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The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

SUGAR BEETS.

A RÉSUMÉ OF THE WORK DONE BY THE AGRICULTURAL EXPERIMENT STATION OF COLORADO.

BY EUGENE P. HUMBERT

WILLIAM P. HEADDEN.

PUBLISHED BY THE EXPERIMENT STATION
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The Agricultural Experiment Station

FORT COLLINS, COLORADO.

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INTRODUCTORY.

By the Director.

Since 1889 the Colorado Experiment Station has issued ten bulletins relating to sugar beets, eight of which have been devoted entirely and two partially to the study. Nearly all of these bulletins are now out of print, but demands still continue for the information contained in them. It is not desirable to reprint these bulletins, yet many of the investigations and conclusions are still pertinent, and it is believed that a summary of these bulletins to render the results accessible will be of much use, and incidentally serve to maintain the credit of the Station for the pioneer work on this subject which it has done in this State, the extent of which is realized by few. The bulletin places the facts developed in the published reports of this Station in compact form, and while attempting to summarize our own publications referred to, it does not attempt to summarize the work of the other stations or of the Department of Agriculture on the same subject.

This early and continuous work of the Station carried on since 1888, and supported in 1898, as it has been, by various interests, especially of the Denver Chamber of Commerce and the C. & S. R. R., has been an important factor in the location of the industry in Colorado on a firm foundation. These investigations have given the data necessary in order that sugar beet factories should be justified. At this time three factories (Grand Junction, Rockyford, and Sugar City) are in operation in the State. Another (at Loveland) is in active construction, and several more are in contemplation for 1902. The industry has every promise of being of much importance to the State, and especially valuable as it does not interfere with any other. The results already reached show that it finds in Colorado, as has been indicated in the early reports of the Experiment Station, a state well adapted to the industry.

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7. Potatoes and Sugar Beets. April, 1889. Profs. Cassidy and O'Brine.
11. Sugar Beets. April, 1890. Director Ingersoll and Dr. O'Brine.
14. Progress Bulletin on Sugar Beets. January, 1891. Dr. O'Brine.
21. Sugar Beets; Potatoes; Fruit Raising. October, 1892. F. L. Watrous.
36. Sugar Beets. March, 1897. Prof. Cooke and Dr. Headden.
42. Sugar Beets in Colorado in 1897. February, 1898. Prof. Cooke and Dr. Headden.
46. A Soil Study. Part I. The Crop Grown: Sugar Beets. June, 1898. Dr. Headden.
51. Sugar Beets in Colorado in 1898. March, 1899. Prof. Cooke.
57. Farm Notes. Alfalfa; Corn; Potatoes; Sugar Beets. July, 1900. Prof. Cooke.
58. A Soil Study. Part II. The Crop Grown: Sugar Beets. August, 1900. Dr. Headden.

PRESS BULLETINS.

1. The Sugar Beet Caterpillar. August, 1899. Prof. Gillette.
3. The Beet Army-Worm. May, 1900. Prof. Gillette.

Also, references in each of the thirteen Annual Reports of the Station.

SUGAR BEETS.

A RÉSUMÉ OF THE PUBLISHED WORK OF THE AGRICULTURAL EXPERIMENT STATION OF COLORADO.

By William P. Headden, Ph. D.

The first experiments made in the State of Colorado to determine the feasibility of growing sugar beets for the manufacture of sugar on a commercial scale were those made at the Experiment Station at Fort Collins in 1888. These were undertaken by Professors Cassidy and O'Brine at the instigation of the late C. L. Ingersoll, Director of the Station. Three varieties were experimented with. The percentage of sugar was quite satisfactory, the authors making the yield of cane sugar from 4,250 to 7,318 pounds per acre.

The object of these experiments is evident from the closing paragraphs of bulletin No. 7,* in which the work is recorded:

"From the above it will be seen that there is quite a wide variation in sugar content in the four varieties tried last season. Enough, however, has been developed to create a lively interest in the cultivation of the sugar beet in this State for the purposes of sugar production—"

From the publication of the results of these first experiments, in April 1889, to the present time, the Station has issued eight other publications on this subject, only one of which republished any of the results contained in previous bulletins.

The work on this subject has taken two directions, cultural and chemical. Bulletins 11, 46, and 58 are devoted to considerations of the latter class; Nos. 7, 14, 21, 36, 42, 51, and 57 almost exclusively to cultural studies, No. 14 alone deviating from this line in containing a statement of the Director and Chemist in regard to the state of the industry in 1890.

