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Experimental Work With Sugar-Beets During 1900.

BY ROBERT H. FORBES.

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THE EXPERIMENT STATION,
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CONTENTS.

Cut showing location of station farm and upper Gila sugar-beet plots

Frontispiece

History and details of the plots 188
Profile map of results 195
Discussion of results 190
Seeding time 197
The plantings of February and March 197
Tonnage 198
Sugar 198
Purity 200
Maturity of the crop 201
Insects and diseases 202
Possibilities for stock-feeding 202
Beets in Salt River Valley, 1900 203
Conclusions and suggestions for further work 204
LOCATION OF SUGAR-BEET PLOTS DURING 1900.

II Plots near Pima, Safford, and Thatcher.
△ Experiment Station farm near Phoenix.
EXPERIMENTAL WORK WITH SUGAR-BEETS DURING 1900.

By R. H. Forbes.

Experimental work with sugar-beets was continued in Salt River valley at the Station farm during the season of 1900. The yield of sugar per acre, on account of scarcity of water, was not as large as it might otherwise have been, although the results excelled those of previous seasons. The principal effort of the year, however, was made in the rich, irrigated portion of Graham county, near the towns of Pima, Thatcher and Safford, where, apparently, there were certain advantages promising an improvement in results previously obtained. This work was necessarily somewhat preliminary in character, as the best results with beets in a new district depend upon a knowledge of local details relating to soil, irrigating water, and climate, which can only be obtained by residence.

Realizing, in connection with agricultural work of this class, the truth of the adage “If you would have something done, go; if not, send,” Mr. Charles G. Arney of the Station farm was detailed to take charge of the plots. Operations were thus kept closely under observation and control, the land, water, and part of the labor being afforded by the farmers upon whose ground work was done.

The methods and appliances used were essentially the same as those employed the previous year, and described in Bulletin 31. The Superior 4-row drill which had served on the Station farm was shipped to the new field of operations, and Kleinwanzlebener seed, secured from the Chino Beet-Sugar Company, was employed. Before planting, the ground was in all cases thoroughly irrigated, then plowed, harrowed, and seeded as soon as possible thereafter. In the cooler weather of February and March this method secured, for the most part, a satisfactory stand of beets. From May on, however, it was necessary to irrigate the seeded ground in order to bring the plants up.
The beets were sampled twice a month for analysis during June, July and August, each sample consisting, usually, of about 20 beets, representing one or more rows dug for the purpose. The sample, wrapped in oiled paper to prevent evaporation, was sent to the chemical laboratories at Tucson, where analysis was made. Three sets of these field samples, also, were weighed as a whole, and the area from which they were dug was measured, in order that tonnage and sugar per acre might be estimated.

The plots selected, which were a half-acre or less in size, were various as to quality of soil, ranging from a light sand to a dense adobe. In most cases the ground had been more or less recently in alfalfa, the nitrogen deficiency of the desert soils being thereby at least partly remedied.

The climatic conditions were found, also, to be quite various. On the higher slopes and sandier soils the growing season for beets, and garden vegetables in general, is much earlier than in the river bottom lands. Plantings should, therefore, be made to advantage much earlier above Safford than on the lower levels near Pima; and on the higher lands of the artesian belt east of Mt. Graham a still earlier season is to be expected, where it is stated that gardening begins from two to three weeks earlier than in the lower valley.

Before the close of the season the work was complicated by scarcity of water, which cut many crops short during the exceptionally dry summer of 1900. All but two of the plots suffered severely for want of water at some time, and to this cause is to be attributed, largely, the failure of some promising plots to come up to expectations.

The efforts of Mr. Arney, however, together with the friendly and helpful interest of the farmers, enabled the Station, as a friendly critic remarked, "to give the beets a good trial in a bad year."

**HISTORY AND DETAILS OF THE PLOTS.**

Plot 1, John Morris', Layton:

**Soil:** Clay loam taking 45 per cent of water, but slowly, Rich in nitrogen,—152 per cent of air-dry soil  In alfalfa many
EXPERIMENTAL WORK WITH SUGAR-BEETS. 189

years; used as pasture and feed lot; in corn for two years past.

Cultural notes: March 16, planted \( \frac{1}{4} \)-acre with drill; April 19, thinned; May 3, irrigated; May 8, hoed; May 19, cultivated.

June 5, suffering seriously for want of water.

June 5, ave. wt. of beets, 2.5 oz.; per cent sugar, 11.6; purity, 75.1.

June 20, ave. wt. of beets 6.5 oz.; per cent sugar, 10.6; purity.

July 1.

June 25, irrigated; July 2, cultivated.

