Bulletin No. 171 - Alfalfa Seed Growing and the Weather: With Particular Reference to Conditions in Utah

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ALFALFA SEED GROWING AND THE WEATHER

With particular reference to conditions in Utah

By

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Meteorologist United States Weather Bureau

BULLETIN NO. 171

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ALFALFA SEED GROWING AND THE WEATHER

With particular reference to conditions in Utah

By

J. CECIL ALTER,
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INTRODUCTION

The demand for alfalfa seed has far outrun domestic production. Since the labor and expense of producing the crop are light, and the profits attractive in favorable years, a desire is manifest wherever alfalfa is grown, to save a crop for seed whenever the meteorological elements favor its setting and maturing. Climate is generally acknowledged to be the limiting factor in alfalfa seed production, and the current weather the major factor affecting the yearly yields.

WHERE THE SEED IS GROWN

According to the United States Census, commercial alfalfa seed growing was restricted in 1909, chiefly for climatic reasons, to Utah, Kansas, Nebraska, California, Arizona, Colorado, Oklahoma, Idaho, Montana and Wyoming, named in order of yields, but domestic demands required importations of inferior seed from foreign countries amounting to 100,000 bushels in 1906, and 50,000 bushels in the war years of 1916 and 1917 (1)a. A varying seed acreage is now grown with a fluctuating degree of certainty rather generally elsewhere over the United States (2).

HUMID CLIMATES UNFAVORABLE

Much of this increase in extent of seed production, however, must be regarded as more apparent than real. The acreage in the humid regions is strictly limited to the thinnest stands on the driest lands, and even there the seed sets in fair quantities only in the occasional extremely droughty years. In Ohio, for example, seed growing is reported (3) to have seldom been profitable, and there are comparatively few growers; in Kansas,

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a. Parenthetical figures in the text refer to the bibliography at the end of this publication.

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the transition region between the humid and arid portions of the United States, it has been found (4) that in the western portion, with a general average annual precipitation of from fifteen to twenty inches, good seed crops are frequently harvested, but in the central and eastern counties where the precipitation ranges from twenty to forty-five inches, profitable crops of seed are

Fig. 1.—Map of Utah showing areas producing alfalfa seed, and alfalfa hay.
secured only in the seasons marked by a general failure of the corn crop due to drought.

**UNCERTAINTY OF THE YIELD**

Even in the more favorable arid regions the seed crop is very exacting in its current meteorological requirements, from the first spring growth, through early summer maturity, to late summer or autumn harvests, and, as one observer expresses it, the crop is never assured until the plants are loaded with clusters of well filled pods (5); and another, that even after the seed is in the bags, the success of the season cannot be fully realized until the affect of the weather on the seed crop in other states is known. Therefore, to every alfalfa grower, there comes the question as to whether the crop shall be cut for hay or saved for seed. In the central and eastern states it comes only in occasional years, but in the arid states, where the altitude, aridity, sunshine, and summer warmth are especially favorable for seed development, producing a seed superior to seed grown in more humid climates, the question comes almost annually.

**SOME SEED YIELDS**

The United States Bureau of Crop Estimates (2) is reporting regularly on condition and yield of alfalfa seed in all states except six New England and eight extreme south-eastern states. The yields in bushels per acre in 1918 are given for a few states as follows: Utah 5.7, Nevada 5.4, California 5.2, Idaho 5.0, Texas 4.7, Arizona 4.6, Montana 4.2, Colorado 3.9, Wyoming 3.6, Wisconsin 3.4, Kansas 3.1, Illinois 2.8, Iowa 2.7, Nebraska 2.6, Missouri 2.6, South Dakota 2.6, North Dakota 2.5, Minnesota 2.5, Ohio 2.4, Michigan 2.4 and Indiana 1.9.

**NATIVE CLIMATES**

Utah seed, from which nearly all the earlier acreage in the United States was planted (7), was of Spanish origin, either the arid west coast of South America or the dry sunny Mediterranean countries. The alfalfa plant under various names has flourished in old world agriculture at least since early Bible times, and doubtless the demand for seed and the desire to grow it have been present wherever the plant was raised. However, despite the world-wide utilization of the plant as an improver of the soil and a food for livestock, the principal alfalfa seed exporting countries are, and for some time have been, Turkestan, Persia, Hungary, Spain, Algeria, Peru, and possibly Chili, the climates of which are similar in important respects to those of the western plains and plateau regions of the United States.
Both Turkestan and Persia, rather heavy and dependable producers of alfalfa seed, are table-land countries whose agriculture is robbed of incoming rains by surrounding mountains, and whose medium latitudes insure a warm summer season. Not a great deal is known statistically of the climate of Turkestan though its map is marked by the Kizil Kum and other deserts, as well as broad semi-productive plains at from 1,000 to 3,250 feet above sea level. These regions have only moderately severe winters and tolerably hot summers, temperatures ranging from 10° to minus 10° F. in winter, and 95° to 105° F. in summer (8).

TOPOGRAPHICAL EXPOSURE OF PERSIA

Persia is a tableland with a vast desert area that covers about three-fourths of the country. The mountains are bare and treeless to a great extent and the plains relatively unproductive and unattractive in their native state, for lack of moisture. The Khorasan desert in the central and eastern portion is saline. There are oases in some valleys along the principal streams, especially toward the headquarters, that are beautiful and of great richness. Many interior streams flow into saline lakes or lose themselves on the barrens. (9).

Dr. A. Supan says of Persia and adjacent regions, Province (8): “This includes all the lofty plateaus bounded by mountain ranges which shield it on every side and so render it very dry. The great height (3,000 to 6,000 feet) makes the winter temperature very severe, but the summer heat is great owing to the continental position. The daily as well as the yearly ranges of temperature are very marked.”

The exposure and general soil and surface characteristics of interior Persia are thus similar to those of Utah. The altitude of Turkestan is more like that of eastern Colorado and the western parts of Kansas and Nebraska. Persia is warmer than Turkestan, its annual minima being given as 14° to 32° F., and its summer maxima at 102° to 113° F. (8). This would appear to be due largely to surface exposure, Turkestan lying immediately to the north of Persia, and sloping northward away from the sun. In both countries the annual precipitation is light, the amount and distribution being very much like that in western Utah, with a January to May maximum and a summer and autumn minimum, hence irrigation is necessary for agriculture.