In No. 14 the question of the relation between the size of the beet and its sugar content was discussed, and the suggestion made that the size of the beets could be controlled by thick seeding and judicious thinning.

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* Potatoes and Sugar Beets. April, 1889. Profs. Cassidy and O'Brine.

The results given are uniform in showing that small beets, such as weigh from one to three ounces, are richer than large ones, thirty to forty ounces in weight, by two per cent. or more.

The conclusion of this bulletin indicates that the author had the general question of the adaptability of Colorado to the production of sugar beets in view rather than any cultural problem, for he says, "*We believe that it has been established that the soil and climate of Colorado are favorable to the production of sugar beets, and that they can be successfully and profitably raised to the advantage, both of the farmer and manufacturer.*"

Mr. Frank Watrous, in charge of the substation at Rockyford, grew beets in 1890, '91, and '92, and records the results of his experiments in bulletin No. 21. The season of 1890 was spent in groping after facts, and the product, though encouraging, was not large. The yield obtained ranged from eight to seventeen tons per acre. Some of these yields were from half acre plots, others estimated from single rows.

In 1891 an experiment in irrigating beets was made, from which Mr. Watrous concludes that, in an ordinary season, one irrigation during the growing season is sufficient to produce the best results both as to tonnage per acre and saccharine matter contained. Four plots of one-fourth acre each were planted to Vilmorin beets. Plot 1 was not irrigated; plot 2 was irrigated once; plot 3 was irrigated twice; and plot 4 was irrigated three times. The dates of irrigation are not given. The results are:

Plot 1. Yield: 9 tons per acre. Sugar: 14.25 per cent. Purity: 80.5 per cent.

Plot 2. Yield: 10.8 tons per acre. Sugar: 15.2 per cent. Purity: 84.3 per cent.

Plot 3. Yield: 9.9 tons per acre. Sugar: 14.22 per cent. Purity: 79.5 per cent.

Plot 4. Yield: 9.9 tons per acre. Sugar: 13.0 per cent. Purity: 76.0 per cent.

In 1892 the plots were 1-100 and $\frac{1}{4}$ acre each, four of the sixteen plots being $\frac{1}{4}$ acre in area. The yields from the $\frac{1}{4}$ acre plots were 18.7 tons, 20.5 tons, 25.0 tons, and 25.7 tons per acre, and the sugar percentage 15.18, 16.7, 15.9, and 18.9. The coefficient of purity was between 82 and 85. The yield from the 1-100 acre plots was somewhat higher, as was to be expected, the sugar content ranging from 13 to 15.8 per cent., and the coefficient of purity from 76 to 85.

The plan of culture adopted as the result of the three years' study is as follows: After land had been plowed, harrowed, and made quite smooth, even, and free from lumps, stones, or trash, seed

was sown with an ordinary hand drill, sowing eighteen pounds to the acre, covering an inch or less in depth, in double rows one foot apart, separated by a space two feet wide. Then, with one horse and a shovel plow, a trench was made in this space, the dirt being thrown on both sides to finish covering the seed. The rows are worked over quickly with a rake or hoe, and the seeding is complete. Beet seed requires considerable moisture to produce germination, hence, in a dry spring, water may be turned in these ditches and beets brought forward, independent of dry weather.

To facilitate irrigation, rows should not be more than three hundred feet in length, preferably less. It should not be necessary to drench the upper end in order to moisten the lower end.

Proper cultivation consists in hand hoeing or working with a fine-toothed cultivator, the surface of the ground being stirred as soon after irrigation as practicable. From experience at this Station it seems safe to state that the more careful cultivation, with the proper amount of water when needed, the more sugar per acre.

Bulletin No. 36 discusses the general outlook for the sugar industry in Colorado. The question of market for the sugar which might be produced in the State is answered as follows: "To produce the sugar consumed by the inhabitants of Colorado would require five factories of large size, employing two hundred men each, who, with their families, would represent about four thousand people. It would require the growing of sugar beets on fifteen thousand acres of land, and add more than three hundred dollars to the income of each of two thousand farms."

Touching the question of profit, the writer says: "*If prices are such as to make the business profitable anywhere, then it will pay in Colorado.*"

The irrigable portions of Colorado below 5,000 feet in altitude and east of the Rocky Mountains, possess the best possible climate for the growth of sugar beets, as do many of the valleys of the western portion of the State, but the parks of Colorado are too cold for the sugar beet to be grown with profit.