July 2, ave. wt. of beets, 8.2 oz.; per cent sugar, 9.93; purity, 75.2; tons per acre, 5.9; sugar per acre, 1174 pounds.

July 20, irrigated.

July 20, ave. wt. of beets, 8.3 oz.; per cent sugar, 10.9; purity, 70.6.

August 6, ave. wt. of beets, 9.2 oz.; per cent sugar, 10.4; purity, 72.4; tons beets per acre, 7.31; sugar per acre, 1521 pounds.

August 10, cultivated.

August 27, ave. wt. of beets, 11.7 oz.; per cent sugar, 8.7; purity, 71.5; tons beets per acre, 11.06; sugar per acre, 1925 pounds.

Plot 2. Hyrum Brinkerhoff's, Thatcher.

Soil: Adobe, largely made soil from river mud, taking 44 per cent of water slowly, drying out slowly. Containing abundant nitrogen, ---, 128 per cent of air-dry soil. In alfalfa many years; broken two years before experimental work was begun; in corn and grain since that time.

Cultural notes: February 28, planted \( \frac{1}{2} \)-acre with drill, rows 20 inches apart; soil in good condition. April 10, young beets seriously injured by frost; April 16-17, thinned and irrigated; April 24-25, hoed; May 11, cultivated; May 25, irrigated; May 30, cultivated.

June 5, ave. wt. of beets 3 oz.; per cent sugar, 8.8; purity, 79.3.

June 20, ave. wt. of beets, 5.9 oz.; per cent sugar, 12.4; purity, 83.6.
June 19-23, this plot suffered seriously for water.
June 23, irrigated; June 28, cultivated.
July 5, ave. wt. of beets, 7.5 oz.; per cent sugar, 12.0; purity, 82.5; tons per acre, 4.85; sugar per acre, 1166 pounds.
July 16-20, suffering for water.
July 21, irrigated.
July 21, ave. wt. of beets, 8.0 oz.; per cent sugar, 13.2; purity, 86.8.

July 26, hoed.

August 3, ave. wt. of beets, 9.9 oz.; per cent sugar, 13.6; purity, 81.6; tons per acre, 7.36; sugar per acre, 2006 pounds.
August 13, cultivated.
August 27, ave. wt. of beets, 7.6 oz.; per cent sugar, 12.8; purity, 82.7; tons of beets per acre, 7.2; sugar per acre, 1844 pounds.

Plot 2 b, Hyrum Brinkerhoff's 2nd:

Soil: Same as Plot 2, alongside.

Cultural notes: May 5, plowed and planted with drill; May 6, irrigated; May 11, hoed; May 25, irrigated; May 29, hoed; June 11-13, thinned; June 12, irrigated; July 1, irrigated; July 5, cultivated.

July 16-20, suffering for water.
July 21, irrigated; July 30, hoed.

August 13, ave. wt. of beets 6.8 oz.; per cent sugar, 11.5; purity, 78.9.
August 21, irrigated; August 30, hoed.

September 7, ave. wt. of beets, 6.0 oz.; per cent sugar, 9.8; purity, 79.9.
September 30, ave. wt. of beets, 2.74 oz.; per cent sugar, 12.9; purity, 82.3.

Plot 2 c, Hyrum Brinkerhoff's 3d:

Soil: Same as Plot 2.

Cultural notes: June 4, planted and irrigated; June 23, irrigated; June 28-29, thinned; July 1, irrigated; July 24, irrigated. Finally "burned up"; young beets could not endure excessive heat and dryness.
EXPERIMENTAL WORK WITH SUGAR-BEETS.

Plot 3, Free Hubbard's, Pima:

Soil: Heavy adobe, bottom land, taking 40 per cent of water very slowly, drying out slowly. Containing sufficient nitrogen,—.107 per cent in air-dry soil. In alfalfa many years; broken less than a year before beginning beet experiments; produced crop of corn and beans since breaking.

Cultural notes. March 5, plowed and planted ½ acre with drill, 20-inch rows; soil in good condition. April 10, some beets injured by frost; April 18, thinned; April 19, irrigated; May 1, retarded by cold weather; May 2–3, hoed; May 22–23, cultivated; May 31, hoed.

June 5, ave. wt. of beets, 2 oz.; per cent sugar, 10.3; purity, 77.9.

June 7, irrigated.

June 19, ave. wt. of beets, 3.5 oz.; per cent sugar, 11.9; purity, 85.6.

July 1, irrigated; July 6, cultivated.

July 6, ave. wt. of beets, 7.2 oz.; per cent sugar, 12.2; purity 81.8; tons per acre, 4.43; sugar per acre, 1076 pounds.