OPTIMUM CLIMATE FOR ALFALFA SEED

The seasons of incipient growth and of harvest must be entirely frost-free as the growing alfalfa plant in all its stages is sensitive to freezing temperatures, which, though they do not
readily kill it, retard it and damage the foliage considerably. In Arizona the most favorable season for maturing seed is in May and June, the blossoming period falling in May and the harvest in June (12), corresponding to late June, July, and early August in western Kansas, and to late July, August, and early September in Utah. It is evident that climatic conditions in Persia require that the blossoming period come even a little earlier than in Arizona.

From these facts it is deduced that monthly mean temperatures somewhere in the middle seventies are favorable for the plant at the critical period of blossoming, and that the ripening and harvesting may follow in a month, or period, that is either warmer or cooler than the blossoming time. Irrigation is generally necessary in Utah and Arizona as in Persia and Turkestan, for the major acreage of the alfalfa seed crop; in such regions the dearth of annual precipitation has diminished significance. Parts of western Kansas, however, depend almost wholly on rain for crop moisture, and have occasional failures of seed due to excessively wet weather; Indiana seldom produces a good crop because of still heavier precipitation in the growing months.

Thus an optimum precipitation is probably a little below the early summer averages for the western third of Kansas; its chronological distribution here, however, may often be inopportune in individual seasons. A very favorable normal distribution of precipitation is noted in Utah, where the weather is wet until the end of May, and dry thereafter, thus giving the first growth of alfalfa sufficient moisture to allow it to respond fully to any favorable temperature conditions, that is, enough to induce the unlimited functioning of the entire root system thus providing the necessary physical vigor for the seed crop to follow; and more particularly to provide storage moisture in the soil reservoir for the prompt use of the crop that is saved for seed. It is desirable that there be few stormy days, especially during the latter half or two-thirds of the crop period.

**PROPORTION OF SUNSHINE AND CLOUDS**

Much has been written on the need for sunshine, reference doubtless having been made more particularly to the need for an openness of the foliage to expose all the branches freely. There is ample evidence, however, that an optimum amount of sunshine is not always the maximum amount in extremely dry regions, particularly during the period when the flowers are fertilizing. Persia and Turkestan have a great deal of sunshine in May and June, the months in which the Arizona crop blossoms and matures, though it is possible that the blooming in Persia comes
partly in April as a rule, which is a cloudier month. Hence, from a study of these climatological data, an average cloudiness during the blooming period or months of from 30 to 35 per cent, such as prevails in western Kansas, Utah, and some other western states, is probably about the optimum. Alfalfa, like most other flowering plants, does not set seed so well on the more shaded or obscured branches, hence the isolated plants, freely receiving the influence of all meteorological elements, set bloom and seed rather abundantly on all branches. In the crowded stands, as with the unpruned and much shaded fruit, the best flowering and fruiting take place only on the outer and upper branches, where pollination, development and ripening are more certain to be effected properly. Cultivation in rows, now becoming common in southern Idaho (14), is desirable for this reason. This practice also makes irrigation easier. When the crop is grown on dry land, cultivation for moisture conservation is also more practicable, as is the general practise in parts of Cache, Boxelder, and Juab counties, Utah.

**METEOROLOGICAL INFLUENCES**

There is a general agreement among authorities (11) that alfalfa should have a moderate supply of moisture during the early growth of the seed crop, just sufficient to produce a vigorous, healthy plant, with no heavy rains thereafter until most of the bloom has fallen; also that moderately warm, sunshiny weather thereafter until harvest time is desirable for setting and securing the seed (12). That is, there is a prolific production of seed when droughty conditions tend to threaten the life of the plant. This is noted in many other plants such as the acorn-laden scrub oak on the arid mountain slope.

**EFFECT OF EXCESSIVE OR DEFICIENT MOISTURE**

The physiological manifestations of the plant itself, under measured meteorological conditions, must reveal its climatological limitations more accurately. With too much moisture through the maturing period, a quantity that is of course greater in Arizona than in Montana because of the greater transpiration and evaporation losses, a rank vegetative growth is produced, the basal shoots about the crown begin to grow in anticipation of the succeeding crop (5), early blossoms begin to drop off, and others continue to appear irregularly and indefinitely (4), and thus the crop finally goes for hay and not for seed.

On the other hand, too little moisture dwarfs the plants and prevents the proper filling of the seed, the need for moisture being critical as the seeds are beginning to add weight. Also ex-
Alfalfa Seed Growing and the Weather

tremely hot weather and prolonged or frequent high winds, when the moisture supply is very deficient and the wilting point very near if not already attained in many plants, cause the blighting or falling of the bloom prior to the fertilization stage. The caution is general by the authorities, that if the soil is wet and the plants making vigorous growth at blossom time, the crop should be cut for hay immediately, as it will not produce seed properly.

SEED FERTILIZING WEATHER

The tripping or releasing of the trigger mechanism which controls the fertilizing organs is due to a touch or movement by wind, pelting rain, or the visits of honey-seeking insects. The confined pistil and stamens have less elasticity or natural sprin
giness when the plant is undergoing heavy transpiration and is nearer the wilting point, due to excessive drought, heat and wind; hence at such time neither bees nor winds are so effective in this important preliminary process to pollination. Bees are evidently the most aggressive agents in opening the flowers and scattering the pollen, if not the most important (15), but they are always less active during damp, rainy weather than on dry sunny days. If fertilization fails to take place, the blossoms will drop, whereas if the flowers fertilize the petals become dry and remain on the stem, often until the seed begin to ripen.

MOISTURE AT BLOOMING TIME

Many observant growers and students of the problem in Utah have noticed beneficial effects of a certain amount of moisture at blooming time, and one authority (16) says the best condition in this period is warm partly cloudy weather with a shower of rain now and then, and plenty of wind, as this combination of the elements seems to aid pollination by opening the blossoms and disseminating the pollen properly. It also prevents the dropping of the blossoms, which is common when the weather is too hot and dry.

