of coarser texture, particularly the silty clay loam and the fine sandy loam of the Oasis series, have also been poor producers.

These same data are shown graphically in Figure I. A study of Table I shows further that the average annual yield has fallen off rather abruptly since 1928. Further study has shown, in general, that up to a certain point the average seed yields have increased as the index of friability increases. In the case of the coarse-textured soils of the Oasis series, the yield decreases as the index of friability increases. This can be expected because somewhere there must be a break in the relationship.

There is one exception to the general statement regarding the relationship between yield and index of friability. The case is with the Woodrow clay loam and Gordon clay, being just reversed in order. This can be accounted for by the fact that the surface foot of the Woodrow clay loam is quite friable, while the second and third feet are heavier than the Gordon clay. The relationship existing between the yield and index of friability will be reserved for later discussion.
TABLE I.

Showing the soil type, the average acre-yield in bushels from 1924-31, the average yield for the 8-year period, and the average index of friability for each soil type.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Year</th>
<th>Avg.:</th>
<th>Index:</th>
<th>8 yrs.:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1924</td>
<td>1925</td>
<td>1926</td>
<td>1927</td>
</tr>
<tr>
<td>Abbot Clay</td>
<td>2.6</td>
<td>5.0</td>
<td>4.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Woodrow Clay</td>
<td>3.1</td>
<td>7.7</td>
<td>7.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Gordon Clay</td>
<td>5.2</td>
<td>6.5</td>
<td>5.5</td>
<td>2.4</td>
</tr>
<tr>
<td>Woodrow C. L. *</td>
<td>5.3</td>
<td>8.1</td>
<td>5.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Oasis Clay</td>
<td>6.2</td>
<td>7.0</td>
<td>6.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Cache S.C.I.**</td>
<td>6.3</td>
<td>10.0</td>
<td>5.6</td>
<td>6.0</td>
</tr>
<tr>
<td>Oasis S.C.L.**</td>
<td>3.7</td>
<td>5.5</td>
<td>4.6</td>
<td>4.1</td>
</tr>
<tr>
<td>Oasis F.S.L.***</td>
<td>5.4</td>
<td>5.1</td>
<td>3.9</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Average Annual Yield: 5.35: 6.36: 5.26: 3.5: 2.04: 1.14: 1.02: 1.1

* Clay loam  
** Silty clay loam  
*** Fine sandy loam

As a result of a study of the data presented in Table I, the following questions arose: (1) What are some of the soil characteristics related to seed yield? (2) What effect does "friability" have on seed yield?

The term "friability", as used in this paper, refers to that characteristic of a soil which has to do with the ease of crushing, crumbling, or rubbing apart of the particles of which it is composed (4). The behavior of a soil under the flow is given considerable weight by farmers as an index of its capacity for agricultural production. Friability is a definite characteristic of a soil and lends itself to measurement.

Experimental Methods

In order to determine the relationship between friability and seed yield, soil samples were gathered from each of the eight soil types of the Delta Area. Where possible, samples were obtained from eight farms
from each of the soil types. Ten borings were made on each farm. A composite sample was made consisting of the ten first-foot borings, one consisting of the ten second-foot borings, etc.

The method used in determining friability was similar to that used by Christensen (4). The soil was ground to a fairly fine state and run through a fine sieve (1 mm.) so that the texture would be comparable. The soil was then mixed with distilled water, made into a stiff mortar, and molded into small cylinders, approximately 2.76 cm. in diameter by 3.37 cm. in length. The apparatus used for molding consists of a hollow steel cylinder supplied with an aluminum piston and a threaded cap in the lower end. By means of the threaded cap and the piston, the length of the cylinder can be regulated. After the soil is pressed into the mold, the cap is removed and the sample forced out by means of the piston.

Six soil cylinders were molded from each soil sample. To determine the percentage of moisture in the mortar, the first and last cylinders were weighed as soon as molded. Trial and error has shown that a more exact crushing strength can be obtained when the moisture percentage runs from 20 to 40 per cent, depending upon the soil texture.