July 21, ave. wt. of beets, 6.9 oz.; per cent sugar, 13.7; purity, 83.7.

July 23, hoed.

August 8, ave. wt. of beets, 8.6 oz.; per cent sugar, 15.9; purity, 84.5; tons beets per acre, 7.13; sugar per acre, 2267 pounds.

August 31, ave. wt. of beets, 7.4 oz.; per cent sugar, 14.5; purity, 84.3; tons beets per acre, 6.61; sugar per acre, 2087 pounds.

Plot 4, John Hoopes', Thatcher:

Soil: Light sand, taking water quickly and drying out quickly to a cemented mass. Nitrogen, scant,—.067 per cent in air-dry soil. In alfalfa and pasture many years; just broken.

Cultural notes. March 6, planted ½-acre, 20-inch rows; ground in good condition; April 6, irrigated; April 17, thinned; April 18, hoed; April 22, trampled and eaten by stock—much injured; May 11, cultivated; May 18, irrigated; May 22–23, cultivated.
June 6, ave. wt. of beets, 2.4 oz.; per cent sugar, 8.7; purity, 68.8.
June 10, irrigated.
June 20, ave. wt. of beets, 5.9 oz.; per cent sugar, 9.5; purity, 78.3.
June 23, suffering for water; July 3, irrigated.
July 3, ave. wt. of beets, 6.6 oz.; per cent sugar, 13.8; purity, 79.5; tons per acre, 3.4; sugar per acre, 9.45 pounds.
July 9, cultivated.
July 16-20, suffering for water.
July 19, ave. wt. of beets, 7.3 oz.; per cent sugar, 10.7; purity, 72.9.
July 23, irrigated; July 27, hoed.
August 3, ave. wt. of beets, 8.3 oz.; per cent sugar, 12.1; purity, 80.4.

Plot 5, Bishop Zundle, Thatcher:

Soil: Sandy loam, taking 23 per cent of water quickly, but drying and draining out rapidly. Nitrogen, scant, — 0.054 per cent in air-dry soil. In cultivation some years (never in alfalfa); in sweet potatoes for the year preceding sugar-beet experiments.

Cultural notes: March 10, plowed and planted ½ acre with drill; 20-inch rows. Ground in excellent condition. April 11–12, thinned the young beets; May 15, irrigated; May 19, cultivated; May 21, hoed.

June 6, ave. wt. of beets, 7.5 oz.; per cent sugar, 13.5; purity, 82.6.
June 12, irrigated; June 17, cultivated.
June 19, ave. wt. of beets, 3.5 oz.; per cent sugar, 12.0; purity, 89.9.
June 22, irrigated; June 27, cultivated; July 2, irrigated.
July 2, ave. wt. of beets, 4.1 oz.; per cent sugar, 14.8; purity, 84.6; tons of beets per acre, 2.9; sugar per acre, 859 pounds.
July 12, irrigated; July 17, cultivated.
July 20, suffering for water. July 20, ave. wt. of beets, 5.7 oz.; per cent sugar, 13.2; purity, 85.3.
July 22, irrigated; July 28, hoed.
August 4, ave. wt. of beets, 7.2 oz.; per cent sugar, 13.0; purity, 85.4; tons per acre, 7.3; sugar per acre, 1898 pounds.
EXPERIMENTAL WORK WITH SUGAR-BEETS.

August 13, cultivated.
August 27, ave. wt. of beets, 7.1 oz.; per cent sugar, 14.5; purity, 87.6; tons beets per acre, 9.41; sugar per acre, 2729 pounds.

Plot 7, Mrs. Layton's, Thatcher:

Soil: Sandy loam, taking 28 per cent of water quickly, but drying and draining out rapidly. Nitrogen, scant,—.072 per cent in air-dry soil. In alfalfa and pastured many years; in garden for three years before planting sugar-beets.

Cultural notes: March 19, plowed and planted with drill in 20-inch rows. Sufficient rain fell to bring beets up without irrigation.

April 24, thinned; April 30, irrigated; May 4-5, hoed; May 18, cultivated; June 1, irrigated; June 4, cultivated.
June 6, ave. wt. of beets, 2.3 oz.; per cent sugar, 9.4; purity, 77.
June 9, ave. wt. of beets, 5.1 oz.; per cent sugar, 10.5; purity, 84.4.
June 23, irrigated; June 27, cultivated.
July 3, ave. wt. of beets, 8.2 oz.; per cent sugar, 70.5; purity, 80.2; tons of beets per acre, 4.7; sugar per acre, 989 pounds.
July 16-20, suffering for water.
July 19, ave. wt. of beets, 8.9 oz.; per cent sugar, 10.4; purity, 73.7.
July 22, irrigated; July 25, cultivated.
August 5, ave. wt. of beets, 8.6 oz.; per cent sugar, 12.3; purity, 79.5.