A heavy rain when the pollen is flying freely is certain to interfere with this important process, particularly if the rain endures long enough to interfere with the work of bees or other nectar-loving insects. Irregular rains, not as needed, but heavy ones, attended by cool, growth-retarding spells, cause wide variat
tions in ripening on the same land and even on the same plant, producing an inferior quality of unevenly matured seed.
MOISTURE FOR SEED FILLING

In the more humid regions it frequently happens that a rain just after the height of the blooming period, produces the new shoots for the next growth at the expense of the seed crop, though in Utah and other arid states where ground moisture is likely to be scarce and transpiration rather high, and the plant stems already quite dry, a good shower of rain or a light irrigation is often desirable to fill out the seed properly. Even if the amount be sufficiently excessive to start a few crown shoots, the seed will continue to develop, and being near the autumn in Utah when the maturing of an additional crop of hay is not practicable, the cutting for seed takes also the additional shoots as a part of the more or less valuable chaff.

SPROUTING IN THE SHOCK

A rainy period of considerable duration which thoroughly wets the alfalfa burrs or pods and does not permit them to become dry, will cause the seed to sprout whether the alfalfa is standing, in the windrow, cock, or stack, though such conditions are rare in most irrigation regions, especially Utah and similar climates. A slightly more troublesome condition perhaps results from an intermittent rainy period of a week or ten days’ duration during which the alfalfa dries out only to be wetted again immediately. This causes the pods to burst open and spill their seed readily making the subsequent harvest very difficult without great loss. The quality of the seed is seldom impaired, however, by such experience.

LOSS FROM SHATTERING

In spite of the dry climate of Utah there is usually very little trouble or loss from shattering of seed and as a rule no great precaution for catching the loss such as canvas-covered hauling racks. The seed may be allowed to reach any degree of ripeness without loss, except only in the case of prolonged rains and subsequent drying. Harvesting and thrashing times in Utah come at the period of driest, finest weather in the year, hence there is usually little concern about the weather.

WEAK GROWTH FOLLOWS SEED

The maturing of a good seed crop is often followed by a rather poor succeeding growth where the seed is harvested in the early or midsummer months, probably because of the dearth of moisture and the stress of hot weather that were required to
force the seed crop, that is, to interrupt the natural shooting from the crown and bring on the seeding process. With ample moisture a good hay or pasture crop is often secured after the seed crop has been matured.

ACCLIMATED VARIETIES

There is usually little winter killing of ordinary alfalfa in any of the better seed growing states and the plant is accredited with the ability to withstand great extremes of heat in summer and cold in winter without especial injury to its root system, though the Grimm, Baltic, and sand lucern varieties and other hardy strains do best in Montana and adjacent regions, while the Peruvian variety does best in the warmer regions of California and Arizona.

DISTRIBUTION IN UTAH

The distribution of seed produced in Utah according to the best data available consisting of assessors’ figures for a few years, railroad and shippers’ figures for other years, and the incomplete records of seed buyers in 1916, 1917, and 1918, is at present about as shown by counties and localities on the accompanying map, (Fig. 1), totaling in an average year about eighty-five cars of a minimum capacity of 30,000 pounds each (60 pounds per bushel), not counting that consumed within the state.

For the past three years about seventy-five per cent of this amount has come from the five west-central counties, probably forty per cent coming from Millard county alone. However, thrashing reports to the United States Bureau of Crop Estimates and the United States Food Administration for 1917 and 1918 show that seed jobs were handled by nearly every thrashing outfit in the State. In all, there are about 1,000 to 1,250 farmers in Utah raising seed more or less regularly, the total seed area being between 13,000 and 15,000 acres or about five per cent of the alfalfa hay acreage.
FLUCTUATING YIELDS

The production in all counties is more or less regular though the amounts from year to year, especially in the major producing counties, have fluctuated greatly, as a direct or indirect result of weather conditions which affect the security of the crop. For instance in 1910 Emery county produced 14,299 bushels, nearly as much as Millard county produces now. Millard county in 1918 produced practically four times as much as it did in 1911, while Emery county in 1918 produced only about one-third as much as it did in 1911. Cache, parts of Boxelder, Utah and Sanpete counties have been fairly uniform producers in a moderate way for many years.

Millard county and adjacent parts of Juab county contain Utah's most dependable and productive seed areas. The regions lie mainly in about four major and several minor areas, principally located about Deseret (including Hinckley, Oasis and Delta), Fillmore, (including Holden, Meadow and Kanosh), Mills and Leamington. Probably the most dependable of all is an area some four by eight miles in extent in the neighborhood of Deseret and Hinckley.

CLIMATE OF UTAH

In reviewing general climatological data in this connection it is not to be forgotten that the loss or diminution of the yields of any particular field will be due frequently to the accidental occurrence of inopportune storms, blighting hot winds, and untimely frosts, the presence of which is not revealed in the averages. A direct statistical correlation of climatological elements with yields per acre for a short period of time is not therefore necessarily final. There should be much value, however, in correctly evaluating a climate in which alfalfa seed does well normally, so that it may be compared directly with the climate of other places where seed growing probably could be, but is not practised at present.

WARM SPRING AND COOL SUMMER FAVORABLE

From an examination of weather data for the State as a whole (Fig. 3) it appears that the seasons with yields above the average had abnormally warm springs and cool summers, while the deficient yields came after abnormally cold late springs in nearly every instance. A warm springtime allows the first crop of hay to mature early, and to develop a vigorous root system. In such seasons also, the seed crop comes on at a more favorable time in summer and matures with greater safety from autumn frost.
The spring season at Deseret is earlier and drier and the summer normally a little warmer, and the seed yields per acre considerably greater, than at Logan. Corinne, roughly representing the Boxelder county seed region, is warmer than Deseret
particularly in summer, and has greater precipitation; its seed yields per acre are much smaller. Farmington has practically the same temperature conditions as Deseret, but the seed yields are only half as great per acre, evidently due to excessive precipitation in spring and early summer at Farmington. (27).