To allow them to dry slowly, the soil cylinders were numbered and were placed for 24 hours in a desiccator containing water. They were then placed in the soil oven and heated to a temperature of 110° C. for 24 hours. When taken from the oven they were weighed, the diameter and length measured, the area and volume calculated, and the cylinders crushed in a specially made machine developed by Christensen (4).

To determine the index of friability the following method was used: The average crushing strength, e.g., 770 kilograms, with an area of 4.75 sp. cm., has an index of friability expressed by the formula $\frac{370}{4.75} = 162.11$. 
which is known as the breaking strength per unit area. The reciprocal of the breaking strength per unit area is the index, expressed in per cent; e.g., \( \frac{1}{162.11} = 6.16 \). Coarse-textured soils are more friable than fine-textured soils; to show this, the reciprocal of the crushing strength per unit area is used.

An index of friability was worked out for the first-, second-, and third-foot zones on 53 farms in Western Willard County.
Part I.

DISCUSSION OF SOME RESULTS OBTAINED FROM INVESTIGATIONS MADE IN MILLARD COUNTY

Perhaps at this point it would not be out of place to discuss briefly the results obtained from a study of other factors that have a relationship to seed production. Frequently there are seasons when only a small percentage of the flowers set seed, even in those regions where conditions for seed production seem to be most favorable. It is found that the same treatment on the same field in different seasons fails to bring equally satisfactory results.

Cultivation

Various cultivation treatments were carried out for two years without important increases in acre-yield of seed. However, cultivation is of importance in weed and insect control.

Clipping

Results from clipping or pasturing-off alfalfa show that clipping at the bud stage, pasturing until the 15th or the 20th of May, or leaving the first crop for seed is most favorable for seed production. This conforms with results of Blinn at the Colorado Station and of Carlson and Stewart at the Utah Station.

Spacing

Thin stands have produced approximately 15 per cent more seed during the past few seasons than have the thicker stands.

Fertilizers

There has been no increase in seed yield from the application of commercial fertilizers.
Soil Moisture Studies

Martin (7) states that a disturbance of the balance between the moisture delivered to the stigma and the atmospheric moisture results in a lack of pollen germination and prevents fertilization. If this statement is correct, one of the controlling factors in the cause of seed failures in Millard County may be established. There is no question that a different soil-moisture and plant relationship now exists than was extant previous to 1928.

The evidence of this fact is based on the following: (1) Previous to 1928 there was a more or less constant water-table in a given location at a depth of 6 feet or less. At the present time the water-table varies from 6 to 15 feet. Over the greater part of the area, the water-table (1932) was found to be below 8 feet.

(2) There is less water available for irrigation purposes. The amount applied previous to 1928 was approximately 2.4 acre-feet. At present (1932) this is approximately 1.6 acre-feet. Previous to 1928 from two to seven irrigations were applied; at present, however, there are seldom more than two applications.

(3) It is probable that the recent shortage of irrigation water has induced a variation in the physical structure of the soil, making it harder to handle and more easy to bake and crack after an application. The baking and cracking of the soil greatly increase evaporation.

(4) The average percentage of alkali on 50 farms in 1919 was 0.576 per cent while in 1932 it was 0.52 per cent. The fact that there has been little change in the total alkali concentration on most farms makes it that much more difficult for the plant to get a sufficient amount of moisture during these years of shortage in irrigation water.
(5) On all farms where samples were taken (except near the Sevier River, where there has always been natural drainage) alfalfa roots are dead below the 5-foot level, indicating that there is not the same relationship between soil and plants as existed when the water-table was higher.

Perhaps one explanation for increase in blighted or blighted seed in these "bad-seed years" is the plant’s inability to furnish the proper water- and food-supply for the maturing of seed during drought.

Insect Survey

The tarnished plant bug, superb plant bug, and green stink bug, when numerous, cause considerable stripping of the bloom.

It has been interesting to note that nearly all writers on the subject of alfalfa-seed production have found that tripping increases seed production (3, 6).