Plot 7 b, Mrs. Layton's 2nd:

Soil: Same as plot 7, adjoining.

Cultural notes: May 5, plowed and planted with drill; May 8, irrigated; June 1, irrigated; June 6, thinned; June 23, irrigated; June 27, cultivated; July 18, hoed; July 22, irrigated; July 25, cultivated.
August 13, ave. wt. of beets, 4.9 oz.; per cent sugar, 12.1; purity, 77.9.
August 17, hoed and irrigated; August 23, cultivated.
September 7, ave. wt. of beets, 4.9 oz.; per cent sugar, 9.1; purity, 76.1.

September 30, ave. wt. of beets, 6.4 oz.; per cent sugar, 8.1; purity, 80.2.

Plot 8, S. S. Marshall, Pima:

**Soil.** Fine loam, bottom land, taking 31 per cent of water quickly, but drying out very slowly; ground water about 9 feet below. Nitrogen, a little scant,—.083 per cent in air-dry soil. In alfalfa five years; in garden for two years preceding sugar-beet experiments.

**Cultural notes.** March 19, plowed and planted ½ acre with drill; rows, 20 inches apart; ground moist at time of planting.

April 25-26, thinned; May 7, hoed; May 22, irrigated; May 28, cultivated.

June 5, ave. wt. of beets, 2.6 oz.; per cent sugar, 9.0; purity, 75.3.

June 19, ave. wt. of beets, 6.2 oz., per cent sugar, 12.5; purity, 85.7.

June 23, irrigated; June 27, hoed.

July 6, ave. wt. of beets, 10.4 oz.; per cent sugar, 11.0; purity, 78.1; tons of beets per acre, 8.62; sugar per acre, 1892 pounds.

July 11, cultivated.

July 21, ave. wt. of beets, 7.9 oz.; per cent sugar, 13.3; purity, 86.3.

August 7, ave. wt. of beets, 13.0 oz.; per cent sugar, 13.7; purity, 83.2; tons per acre, 12.3; sugar per acre, 3361 pounds.

August 7, irrigated north half of plot.

August 28:

North half of plot, with one extra irrigation August 7: Ave. wt. of beets, 13.1 oz.; per cent sugar, 10.1; purity, 78.9; tons per acre, 14.41; sugar per acre, 2912 pounds.

South half of plot, without extra irrigation August 7: Ave. wt. of beets, 12.0 oz.; per cent sugar, 13.0; purity, 82.5; tons per acre, 11.92; sugar per acre, 3088 pounds.
EXPERIMENTAL WORK WITH SUGAR-BEETS.  195

Plot 9, Heywood's, Thatcher:

Soil: Light sand: previously in garden.

Cultural notes: February 20, planted a small plot by hand to test earliness of season for planting; February 23, irrigated; March 6, beets coming up; March 8, severe frost, but beets not injured; April 21, thinned and hoed; May 1, irrigated.

June 6, ave. wt. of beets, 3.3; per cent sugar, 13.5; purity, 81.4.

June 10, irrigated; June 15, hoed.

June 19, ave. wt. of beets, 5.8 oz.; per cent sugar, 11.8; purity, 81.2.

July 3, irrigated.

July 3, ave. wt. of beets, 6.6 oz.; per cent sugar, 13.9; purity, 78.2.

July 7, hoed.

July 19, ave. wt. of beets, 7.6 oz.; per cent sugar, 11.6; purity, 80.0.

July 23, irrigated; July 27, hoed.

August 3, ave. wt. of beets, 8.1 oz.; per cent sugar, 13.0; purity, 81.8.

Plot 10, S. S. Marshall's, Pima (his own planting):

Soil: As in plot 8, etc.

Cultural notes: Planted about March 1, and watered up; well tilled and abundantly irrigated.

June 20, ave. wt. of beets, 7.1 oz.; per cent sugar, 14.3; purity, 85.3.

July 6, ave. wt. of beets, 9.8 oz.; per cent sugar, 12.4; purity, 80.7.

July 21, ave. wt. of beets, 10.4 oz.; per cent sugar, 13.4; purity, 84.9.

August 8, ave. wt. of beets, 13.0 oz.; per cent sugar, 14.4; purity, 87.6.

PROFILE MAP OF RESULTS.

For convenience in studying the preceding results, a profile map is submitted, showing by different broken lines the average
weight, percentage of sugar, and purity of juice, in the beets at various times during the last three months, when samples were being taken. The resultant of these three factors, also, is shown by the solid line designated for approximate available sugar in beets, which means the amount that may be manufactured from them.