EFFECT OF SUMMERS TOO HOT OR COLD

Fillmore, usually credited with smaller yields than Deseret, has a warmer summer and a wetter spring and summer than Deseret. Manti, with a cooler and wetter spring and summer than Deseret also has a lower yield per acre. At Emery the spring

![Graph](image-url)

**Fig. 4.**—Temperature and precipitation departures from twenty-four year average for Deseret, Utah, and alfalfa seed yields in bushels per acre for Millard County.
Fig. 5.—Temperature and precipitation departures from normal in three areas in northern Utah and seed yields for county in which each area is located. Temperature (---), Precipitation (- - - - -)
and summer are cooler than at Deseret and July and August are much wetter; the Emery yields are smaller. Deseret, including the surrounding areas about Oasis, Delta and Hinckley, probably has the most nearly ideal climate found in Utah for seed production, being the most reliable and highest yielding seed region.

WEATHER IN GOOD AND POOR YEARS COMPARED

On accompanying diagrams, (Figs. 5 and 6) the monthly temperature and precipitation have been plotted for the seasons of least and greatest yields per acre for all yield records available, though it must be noted that the stations selected represent the seed regions of the counties for which the yields are given, only in a general way.

At Logan the warm dry spring and cool summer which was dry in July and August (1915) produced the greatest yield; and a cool wet March (1913) and a wet summer gave a minimum yield. Corinne, with a comparatively hot summer normally, had an abnormally long cool summer after a warm spring (1915) when the heaviest yields were obtained in that county. The season of lowest yield was cool throughout spring and summer (1912), probably emphasizing the need for a warm spring. Farmington with normally wet springs had a heavy yield in the year 1910 with very dry weather in spring and early summer; and the deficient yield came after a cool, late wet March and an abnormally wet June (1913). In fact the May weather, while averaging warmer than normal, was undoubtedly unfavorable because of a number of severe frosts. Fillmore, also a hot summer region normally shows a maximum yield in the year (1914) with a warm dry spring and a cool wet summer, and a minimum yield in a year (1912) with a cool wet spring and a moderately cool dry summer.

At Manti in 1910 a light first cutting was made because of a shortage of irrigation water, probably not later than June 20th, according to the cooperative weather observer, thus giving the seed crop a good start. The summer rains that season were timely and ample. The Emery county crop got a good start in March, 1914, as only the first half of the month was cold, thus giving much the effect of a warm month.

The yield data used in these diagrams and tables are the assessor’s figures for 1910 to 1915 inclusive, the only assessor’s figures available. They are much lower than yield data by the United States Bureau of Crop Estimates, where compiled, which are, for the State, in bushels per acre, 1912, 7.0; 1913, 5.5; 1914, 6.0; 1915, 4.8; 1916, 5.4; 1917, 5.5; 1918, 5.4; average for the period, 5.7.
NORMAL ADVANCE OF SPRING TEMPERATURE

The average temperature rise in springtime in Utah is about one degree every four days in March and April and one degree
in $3^{1/2}$ days in May. Thus, considering the State as a whole, according to the published climatological data of the United States Weather Bureau, the spring of 1913, with a light yield, was 16 days later than average at the end of March, and 18 days at the end of April. In 1914, a year of large yield, the season was a week ahead of normal at the end of March and 12 days ahead at the end of April.

In 1910, a year of large yield in Millard county, March was as warm as if it had been set ahead 27 days in the calendar; April was 16 days ahead. The large yield that season would probably have been still larger but for the damage from the prolonged rains of mid-September. In 1911 March was 10 days ahead of normal, and while April lost $4^{1/2}$ days, the season was still advanced. The poor yield in 1912 was produced by a March retarded 4 days, and April 14 days, which forced the seed crop into a series of frosts in middle and late September. The 1913 season was delayed 14 days in March, and while it was $5^{1/2}$ days ahead, considering the April departures from temperature normals, it was still backward, and a small seed yield was reported. March 1914 was 14.4 days ahead of normal, considering the Deseret-Fillmore temperature departures and April added 10 more days to this precocity, and a good yield was secured.

The temperature values for 1915 might deter one from too great a dependence on the March and April values, only, on which to base a forecast of crop yields. In that year in Millard county March was 5 days ahead of average and April 20 days ahead, though with the average first cutting date still 30 days off at best, May was retarded 10 days and June 14 days more, bringing cutting time actually a little later than the average date, if we may assume that the alfalfa development and growth responds proportionately to uniform temperature conditions, with moisture ample. The Deseret cooperative weather observer reports that the killing frost of early May retarded the alfalfa in spite of its fine start. Undoubtedly the freezing temperatures of June 12-14th retarded it still further; and high winds and hot weather in July were destructive causing the seed to strip (blight), followed by damaging frosts in mid-September (25).

The yield in 1916 was abnormally heavy, following a March that was 14 days ahead and an April 9 days ahead of average. Again in 1913, with a still heavier yield in Millard county the March temperature placed the month 10 days ahead; and while April and May were retarded, June, the last period before cutting the hay crop, was full four weeks in advance of the average, thus getting the hay off in good time. In this season, however, the weevil delayed the seed crop.
PHENOLOGICAL DATA FOR DESERET

Mr. Samuel W. Western the cooperative weather observer at Deseret has given additional phenological information of value for other years. In July, 1901, the seed crop was badly damaged at blossom time by high south wind, during a period of unusually high temperatures, which blighted the flowers. The mean maximum temperature that month was 95.7°, whereas the normal is 90.9° as shown in the tables herewith. There were six days with temperature of 100° or greater, all after the 17th and evidently during the blossom time, with no cloudy days to mitigate this influence.

In 1902 irrigation water gave out at the end of July, thus the extreme dry weather that summer greatly reduced the seed prospects. In August 1903 much high south wind was detrimental to the seed, the mean maximum temperature being 92.4° that month or nearly three degrees above normal. There was only one cloudy day, an unimportant shower of rain, and irrigation water was scarce. On August 21, 1904, a killing frost destroyed most of the seed crop; and in 1908 there was a splendid prospect for seed until August 31 when a temperature of 26° killed most of it.