It is not known what the percentage of tripping was which occurred in the fields of Millard County before the present "bad years". During the season of 1932 thousands of blossoms were examined, and it was found that less than 1 per cent of them were tripped. This lack of tripping may be an explanation of the poor seed yield. However, during the season of 1931, a count on one of the highest-producing farms showed that approximately 10 per cent of the blossoms were tripped. The most interesting observation made was that the majority of buds were going into the bur without fully coming into bloom. This situation is the normal one in the Millard area during good seed years.

The high percentage of tripping in the field mentioned was doubtless due in no small measure to the numerous ground bees present. In this field 50 ground bees for each 100 strokes of a net were present. The more
experienced seed growers state that ground bees were once numerous but they are extremely scarce at the present time.
Part II.

SEED PRODUCTION AS RELATED TO INDEX OF FRIABILITY

In response to the question of the relationship existing between seed-yield and index of friability, indexes of friability for the three zones, consisting of the first 3 feet of soil, have been worked out for 58 farms. To study this relationship, crop data from the best seed year (1925) and from one of the poorest seed years (1932), as well as an 8-year average, were used. Since the alfalfa plant is deep rooted, the average index for the 3 zones was used.

Simple correlation coefficients for the 1925, and 1932, as well as 8-year average yield and the index of friability are shown in Table 2. A significant relationship is shown between the 8-year average yield of seed and the index of friability. An 8-year average is a better basis of comparison than is a single year because there is less danger from the influence of other factors. A fairly significant relationship is shown between the 1925 yield and the index of friability; however, there is no correlation for 1932.

In order to make a more complete study of the relationship existing between seed yield and index, the average index has been compared graphically with the 9-year average seed yield for each soil type (Figure1.). It will be observed that a satisfactory relationship exists between the average seed yield and index.

Those farms on which soil study was made were classified according to type and the 9-year average seed yield computed from available crop data. The relationship between this average yield and index is shown graphically in Figure 2.

Both Figure 1 and Figure 2 show a relationship between the index of
TABLE II.

Showing simple correlation coefficients between index of friability and seed yield for the good seed year (1925), for the poor seed year (1932) and for the 8-year average (1924-31) inclusive.

<table>
<thead>
<tr>
<th>Year</th>
<th>Correlation Coefficients with the Yield Placed on Percentage Basis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1925</td>
<td>$r = 0.4507 \pm 0.054$</td>
</tr>
<tr>
<td>1932</td>
<td>$r = 0.0576 \pm 0.0001 \neq 0$</td>
</tr>
<tr>
<td>1924-31 Incl.</td>
<td>$r = 0.5295 \pm 0.0923$</td>
</tr>
</tbody>
</table>

Correlation and the 9-year average seed yield. However, this relationship does not exist for the coarse-textured soils of the Oasis series.
CURVES SHOWING NINE YEAR AVERAGE YIELD OF ALFALFA SEED AND INDEX OF FRIABILITY FOR EACH OF EIGHT SOIL TYPES WITHIN THE DELTA AREA.
Curves showing nine year average yield of alfalfa seed and index of friability for each of six soil types found on farms having approximately one type of soil only.
The 1924 to 1932 average yield of alfalfa seed on each soil type in the Delta area.
SUMMARY

1. This paper presents the results of a study of alfalfa-seed production as related to soil types.

2. Since 1928 the seed crop in Millard County has been practically a failure.

3. For an 8-year period a relationship between soil type and seed yield has existed.

4. The Cache silty clay loam and the Oasis clay have been better seed producers than have the finer-textured soils of the Abbot clay, Woodrow clay, and Gordon clay types, or than the coarser-textured soils of the Oasis silty clay loam and the Oasis fine sandy loam types.

5. Other factors such as early clipping and spacing have increased seed yields.

6. Insects, such as the tarnished plant bug, superb plant bug, and the green stink bug, when numerous, cause some damage to the alfalfa bloom.

7. The changed soil water condition may be a factor causing the present seed failures in the Western Millard County Area.

8. It is evident that a relationship exists between seed yield and soil character "friability". This relationship between seed yield and index of friability is shown graphically as well as by simple correlation coefficients.
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