Each vertical space above base lines of plots on the profile stands for 1 oz. in weight of beets, 1 per cent of sugar, 1 degree of purity above 70, and .1 oz. approximate available sugar in average individual beets.

Times of irrigation, drouth, and other items are also indicated.

DISCUSSION OF RESULTS.

SEEDING TIME.

In that part of the upper Gila district, where this work was conducted, it appears that beets may be grown, planted from early spring until late in the autumn. The seeding season extends from about February 1 to about October 15, varying locally, according to slope, altitude, soil, etc. Between three and four months, from about October 15 to about February 1, are not available for seeding, while in Salt River valley for an equal time during midsummer, from May to September, it is too warm to start beets.

In the Gila River bottom, near Pima, young beets from seed planted March 19 were not injured by frost, although apparently retarded by chilly weather as late as May 1. At Thatcher, at about the same altitude, young beets from seed planted February 28

*This resultant was obtained by multiplying the other three factors. For instance, in plot 8, August 7, average weight of beets was 13 oz., sugar 13.7 per cent, purity 83.1; and 13 oz. multiplied by 13.7 per cent sugar multiplied by 83.1 percent purity = 1.48 oz. of sugar, approximately, which could be made from the representative beet of this plot at this time.

Obtained in this way, available sugar is somewhat higher than when calculated by deducting an amount equal to impurities in juice from total sugar contained, but is lower than the 90 per cent obtainable from 83 purity beets by the best processes. The available sugar line, therefore, stated in this way, serves as a basis for judgment and comparison.
were severely injured, but not destroyed by frost on April 10. In Layton, a planting made February 23 was destroyed by frost on March 8.

Autumn plantings will endure the winter if the beets are of about six-leaf size. At Pima, a plot seeded September 6, in which the leaves had attained a length of about 10 inches, was not seriously injured by cold up to January. But in a later planting, made September 15 on the same ground, the young beets, having 6 to 8 leaves, were partly destroyed by frost. A planting made October 5 at Thatcher was severely taxed with the cold, but the plants have survived the winter satisfactorily.

At lower altitudes it would seem that plantings made from October 1 to February 15 were in danger from frost.

Germination of seed was satisfactory during February and March, planting being done as soon as possible after irrigating and preparing the ground. From this time on, however, it was necessary to irrigate the seed in the ground in order to bring the young beets up. Plantings made May 5, June 23, July 10 and August 8 all gave large tonnage, being sufficiently irrigated. The planting made at Pima August 8 was harvested on December 20 to feed to cattle, many of the beets having a weight of 10 to 15 pounds. For stock feed, therefore, it appears that sugar beets may here be available from the field for fully the last six months of the year, and thereafter until their quality is injured by the second year’s growth for seed production.

THE PLANTINGS OF FEBRUARY AND MARCH.

Plots 1, 2, 3, 4, 5, 7, 8, 9 and 10, planted from February 20 to March 19, were conducted with reference to sugar production, and, though the soil is of several types and the supply of irrigating water was uncertain, certain facts seem to hold in the majority of cases.

TONNAGE.

In nearly every case it appears that the weight of the beets continued to increase until about the first week in August. The falling off in weight (barring error in sample-taking) noted in plots 2, 3 and 8, may be associated with a second growth of tops
which occurred, especially in the well-irrigated plots, at this time. Plots 1, 5 and the more irrigated half of 8, planted a little later than the average, continued to increase in weight of beets and tonnage until the end of August.

The size of the beets is seen to have been affected by texture of soil (doubtless in connection with available water) and by the nitrogen available for the crop. In plots 4 and 7 the smallness of the beets may have been due both to scarcity of water and to the poverty of these soils in nitrogen. Plot 5, also poor in nitrogen, was better watered, on the whole, than either 4 or 7; but this advantage was offset by the very thick stand of beets, which tended to lessen individual size, but to increase tonnage, finally.

In plot 1, which, like plot 5, was comparatively well watered, the superior tonnage (11.06 tons per acre) was probably caused by the large percentage of nitrogen observed in this soil.

Plots 2 and 3 were both on heavy soils, equally rich in nitrogen. The water supply in plot 3 was better, and the beets more regular in size, the stand in plot 2 having been less uniform on account of drought and irregular germination.

The influence of water on tonnage was especially shown in plot 8, the north half of which was irrigated once more, August 7, than the south half. The average weight of beets in the north half was 13.1 oz. as compared with 12.0 oz. in the less irrigated south half; but the per cent of sugar and the purity were at the same time lessened.