CAUSES OF FAILURE ELSEWHERE

The causes of the failure of the alfalfa seed crop in the less dependable regions of Utah are given by the observers and growers as drought, hailstorms, over-irrigation, lack of irrigation water, frost in spring and autumn, hot winds, slow growth due to cold and wet weather, grasshoppers, and weevil, these insects being mentioned most frequently. Many farmers have abandoned alfalfa seed growing because of the greater dependability of sweet clover and its higher price, and because of the increase in the price of alfalfa hay.

FAVORABLE ALTITUDES

The better established seed regions in Utah are at altitudes ranging from 4300 to 5500 feet above sea level, the larger and more reliable Millard county district being a broad prehistoric lake bed plain from 4500 to 5000 feet elevation. In all these altitudes the second crop is usually saved for seed; though if the spring season be retarded by cold and wet weather the first crop is clipped a little short so the seed crop may have ample time in which to mature before the average autumn frost season.

At altitudes ranging from 5500 to 6500 feet above sea level the seasons are so short as to necessitate saving the first crop for seed. Here it has usually been found best to pasture the
fields uniformly until time to start the seed crop off evenly, owing to the danger of late spring frosts, which would not only retard the seed crop greatly but cause an uneven development.

**TOPOGRAPHY AND FROST**

The actual altitude exerts less influence on the average date of the first and last killing frosts of summer than the immediate surface configuration or topography. Deseret, altitude 4540 feet, is far out on a broad level plain, and gets the latest killing frost in spring on May 30 on the average. Fillmore, at 5100 feet altitude, near the slope of the Wasatch mountains yet on the edge of the plain extending to Deseret, has nine more days of freedom from spring frosts. Manti, also a foothill slope situation at an altitude of more than 1000 feet above Deseret, gets its killing frosts in spring May 24 on the average.

**AVERAGE CUTTING DATES**

The average dates for cutting the first crop of hay are given as (18) about June 5 at altitudes around 4250 feet; June 15 at altitudes around 4500 feet; and June 20 at altitudes of 5300 to 6300 feet, varying of course with the general topography. This same authority gives the second crop an average of 53 days to mature in Utah for hay, though in most of the seed producing regions this will probably not exceed 40 days in an average season.

**TIME REQUIRED TO MATURE A SEED CROP**

The time required to mature a crop of seed, usually considered as equal to the time of maturing two crops of hay, depends almost entirely on the current weather conditions and the moisture supply; incidentally also on weevil, soil, and other factors. In the central parts of the United States the second crop matures in from 30 to 36 days (7), the period being the shorter if the weather is rather warm, and rains timely and ample. This is about the time required for the second cutting to come into early blossom in the Utah seed regions, when temperatures are normal and moisture ample.

Additional moisture in the form of over irrigation or excessive rain will prolong the maturing season, and force the seed setting time nearer the season of autumn frosts. The withholding of irrigation water, and the absence of rain, conditions which are often realized in average years in western Utah, serve to force the seeding period ahead appreciably. Thus by careful planning it is often possible to bring the seeding season some-
### Alfalfa Seed Yields for Millard County; Weather Records for Deseret, Altitude 4540 Feet, by Samuel W. Western.

<table>
<thead>
<tr>
<th></th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug.</th>
<th>Sept.</th>
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<tr>
<td><strong>Mean Max. Temp.</strong></td>
<td>55.9</td>
<td>64.6</td>
<td>72.1</td>
<td>83.6</td>
<td>90.9</td>
<td>89.6</td>
<td>79.8</td>
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<tr>
<td><strong>Mean Min. Temp.</strong></td>
<td>25.9</td>
<td>31.8</td>
<td>38.9</td>
<td>46.9</td>
<td>53.9</td>
<td>52.9</td>
<td>41.5</td>
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<tr>
<td><strong>Mean Mo. Temp.</strong></td>
<td>40.7</td>
<td>48.2</td>
<td>55.8</td>
<td>65.2</td>
<td>72.5</td>
<td>71.3</td>
<td>60.7</td>
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<td><strong>Total Precip.</strong></td>
<td>0.89</td>
<td>0.95</td>
<td>1.03</td>
<td>0.39</td>
<td>0.42</td>
<td>0.46</td>
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<tr>
<td><strong>Clear Days</strong></td>
<td>13</td>
<td>13</td>
<td>14</td>
<td>19</td>
<td>18</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td><strong>Killing Frosts</strong></td>
<td>30th</td>
<td>(110 days)</td>
<td>17th</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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| **1910 Seed Yield 6.00 bu. per acre** |
| Mean Max. Temp. | 64.5  | 69.4  | 77.1 | 87.5 | 92.2 | 90.6 | 81.7  |
| Mean Min. Temp. | 29.8  | 34.5  | 41.7 | 50.6 | 57.2 | 53.9 | 48.0  |
| Mean Mo. Temp.  | 47.2  | 52.0  | 59.4 | 69.0 | 74.7 | 72.2 | 64.8  |
| Total Precip.   | 0.60  | 0.10  | 0.28 | 0.04 | 0.38 | 0.50 | 2.19  |
| Rainy Days      | 2     | 1     | 2    | 1    | 4    | 4    | 7     |
| Clear Days      | 19    | 21    | 17   | 23   | 13   | 18   | 21    |
| Killing Frosts  | 16th  | (106 days) | 30th |

| **1911 Seed Yield, 6.00 bu. per acre** |
| Mean Max. Temp. | 57.0  | 63.7  | 72.2 | 83.0 | 90.4 | 90.0 | 80.2  |
| Mean Min. Temp. | 29.8  | 30.3  | 39.0 | 51.7 | 57.2 | 56.6 | ...   |
| Mean Mo. Temp.  | 43.4  | 47.0  | 55.6 | 67.4 | 73.8 | 73.3 | ...   |
| Total Precip.   | 0.63  | 0.31  | 0.20 | 0.10 | 0.10 | 0.12 | 1.28  |
| Rainy Days      | 5     | 3     | 2    | 2    | 1    | 3    | 3     |
| Clear Days      | 16    | 21    | 22   | 16   | 15   | 27   | 15    |
| Killing Frosts  | 21st  |       |      |      |      |      |       |