The common cause of failure among beginners is a lack of thorough preparation of the soil. The plowing should be done in the fall, subsoiling to fifteen or eighteen inches. If this is done, a thorough harrowing just before planting will be all that is needed.

If the plowing is done in the spring it should be delayed until just before planting. The planting is done with a drill. An ordinary wheat drill may be used, but there are special drills for planting beets. Twenty-four inches is recommended as the distance between rows, being none too far apart for irrigation.

The quantity of seed recommended to be sown is at the rate of twenty pounds to the acre. This quantity is large, but advisable in order to get a full stand. The seed should be put in about an inch and a half deep. If the ground is thoroughly wet at the time of planting half an inch may suffice. If the plowing is done in the spring it may be advisable to irrigate the ground thoroughly before plowing, and thus insure a good supply of moisture in the subsoil.

If, after the seed is sown, the weather is so dry that the seed has to be "irrigated up," the chances of a profitable crop are slight. The seed can be successfully "irrigated up" by running a furrow six inches from the drill and allowing a small head of water to run until it has wet the seed by soaking sideways.

The planting may be done from the last of March till the middle of June. Sugar beets sown the first of May will be ready for harvesting about the first of October.

The first cultivation should take place as soon as the plants are up enough to enable one to follow the row. Whatever implement is used, it should merely scratch the surface of the ground, leaving it level and killing the small weeds without throwing dirt onto the young plants. The weeds must be kept down. The ground should be cultivated after each irrigation to level the ground and make a dirt mulch on top to preserve the moisture.

The beet crop in Colorado will need one, and possibly two or three, irrigations. The last irrigation should be given about six weeks before the crop is mature.* In 1895 a heavy rain in September kept the beet crop in full growth until frost, and produced a crop with much less than the usual amount of sugar.

The plants should be thinned when they have four leaves, leaving but one plant in a place. The distance between plants should be eight to ten inches. There is generally but little difference in the weight of the crop in cases where the beets stand six, eight, and ten inches apart. It is easy to grow beets weighing five pounds each, where the soil is rich, by thinning to twelve inches, but such beets are inferior to beets averaging less than two pounds for sugar, and also for stock feeding.

In thinning, the plants are cut out by means of a sharp hoe, leaving bunches of a few plants each, which must be thinned to a single plant by hand.

The soil of Colorado is generally rich enough to grow several crops of beets without fertilizing, but it must eventually be fertilized in order to maintain the yield.

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* This is a general statement, and must be deviated from in special cases.—H

In case alfalfa ground is broken up beets should not be grown on it the first season, but rather a crop of wheat. This will put the soil in better condition and will rot the alfalfa roots. It is not advisable to grow beets more than two years in succession on the same ground.† Alkali ground may be an exception.

If barnyard manure is used to fertilize the soil, the beets can advantageously follow a crop of corn.

The best varieties are the Kleinwanzlebener and Vilmorin.

The harvesting is done either by means of a beet puller or by plowing a furrow near the beets and pulling them by hand.

The topping is done by means of a heavy knife. Topping machines have, as yet, not been successful.

The factories work on beets hauled directly from the field up to the time freezing weather sets in. Beets to be used in the later part of the season should be protected from freezing; for this purpose they may be put into shallow pits and covered with straw and dirt, either near the factory in pits provided by them, or in the field.

The cost of growing an acre of beets varies in different parts of the country, the size of area planted, the condition of the ground, etc. The range is from thirty to forty-five dollars, or from two to four dollars per ton.

About eleven tons of sugar beets per acre at four and a half dollars per ton is a fair average crop, with a possibility of a much larger yield. Compared with alfalfa or wheat, the return seems large, but much more labor is required to produce it.

Sugar beets have a high value for stock feeding. They have been fed at the College with good results, except where fed to steers. The beets seem to be too watery for profitable feeding to steers where the feeding is done out of doors in cold weather. It is advisable not to feed them to fattening lambs for the last six weeks before marketing, grain being preferable at this period, so that the flesh and fat may harden for shipment.*

The tops are good feed for all classes of farm animals. They may be fed at once, as soon as harvested, or put in a silo and fed through the winter.

The next record of results occurs in bulletin No. 42. In 1897 we made an effort to enlist persons in different parts of the State in the raising of sugar beets. The Station has already established beyond any doubt the adaptability of both the soil and climate of this

† Without fertilization.