In plots 8 and 10 were combined the favorable conditions of a loam soil containing sufficient nitrogen, and adequate water supply. The highest tonnage obtained (13.17 tons per acre), of fair quality, resulted from these favorable conditions in spite of the late planting, which did not occur till March 19.

**SUGAR.**

The maximum sugar percentages occur at different times during June, July and August, the fluctuations being apparently influenced by various conditions*. In plots 3 and 8, which were, on the whole, most satisfactory as to treatment and water supply, the increase in sugar was fairly constant during June, July and the first few days of August, but decreased some-
what after that time, a fact which may be connected with the tendency to second growth during the latter part of the summer. The combined figures for all the first-planted plots during June, July and August give the following averages relating to sugar:

<table>
<thead>
<tr>
<th>Date</th>
<th>Average % of sugar in beets</th>
<th>Average ounces of sugar in individual beets.</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 5-6</td>
<td>10.60</td>
<td>.20</td>
</tr>
<tr>
<td>July 20</td>
<td>11.82</td>
<td>92</td>
</tr>
<tr>
<td>July 27-31</td>
<td>12.27</td>
<td>126</td>
</tr>
<tr>
<td>Aug. 19-21</td>
<td>12.58</td>
<td>131</td>
</tr>
<tr>
<td>Aug. 27-31</td>
<td>12.58</td>
<td>113</td>
</tr>
</tbody>
</table>

In most cases a shortage of water seems to have been followed by a decrease in sugar percentage. In but one instance, however, (and that probably due to accident in sampling) did the total sugar become less in quantity; owing to increase in weight of beets. These facts indicate that drouth causes the beets to curtail sugar production in favor of maintenance of structural growth.

This slow increase of sugar shown in the table for the hot months is hardly as much as would be expected in a cooler climate; and this adverse influence (presumably of heat) is yet more evident in the younger beets planted May 5, which actually lost in sugar percentage during August and September. These observations indicate the necessity of as early planting as possible, in order that the beets may be comparatively mature before the hottest weather sets in.

It is a matter requiring explanation that beets should increase in sugar, even as they do, during our summer months, when the temperatures are considered. A self-recording maximum and minimum thermometer was placed by Mr. Arney on the north side of a broad board stake among the beets in plot 3, readings being made each day. For the month from July 20 to August 20, the average minimum temperature was 62 degrees F. and the average maximum, 107 degrees F., making a mean for the month of 84 1/2 degrees. When it is remembered that a mean temperature of 70 degrees F. is accepted as most favorable for the production of sugar during the third, fourth and fifth months of the life of the beet, these percentages are unexpected. It is not improbable that in our arid atmosphere
the great evaporation which must take place from leaf surfaces materially reduces the temperature of plant tissues, a supposition which accords with the well known fact that, with the same thermometer readings, the sensible temperature in arid regions is much less than in humid regions.

PURITY.

The purity of the beets in the various plots is conspicuously variable. All plots agree, however, in showing a strong decline in purity about July 1, from which, as a rule, they gradually, but not always completely, recover. This loss of purity is not associated with soil, for it occurs on all soils alike. Neither, at first thought, does it seem connected with temperature, for in the following weeks of equally warm weather purity often increases. It would seem that this sudden loss in purity, under our climatic conditions, is characteristic of a certain period of development in the beet itself, a period, evidently, during which the juice is charged with soluble materials other than sugar.

The relation between the fluctuations of purity and the increase in weight of beets is shown by a table in which are stated the average purities and weights of beets from May 23 to the end of August:

<table>
<thead>
<tr>
<th>Month</th>
<th>Average weight, ounces</th>
<th>Average purity</th>
<th>Average per cent sugar in beets</th>
<th>Average per cent impurities in beets</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 23</td>
<td>1.2</td>
<td>71.9</td>
<td>8.7</td>
<td>3.40</td>
</tr>
<tr>
<td>June 5-6</td>
<td>2.45</td>
<td>77.17</td>
<td>10.60</td>
<td>3.13</td>
</tr>
<tr>
<td>June 20</td>
<td>5.3</td>
<td>83.1</td>
<td>11.62</td>
<td>2.40</td>
</tr>
<tr>
<td>July 2,5-6</td>
<td>7.62</td>
<td>80.1</td>
<td>12.29</td>
<td>3.05</td>
</tr>
<tr>
<td>July 19-21</td>
<td>7.89</td>
<td>80.4</td>
<td>12.27</td>
<td>2.90</td>
</tr>
<tr>
<td>Aug. 3-13</td>
<td>8.05</td>
<td>81.81</td>
<td>12.58</td>
<td>2.90</td>
</tr>
<tr>
<td>Aug. 27-31</td>
<td>9.03</td>
<td>81.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From this table it appears that from May 23 to June 20, which was a very hot period of time, not only were the beets growing rapidly, but were also increasing in purity. From June 20 on, the growth of the beets was more slow, while the purity dropped and remained below the maximum.