| **1912 Seed Yield, 4.74 bu. per acre** |
| Mean Max. Temp. | 49.9  | 59.0  | 70.6 | 83.3 | 86.8 | 88.3 | 72.0  |
| Mean Min. Temp. | 29.3  | 30.9  | 40.2 | 49.2 | 56.1 | 52.6 | 38.1  |
| Mean Mo. Temp.  | 39.6  | 45.0  | 55.4 | 66.2 | 71.4 | 70.4 | 55.0  |
| Total Precip.   | 1.67  | 1.06  | 0.52 | 0.14 | 0.57 | 0.16 | 1.00  |
| Rainy Days      | 10    | 7     | 4    | 3    | 4    | 3    | 3     |
| Clear Days      | 8     | 9     | 11   | 14   | 8    | 22   | 24    |
| Killing Frosts  |       | 16th  | (91 days) | 15th |

| **1913 Seed Yield, 5.28 bu. per acre** |
| Mean Max. Temp. | 52.6  | 66.2  | 77.4 | 82.9 | 91.2 | 92.3 | 80.6  |
| Mean Min. Temp. | 19.9  | 32.6  | 40.6 | 46.6 | 54.2 | 55.2 | 43.8  |
| Mean Mo. Temp.  | 36.2  | 49.0  | 59.0 | 64.8 | 72.7 | 73.8 | 62.2  |
| Total Precip.   | 0.19  | 0.79  | 0.08 | 0.97 | 0.35 | 0.65 | 0.39  |
| Rainy Days      | 5     | 3     | 1    | 6    | 1    | 3    | 4     |
| Clear Days      | 10    | 17    | 18   | 13   | 15   | 14   | 17    |
| Killing Frosts  | 15th  | (131 days) | 23rd |

| **1914 Seed Yield, 6.24 bu. per acre** |
| Mean Max. Temp. | 60.9  | 64.1  | 77.2 | 81.4 | 87.1 | 93.0 | 82.0  |
| Mean Min. Temp. | 26.2  | 36.5  | 42.7 | 48.3 | 55.2 | 54.8 | 44.2  |
| Mean Mo. Temp.  | 43.6  | 50.3  | 60.0 | 64.8 | 71.2 | 73.9 | 63.1  |
| Total Precip.   | T     | 3.60  | 0.10 | 1.33 | 1.43 | 0.10 | 0.20  |
| Rainy Days      | 0     | 10    | 1    | 5    | 5    | 1    | 1     |
| Clear Days      | 21    | 6     | 17   | 17   | 16   | 26   | 23    |
| Killing Frosts  |       | 6th   | (108 days) | 22d |

| **1915 Seed Yield 4.64 bu. per acre** |
| Mean Max. Temp. | 56.3  | 68.5  | 68.6 | 79.4 | 89.1 | 91.6 | 78.6  |
| Mean Min. Temp. | 27.4  | 37.9  | 38.8 | 44.0 | 53.1 | 50.8 | 43.0  |
| Mean Mo. Temp.  | 41.8  | 53.2  | 53.7 | 61.7 | 71.1 | 71.2 | 60.8  |
| Total Precip.   | 0.33  | 0.99  | 1.77 | 0.87 | 0.22 | 0.14 | 0.69  |
| Rainy Days      | 4     | 7     | 5    | 2    | 2    | 2    | 2     |
| Clear Days      | 14    | 4     | 11   | 20   | 22   | 26   | 23    |
| Killing Frosts  |       | 13th  | (93 days) | 14th |
where near a desired time (14). Ordinarily it takes longer to mature a crop at the higher altitudes because of the cooler weather.

**GROWING SEASON AT DESERET**

In an average season at Deseret about forty days' time is required for the seed crop to come into early blossom, the time it would be cut for hay. Then, according to general experience elsewhere forty additional days should be allowed for maturing and harvesting the seed. In the Deseret region it has often been less than this. It required less than sixty days for the 1918 crop to reach the early seed harvesting stage in the fields that were mulched against the weevil. That crop was started, by the cutting of the first crop, on June 1.

A review of the notes on the meteorological reports from Deseret for many years shows that the usual time for taking the first crop for hay is from June 15 to 20. Forty days for reaching the cutting stage for what would be the second hay crop brings the time to July 15-30, and in an average season of normal treatment the seed crop should be garnered therefore in another forty days or from September 4 to 9.

An average seasonal development for western Utah generally, as determined from the various reports of cooperative weather observers, is about as follows: turning green in the last few days of March; a foot high by the end of April; two feet high by the early days of June; hay harvest June 15 to 20; second crop blooming in late July; and burring for seed in early August, with seed cutting completed during the first ten days of September.

**KILLING FROST DATES**

The average date of first killing frost in autumn at Deseret is September 17. The frost will fall earlier than this in about one-half the seasons and later the other half. The chances in favor of a frost increase rapidly after the 17th, but they decrease before that date. By considering the deviation of the several individual dates from the average date, it has been determined (19) that the date of killing frost in any season may fall as much as eight days either way from the average date, or as early as September 9 or as late as September 25, one year in four; and it may fall as much as 14 days from the average date, or as early as September 3 or as late as October 1, one year in ten. These values are for Deseret, only.
To avoid injury from the occasional early autumn frost, the commonest practice in Utah is to cut all the seed practicable. The proper time to cut seed normally is when from two-thirds to three-fourths of the pods or burrs have turned brown; the rest of the burrs at this time will be yellow (turning ripe), or green, due probably to shading or other causes. The yellow stage of the burr endures about a week under ordinary conditions during which time the seed, if cut, will ripen without injury to its vitality, from sustenance in the stems if they are sturdy, though each burr will contain some small and immature seed. Thus, on the issuance of a frost warning all the yellow-burred part of the crop can be cut, though since it is adding many pounds per acre per day in weight, and also appreciably in quality, only those portions of the field most subject to frost should be cut, unless the expectation is for a general and severe freeze. A frost on freshly cut seed, as it lies in the field in windrows or bunches, injures the exposed burrs about the same as if left standing, though fewer burrs are thus exposed to the frost and the injury is far less extensive.