* The author does not make any statement as to the extent to which grain should replace the beets at this period, whether wholly or only partially.—H.

section of the State to the cultivation of the sugar beet, and also of that of the Arkansas valley, where the substation at Rockyford is located, but no co-operative work, including all sections of the State, had been entered upon. The Station received from the Department of Agriculture at Washington, five hundred pounds of beet seed, and from A. Keilholz, Quedlinburg, Germany, two hundred pounds. This seed was sent to six hundred and eleven persons residing in in forty-seven counties of the State. Most of the analyses of these beets were made by the Department of Agriculture in Washington. The State was divided into five sections, as follows:

1. The valley of the South Platte and its tributaries.
2. The Divide south of Denver, where crops are raised without irrigation.
3. The valley of the Arkansas.
4. The valley of the Grand.
5. The San Luis valley.

The varieties used were the Kleinwanzlebener, Vilmorin, and the Imperial White. As there were one hundred and six samples of the Kleinwanzlebener variety out of the one hundred and twenty-five recorded, no distinction is made between the varieties in this summary.

The percentage of sugar in the samples from the Platte valley ranged from 11.5 to 20.0, the coefficient of purity from 73 to 86, and the crop in tons from 9 to 47.

The percentage of sugar in the samples from the Divide section, grown without irrigation, ranged from 11 to 18, the coefficient of purity ranged from 71 to 87, and the yield in tons from 9 to 22.

The percentage of sugar in the samples from the Arkansas valley ranged from 12 to 20, coefficient of purity from 73 to 86, and the crop in tons from 12 to 40.

The samples from the Grand valley showed percentages of sugar ranging from 12 to 19, coefficients of purity ranging from 74 to 86, and crops from 15 to 42 tons.

The samples from the San Luis valley * showed percentages of sugar ranging from 11.5 to 17.9, coefficients of purity from 74.2 to 86.9.

The time of ripening of beets in Colorado will vary, of course, but the average of the samples taken between September 25th and October 10th is 14.1 per cent. sugar and 80.7 per cent. purity, which is an excellent grade of beet. To get the crop to ripen is the principal aim of the beet grower. The most important factor in this is

* Altitude 7546 feet.

that the beet shall be kept growing all the time from the sprouting of the seed until the harvest. Some of the conditions on which the ripening of the crop depends are beyond the control of the grower. In Colorado it is true in general that the crop will not ripen until the vigor of growth has been checked by frost. The best means of determining whether a crop is ripe or not, that is, in condition to go to the factory, is by means of an analysis, but a good judgment can be formed by cutting a beet and noticing the rate at which the cut surfaces darken.

The increase in percentage of sugar and coefficient of purity during ripening is about three per cent. for the former and about five per cent. for the latter.

Some very suggestive facts relative to methods of culture were observed during this year's study. Certain principles of beet growing have come to be considered as essential to the production of the best beets. These principles were violated by most of the growers of beets this year, it being their first experience, and yet they obtained good results. It is said that beets should never be planted on new ground. This was violated with good results, giving, in one case, beets of 15.2 per cent. sugar and 82.4 per cent. purity, and in another 19.4 per cent. sugar, and in others the beets were above the average. Ground which had been broken but one year gave uniformly good results. So, too, in regard to time of plowing and subsoiling. All writers on sugar beet culture agree that beets should not be planted on ground that has been recently manured. Sixteen persons report manuring with stable manure. The crops were late in ripening, but with three exceptions, the quality was good. The results as a whole indicate much more gain than loss from the application of stable manure.

The hardest part of beet raising is to get a full stand all over the field. The poor growth of the seed is due to lack of moisture, too deep planting, and poorly prepared ground. The lack of moisture can be overcome in two ways—by irrigating before or after planting the seed. The latter seems to be more promising as a general method. Of fifteen persons trying this method, eight report having obtained a thick stand, being twice as large in proportion as those reporting a thick stand by depending on rain or the original moisture in the ground.

Mr. Geo. H. West, of Greeley, contributed an interesting article, published in bulletin No. 42, containing the observations and conclusions of his study of the subject, which he designates "Growing Sugar Beets for Factories." Mr. West studied this subject in Nebraska, Utah, and New Mexico. Of the growing of beets in Nebraska he says: The farmers are largely Germans, with some Rus-

sians. Women and children work with the men in the fields. Where a large acreage is in beets, the thinning, weeding, hoeing, pulling, and topping is done by contract. Laborers receive from fifteen to twenty dollars per month, the usual wages by the day being one dollar and board. On contract work the rate is from fifty cents to one dollar for boys; one dollar for men and women, without board. For a man and team, two dollars and fifty cents per day; for man and horse, one dollar and seventy-five cents. Land rent from three dollars and fifty cents to six dollars per acre.