It is probable that during the first period, while the beets were growing rapidly, the soluble compounds other than sugar
in the juice were used up in the construction of new tissue, thus maintaining the juice in a higher state of purity. When this rapid growth was checked, however, these soluble compounds, especially mineral salts from the soil, though unused, continued to accumulate, for the reason that the rapid evaporation from the beet leaves during our hot, arid summer days would necessitate a large intake of water, containing salts in solution, from the soil.

The two plots of young beets, planted May 5, increased in weight but little during August and September, and did not attain the purity or the sugar percentage averaged in the older plots.

MATURITY OF THE CROP.

The maturity of the crop, by which is meant the time when the greatest amount of sugar per acre was contained, is indicated in the following table, which also states tonnages, at what time the plots contained the largest amount of available sugar, and other data:

TABLE SHOWING YIELDS OF BEETS AND SUGAR PER ACRE.

<table>
<thead>
<tr>
<th>Plot</th>
<th>July 2, 5-6</th>
<th>August 3, 13</th>
<th>August 27-31</th>
<th>Date of maturity from planting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. John Morris, Clay loam, 0.15% N.</td>
<td>Tons per A. Sugar per A. Available. 5.9 1174 lbs. least quantity.</td>
<td>7.31 1521 lbs. Intermediate.</td>
<td>11.0 1926 lbs. Most.</td>
<td>164 days.</td>
</tr>
<tr>
<td>2. Brinkerhoff Adobe, 0.12% N.</td>
<td>Tons per A. Sugar per A. Available. 4.85 1166 lbs. Least.</td>
<td>7.38 2006 lbs. Most.</td>
<td>7.2 1844 lbs. Intern.</td>
<td>157 days.</td>
</tr>
<tr>
<td>3. Free Hubbard, H'vy adobe, 0.107% N.</td>
<td>Tons per A. Sugar per A. Available. 4.43 1076 lbs. Least.</td>
<td>7.18 2267 lbs. Most.</td>
<td>6.61 2087 lbs. Intern.</td>
<td>157 days.</td>
</tr>
<tr>
<td>4. John Hoopes, L't sand, 0.067% N.</td>
<td>Tons per A. Sugar per A. Available. 3.4 945 lbs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Bishop Zundle, S'dy loam, 0.056% N.</td>
<td>Tons per A. Sugar per A. Available. 2.9 859 lbs. Least.</td>
<td>7.3 1898 lbs. Intern.</td>
<td>9.41 2729 lbs. Most.</td>
<td>170 days.</td>
</tr>
<tr>
<td>7. Lavon, L't sand, 0.072% N.</td>
<td>Tons per A. Sugar per A. Available. 4.7 989 lbs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. S. S. Marshall, Fine loam, 0.083% N.</td>
<td>Tons per A. Sugar per A. Available. 8.62 1892 lbs. Least.</td>
<td>12.3 3361 lbs. Most.</td>
<td>14.4 3442 lbs. Intern.</td>
<td>140 days.</td>
</tr>
</tbody>
</table>
Taking 10 tons of beets containing 15 per cent or 3000 pounds of sugar per acre as a standard (about the average crop for 1897 in the U. S.), it is observed that this yield was excelled in plot 8 with 3361 pounds per acre, and approached in plot 5 with 2729 pounds per acre.

Considering the combination of drouth and hot weather, the tardy planting and the unsuitable soil of some plots, these results are encouraging and justify the repetition of the work, which is now under way.

INSECTS AND DISEASES.

During the early part of the season, April and May, the tender leaves of the young beets were somewhat, but not seriously, injured by various insects which were not identified. This was especially the case in plot 7, situated near an old barnyard.

In July, in all the plots, an unidentified, dry rot appeared, which made appreciable inroads on the stand of beets. This rot was most evident in heavy ground, but was scarcely noticeable in light, sandy soils. The estimated percentage of loss in various instances was: Morris' plot 1, 9.3 per cent; Brinkerhoff's plot 2, 5.4 per cent; Hubbard's plot 3, 6.9 per cent; Zundel's plot 5, 6 per cent; Marshall's plot 8, 5.7 per cent.

POSSIBILITIES FOR STOCK FEEDING.