Irrigating to Mitigate Frost Injury

The practice of applying irrigation water to the fields on the evening or afternoon prior to an expected frost as a protection has been fairly well demonstrated in the Deseret-Hinckley district, and it is growing rapidly in favor wherever the water is available. After a rather strikingly successful demonstration of the saving effects of irrigating in 1917 by the County Agricultural Agent (20), emulating the successes of several leading growers in former years, every field that had water in 1918 in this general district was irrigated to ward off frost damage. Some growers successfully protected against the frost of May 6, 1919, by irrigation water, opportunely applied.

The light watering that is usually desired as the seed begin to swell in order to assure the proper weight and plumpness may be deferred or divided to enable the application to be made as a frost protection measure, if the frost season be near. The watering will prolong the growing season and retard the ripening of the seed, but it makes a much greater quantity of seed; and by warding off a light frost doubtless improves the quality of the seed, as well as the quality and quantity of chaff.

There has been some experimental smudging, by burning wet straw and manure on the windward sides of large areas, and
in view of the success of this general form of protection in many important fruit and truck regions of the United States it might successfully be applied on the broad level plains of western Utah on large, compact areas of alfalfa seed, though this has not yet been demonstrated. The coldest weather usually occurs about sunrise, and damaging temperatures are usually of brief duration; for instance, a minimum of 25° F. may be recorded and the temperature be below 30° F. for not to exceed two hours, as shown by the thermograph. (Fig. 9).

**FROST WARNING SERVICE**

The Salt Lake City office of the Weather Bureau is cooperating with growers in the more important seed regions of Utah in the frost warning and protection work. Frost warnings are furnished to all districts. Early frosts in autumn are very often followed in Utah by many days, if not weeks, of fine weather; moreover, the first frost is usually much less severe, hence the advisability of preventing loss, or injury to seed wherever possible.

**EFFECTS OF THE FROST**

A light frost or a temperature of 31° or 32° F. in the foliage is harmless to seed in the brown burrs but it will blacken or "ripen" a few seed in the more exposed yellow burrs, and also injure some of the seed in the green burrs, though the green burrs are usually protected from such a frost by the foliage which has delayed their development.

The frosted seed turn black and shrink in size, and lose somewhat in lustre and richness of color, and while growers claim its vitality remains, and much of such seed is used for home consumption, it is much less desirable on the market. A

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**Fig. 7.**—Alfalfa seed of good quality; not recleaned; grown at Deseret, Utah. Not frosted.

**Fig. 8.**—Alfalfa seed of good grade of purity, but shriveled and darkened by suffering a frost of 26° in the foliage at Mills, Utah.
temperature of 26° or 28° F. in the foliage will cause heavy damage to seed in both the yellow and the green pods, the injury varying with the amount of leaf foliage, moisture available in and about the plants, and the proportion of immature burrs. The quality of the chaff is also impaired by such a frost.

Fig. 9.—Continuous temperature record, written by a thermograph within the alfalfa foliage, showing the range from highest temperature to lowest temperature daily, the time of occurrence of highest and lowest temperatures, and the duration of the highest and lowest values.

TEMPERATURES IN THE ALFALFA FOLIAGE

Differences of temperature between values observed in an ordinary government thermometer shelter in use at the Deseret cooperative weather station and those in a similar shelter located near the ground in which the thermometers are disposed about as high as the alfalfa blossoms, are rather great at times. This special meteorological station was established by the Weather Bureau for the benefit of growers in the Deseret-Hinckley district in 1914, and is located about one mile northeast of the regular cooperative station, under the supervision of the same observer. This latter station consists of maximum and minimum thermometers and a thermograph; the shelter rests on 4-inch sills on a low faint dike running through a thrifty alfalfa field.

In general the temperature differences between these stations are found to increase as the actual temperatures decrease, sometimes being as much as 6° F. or more. In rainy, cloudy or windy weather the values are usually about alike. But in clear quiet weather the temperatures near the ground, that is, in the foliage, are very much lower than those observed in the regular shelter 4 feet above the ground.
SEED ON INFERTILE SOILS

Alfalfa on a fertile soil usually shows a more prompt and definite response to favorable meteorological conditions than the crops on the poorer soils. Some of the seed in the Deseret-Hinckley district grows upon an adobe, alkaline soil that has a shallow water table. On parts of this there is little or no irrigation water but the plants have been standing from 20 to 40 years and are deeply rooted. Some of these alkaline, undrained fields produce such a scrawny, miserable growth of plants that cutting and harvesting are very difficult, yet these puny plants usually load themselves so heavily with excellent seed as to bear the branches to the ground.

On the better soils where from 4 to 8 times the yields per acre are produced, one light watering at the beginning of the seed crop growth, and another at the seed filling time usually suffices in this region, where the average annual precipitation is 8.28 inches, (at Deseret). But in districts of heavier rainfall, and especially east of the Wasatch Mountains where the summer precipitation is very much heavier, the second watering is neither so essential nor desirable.

ALFALFA WEEVIL AND GRASSHOPPER WEATHER

The alfalfa weevil appears more predatory on the early stage of the crop left for seed in seasons of late springtime, as the height of the egg-laying season is normally about the middle of May, the larvae stage about 10 days later, cocoons by the 10th of June, pupae a few days later and the adults by June 20, earlier or later depending upon the season (24). The first cutting comes about this time, affording ample opportunity for dust mulching, a process which is especially effective if it can be done in the more helpless stages of the weevil's existence. Every effort is necessary in belated seasons to force the growth and development of the seed crop, the delays in incipient growth often being due very largely to weevils where they are abundant.

The statement is sometimes made (7) that grasshoppers are less troublesome in the eastern states than in the arid West, due to the cool wet winters. Also that they are more numerous in a summer following a winter of little alternate freezing and thawing weather, as the severe changes are said to destroy the eggs (23). It appears in Utah, from an examination of the observer's remarks on the meteorological forms rendered to the Weather Bureau, that grasshopper devastation from year to year in the cultivated fields is nearly always greatest in the droughty years when the native vegetation in the canyons and along the irrigation and other waterways is scantiest.
DUST MULCHING

A practice reported (25) is of interest in this connection. The first or hay crop in 1918 in certain fields at Deseret was cut June 1, the hay being rushed from the field. The land was then harrowed and wire-dragged thoroughly producing a fine dust mulch, burying the weevil completely, and incidentally conserving the ground moisture in the land just exposed to the hot sun. Neighboring fields that were not so treated, or in which the dusting was delayed until the weevil became more active, were retarded from two to three weeks at seed harvest time. The first mulched fields were practically ripe by August 26, while other fields adjacent became ripe from September 10 to 20. The dust mulching is practicable, and the resulting weevil destruction highly efficient, only in the hottest, driest weather.