The average yield in 1897 was 7.25 tons, and the sugar extracted by the factory at Norfolk was 10.95 per cent. The percentage of sugar in the beets was 13.1 per cent., purity 81.5 per cent.

The Grand Island beet raisers averaged 8.1 tons per acre. The average percentage of sugar in the beets in 1897 is said to have been 12.87, and purity 79.5. The percentage of sugar obtained from these beets by the factory was 8.72.

The tables given show that in 1897 the factories at Norfolk and Grand Island treated the largest tonnage and made the highest saving attained up to that year. The range of farm wages is from fourteen to twenty dollars per month, with board; and from one dollar to a dollar and a quarter by the day. Women and children generally work on the contract plan. Many girls get a dollar a day in the beet fields, and prefer it to house work. Boys from ten to eighteen years of age receive from fifty to eighty cents per day, a man and team two dollars and fifty cents, and a man and horse one dollar and seventy-five cents per day. Contracts can occasionally be made, as in Colorado, at two dollars per day for man and team. Land rentals range from four dollars to seven dollars per acre. The crop of 1897 is said to have been reduced fully one-third by drought. No beets are grown by irrigation in Nebraska.

At Lehi, Utah, the conditions are said to be ideal for the growing of beets and running a sugar factory. The farms vary from five to forty acres in extent, and fully nine-tenths of them are worked by the owners. Mortgages are rare and the farmers prosperous. The women do not work in the fields, and the girls seldom work there unless at home. Much of the hand labor is done by boys. The average acreage per grower is less than four acres. The highest average yield per acre was in 1896, 13.5 tons. The average per acre from 1891 to 1897, inclusive, was 9.44 tons. The highest average percentage of sugar in the beets was, in 1896, 13.9 per cent. The average percentage from 1891 to 1897, inclusive, was 12.4 per cent. The average percentage of sugar extracted, 1891 to 1897 inclusive, was 8.46. Land rentals range from $7.50 to $15.00. The soil shows a

great diversity about Lehi, but is generally a heavier soil than the uplands of northern Colorado.

The Eddy, New Mexico, sugar beet factory has been run for two seasons only, 1896 and 1897. The valley, though a natural fruit garden, lacks the farming population, and pernaps, too, the close, careful cultivation and knowledge of irrigation of the older farm districts of Colorado. In 1897 they grew 1,900 acres of beets; yield, three tons per acre; percentage of sugar, 14.2; purity, 80 per cent.; percentage of sugar extracted from the beets, 10.53.

The average cost of growing and delivering a crop of beets at Norfolk, Nebraska, is $26.50 per acre; the average profit, $11.04. The yields range from five to fifteen tons per acre. The net returns vary from a profit of $29.00 to a loss of $7.55 per acre. At Grand Island, Nebraska, the average was $28.73 per acre, and the average profit $9.27. The yield varied from five to twelve tons per acre, and the net results from a profit of $17.00 to a loss of $12.00 per acre. Mr. West puts the average cost of growing and marketing sugar beets in Nebraska at $30.00 per acre, and states that the officials of both factories put it at the value of seven tons of beets, or $28.00.

The average cost of growing beets in Utah, not including land rentals, is put at $32.50 per acre. The average yield is stated at 10.1 tons, but the yield for 1897 was 6.75 tons. Improved beet cultivating implements had not, at that time, been introduced into Utah, and this, with the higher land rental and cost of irrigation, raises the actual cost to probably $40.00 per acre.

Relative to the profits of beet culture, Mr. West says: Large yields are regularly obtained by those farmers who do thorough, clean work, and intimates that therein lies a big secret of success.

It is also pointed out that the labor question is a most serious problem in this industry. It is too important to be entirely passed over, even in a summary such as this.

Concerning the feeding of pulp to cattle and sheep he gives results obtained in Nebraska and Utah. At Lehi the pulp is placed in silos with addition of about one-half per cent. of its weight of salt. The cattle always have access to plenty of hay, pulp, and water. *They never feed a pound of grain in fattening the stock,* unless the pulp gives out.