The value of sugar beets as a stock feed is well known, and they are sometimes grown for this purpose rather than for sugar-making. Cattle and horses are especially fond of this sweet provender, and it may be that, for the present, the beet-sugar factory of this region will run on four legs and flourish a tail. At the Station farm last year, Professor True found sheep to make greater gain on a ration of sugar beets with alfalfa hay, and sorghum, than with the latter alone, singly or combined. The economic question of cost of sugar beets as compared with other forage from the same ground is, of course, to be considered in any case.
EXPERIMENTAL WORK WITH SUGAR-BEETS

For the purpose of stock-feeding, tonnage can be greatly increased in suitable soil where sufficient water is available for irrigation.

On August 6 a beet weighing 15 pounds was taken from a planting in the fine loam soil of plot 8, made March 19; and on December 20, 10 and 15-pound beets were secured from plantings made August 8 on the same ground. It is safe to say that for the last six months of the year heavy tonnage of beets for stock-feeding may be obtained from seed planted the same year.

In this way a substitute may be developed for mangels, which, as has been found on the Station farm, suffer from their exposure to the hot, summer sun in southern Arizona, by reason of their characteristic habit of projecting above the surface of the soil.

In this connection, also, is to be considered the value of sugar beets in removing alkaline salts from the soil and thus making it more tolerable for less hardy crop plants.

BEETS IN SALT RIVER VALLEY.

The following items on the plots grown on the Station farm at Phoenix are of interest in connection with preceding discussions. The table is compiled from data furnished by Professor McClatchie.

DATA CONCERNING SUGAR-BEET PLOTS, 1899–1900.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Soil</th>
<th>Date of planting</th>
<th>First irrigation</th>
<th>No. of irrigations</th>
<th>Date of sampling</th>
<th>Aver. wt of beets, oz.</th>
<th>Sugar in beets, per ct.</th>
<th>Purity</th>
<th>Tons of beets per A.</th>
<th>Total sugar per lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clay loam</td>
<td>Dec 26  April 1</td>
<td>5 June 15</td>
<td>93</td>
<td>15 1</td>
<td>88.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Adobe</td>
<td>Jan 23  April 4</td>
<td>4 June 15</td>
<td>73</td>
<td>13 8</td>
<td>83.2</td>
<td>4901</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each plot was cultivated after the first three irrigations. The season was hot and dry, and consequently unsuited to beet culture. Growth was slow after April, regardless of the amount of water applied.
The result shown for plot 1, yielding 4901 pounds of total sugar per acre, which is much the best for the Territory this year, or heretofore, is partly due to the very early time of planting, December 26, which enabled the beets to attain fair size before they were checked by the hot weather.

In growing beets for sugar in Arizona it is evidently of highest importance that the most should be made of the temperate spring season, and upon the time available between destructive frosts and warm weather largely depends the results obtained. That the upper Gila district has any advantage over Salt River valley in this regard is not certain, as the late frosts, which, in some cases injured the beets during March, may offset the advantage of a slightly later arrival of hot weather. So far as records show, the mild spring season is about of the same duration in the two districts.

CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK.

1. Time of Seeding: When sugar production is the object, it is needful that the beets be planted as early as possible (sooner or later in February, according to the season) in order to secure full advantage of mild weather. Mulching for protection of young beets would probably be an advantage were it practicable, and choice of location with reference to frosts, etc., is important.

When the object is stock-feed, planting may be done at any time after killing frost until September 1st.

2. Soil and Water: The great advantage of a proper soil and an abundant water supply is apparent from the tables of results. In promoting the culture of beets in a new district a soil survey should be made, which would at once indicate the most suitable localities for this purpose.

3. Climate: The effect of hot, arid climate on the sugar beet, as indicated by the checking of growth and sugar percentages, and the loss of purity, suggests the importance of considering aridity in connection with temperature in the climatology of the beet. Excessive evaporation from the foliage must tend to concentrate im-
purities in the juice, although a probable lessening of sensible temperature by this same cause should still favor growth and production of sugar. Caution not to irrigate excessively in hot weather is also suggested by the same considerations. That half of plot 8 receiving an unnecessary extra irrigation August 6, fell from 82.5 to 79.9 in purity, and by consulting the profile map it may be seen that subsequent to the middle of June, when the growth of the beets became more slow, irrigation was followed by decrease of purity in a majority of cases.

In this connection, the location of the California sugar-beet belt along the humid coast is doubtless due to higher humidity, as well as to favorable temperature.

The creation of strains of beets better suited to our conditions, and the production of home-grown seeds to take the place of the imported article produced under different climatic conditions, are also suggested as future possibilities.

4. *Stock Feed*: The production of beets for stock feeding, taking the place of mangels, is worthy of further investigation for southern Arizona, as is also the usefulness of the crop in removing excess of alkaline salts from the soil.