SPRAYING FOR WEEVIL DESTRUCTION

For this and other reasons the practice of spraying the fields from one to two weeks prior to the first cutting, with arsenate of lead or zinc arsenite, now being introduced (26) for killing the larvae, is probably more desirable. In case of wet cool weather after the first cutting the dust mulching could not be practised. It has been found (26) that in late spring seasons the development of the weevil often lags behind that of the alfalfa, hence in these seasons the first crop escapes, and the entire season's weevil activity is thrown upon the young seed crop.

CLOSE PASTURING

Another ingenious and rather efficient method of giving the seed crop an early start, where it can be practised (6, 24) is to pasture the first crop quite heavily, especially with sheep, as these animals eat the first growth off close to the crown right up to the time for starting the seed crop. In this way the weevil is prevented either from egg-laying to any great extent, or from making subsequent development generally, as egg-laying does not usually begin in earnest until the alfalfa is 6 or 8 inches high and the days are becoming long and warm. Cultivation is also practised some to delay the starting of the seed crop until after the spring frost danger is past.

THE WEEVIL IN WINTER

The adult weevil goes into hibernation in late summer or early autumn; and if the summer and autumn be long and warm a greater percentage of weevils perish before hibernating be-
gins; but if the summer is cool, late and cloudy, more of the weevils will go into hibernation and probably be more prolific in the following spring (24).

**SUMMARY**

Alfalfa growers everywhere are impelled by the demand for seed to grow it whenever meteorological conditions permit. The climate is the limiting factor in seed production generally and current weather is the major control affecting any yield. A certain amount of stress on the plant due to drought is necessary to force the setting of the seed.

Seed crops are matured occasionally in nearly all parts of the United States, but the certainty of the crop and the security of the industry are greatest in the Plateau States, where the yields per acre are much the greatest. A crop is grown in the Central States in those seasons when the corn crop fails because of drought; the yields here run from 2 to 3 bushels per acre; but over the more arid West, crops of from 4 to 6 bushels are grown about four years out of five. The failures of the western crops are due principally to such causes as temporary shortage of irrigation water; excessive wet from inopportune rains, perhaps on a recent watering; desiccating winds at blossom time; untimely spring or autumn frosts; grasshoppers; and weevils.

The alfalfa plant when considered for seed is very exacting in its meteorological requirements, the conspicuous elements of which are, a rapid and early rise of springtime temperatures, without setbacks or lack of moisture, to get the first or hay crop off the field, also to place the right amount of moisture in the soil for producing a vigorous and thrifty root system, and get the seed crop started off in time to mature before autumn frosts. The summer must be quite dry to produce seed rather than stem and leaf growth, and yet moisture must be ample and timely for filling the seed. Heavy rains must not wash away the pollen. If dependent on natural precipitation, two or three inches a month from March until June in Utah, with from one-half to an inch a month in light showers from July to September are desirable.

The summer must not be too warm, particularly at blossom time, as the wilting and blighting of the bloom occurs readily when moisture is deficient and winds and temperature excessive. The optimum mean temperatures in western Utah are about as follows: March, when the hay crop begins growth, 40°F.; April 48°F. for rapid development; May 56°F.; and June 65°F. These temperatures are considered favorable in any locality, though,
the months may be of different names. The seed crops should have a July mean temperature of about 70° F. and August 75° F., for the blooming and seed setting periods. If the average September temperature is 60° F. or lower it appears that there is a strong probability of frost before harvesting is completed.

An excess of cold cloudy weather at blossom time is unfavorable, an optimum being about 30 to 35 per cent cloudiness. There must be sufficient sunshine, or thinness of the branches, and wind, to effect pollination; and the trigger mechanism controlling the fertilizing organs must have the proper elasticity, due to proper weather conditions; and the weather must favor the work of bees and other nectar-loving insects.

The seed crop is a more or less direct result of the meteorological conditions which produce the preceding crop of hay. This crop must have ample moisture to allow it to respond fully to temperature conditions, and to induce unlimited and uniform functioning of the entire root system, and to provide storage of moisture in the soil for the seed producing plant.

The varieties known to have been acclimated are the Baltic, Grimm, sand lucern and some others, where the general average winter temperatures are from 20° to 25° F. and summer temperatures 70° to 75° F. degrees; but the Peruvian variety does best where the winter mean temperature is above freezing, and the summer means 85° to 95° F.

Seed yields greater than average in Utah seem to require an abnormally warm spring, with temperatures from 3° to 5° F., above normal, at least during March and April. Such a spring should be followed by a summer from 2° to 4° F. cooler than usual to give a slow and gradual growth and a consequent better and more extensive setting of seed. Mean monthly maximum temperatures above 90° F. in the blooming months are unfavorable, and short periods with temperatures above 100° F. when moisture is deficient cause light yields.

The seasons are somewhat longer and freer from frosts on the gently sloping lands near the mountains than far out on the flat lands, the season being lengthened from two to three weeks. The cutting dates vary with the accumulated excesses or deficiencies of temperature about the normal, and with the general altitude of the region; they can be forced or delayed somewhat by withholding or applying irrigation water.

The average maturing season for the principal seed regions of Utah is about 80 days, the first cutting coming about June 15 to 20. Forty days are then required to reach the early blossom stage, or cutting time for hay, being July 25 to 30. Forty
additional days necessary for maturing the seed brings the harvest about September 4 to 9, one or two weeks before the average date of first killing frost in autumn.

The extent of frost injury is greatly lessened by cutting the partly ripened seed just prior to a frost, as the seed is much better protected in the bunch or windrow; a light frost is warded off by irrigating the land just prior to the frost. Weevil depredations are greater in cold wet spring seasons; and dry, hot weather in summer favors weevil extermination by dust mulching. After a late spring, heavy pasturing and spraying are recommended for weevil extermination.

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