John Reimers, Grand Island, Nebraska, had had three years' experience in feeding pulp to cattle. He fed fifty pounds of pulp, twenty pounds of corn meal, a little bran, and oil cake, and the usual amount of hay per day, as a full ration. Hake Bros., also of Grand Island, fed lambs a mixture of four pounds of pulp to one or one and a half pounds of corn meal, besides hay, as a full ration.

The results are highly satisfactory. The pulp is said by Superintendent Geo. Austin, of Lehi, to give the best results after fermenting in the silos for thirty days, and should not be fed sooner than this.

The experiments made in 1898 are grouped as follows in bulletin No. 51:

1. *Different dates of planting.* Results in favor of early planting in respect to yield, sugar content, and purity.

2. *Planting on freshly plowed ground as compared with planting on ground plowed a few days before planting.* Resulted in favor of planting on freshly plowed ground by 2.3 tons in yield, two per cent. in purity, and a slight excess in sugar.

3. *Seed irrigated at planting as compared with that not irrigated.* Results obtained on the College Farm showed no advantage from this practice. The soil was a rather heavy loam and was moist at planting time. Good results have been observed from this practice on lighter soils.

4. *Soaking seed before planting.* Results did not show any gain from the soaking of the seed.

5. *Sowing at the bottom of a three-inch furrow.* The resulting stand was not so good as that obtained by sowing at ordinary depths. The yield was once as good and twice poorer than that from similar rows of ordinary planting. The percentage of sugar and purity were not perceptibly different from other plantings.

6. *Different depths of planting.* The depths at which the seed was planted were from one-half an inch to an inch and a half. The first series, planted May 11th in a wet soil, showed no difference, but the later planting, made May 27th when the soil had dried out considerably, showed an advantage in favor of the deepest planting, amounting in comparison with the shallower plantings to more than one-third of the crop. The stand, yield, and quality were all better than in the cases of shallower planting.

7. *Transplanting.* Transplanted beets are usually ill-shaped. The yield may be good, percentage of sugar and purity high, but the method would not be a financial success.

8. *Different distances of thinning.* The results obtained show that the distance apart of the beets, from four to ten inches, has but slight influence on the quality of the crop as to sugar and purity. In a general way the thicker stand tends to a larger yield, but there are exceptions to this statement.

9. *Different dates of thinning.* The results show that the

thinning of beets can be extended over a period of two weeks without injury to the crop.

10. *Variety tests.* Six varieties, Zehringen; Vilmorin's Improved, grown in Russia; Kleinwanzlebener, grown by Vilmorin; Pitschke's Elite; Vilmorin's French, very rich; and Schreiber's Elite were grown side by side with Kleinwanzlebener, strain not given, with almost identical results in percentage of sugar and purity, the sugar ranging from 15 to 17.20 per cent., and the purity from 76 to 81.9. The average of all the samples analyzed in this test is 16.04 per cent. sugar, and 78.9 purity.

11. *Number of irrigations.* At Rockyford, beets were grown without irrigation, with one, and with four irrigations. This experiment was of little value, being defeated by the unusually heavy rains of that season.

At Pueblo, Mr. C. K. McHarg applied water to one-half of some experimental plots twice after the 20th of August, the other half receiving none after that date. The two later irrigations produced an increase of one-seventh in the weight of the crop, and the percentage of sugar was increased; beets from the half irrigated late, contained 16.42 per cent. sugar, 81.0 purity, and those from the other half contained 15.79 per cent. sugar, 81.7 purity.

12. *American grown seed vs. imported seed.* Two samples of American grown seed were used, one grown in Utah and the other in New Mexico, both were strains of Kleinwanzlebener beets. The imported seeds were the Original Kleinwanzlebener, Vilmorin, Mangold, and Elite Kleinwanzlebener.

The Elite Kleinwanzlebener and the Vilmorin were sent us by the U. S. Department of Agriculture as the best beet seed that they could get. The Original Kleinwanzlebener was selected by the Utah Sugar Company as, in their judgment, the best brand of seed on the market from which to raise their own seed. The Utah grown seed produced as large a crop and one richer in sugar and purity than the average of these three. It excels its parent strain in richness and purity, and is but little inferior in quality of crop.

The New Mexico seed equals the Vilmorin and is not far behind the original Kleinwanzlebener.

The germinating quality of the seed is quite satisfactory.

In 1899 the questions whose solution were attempted were:

Does it pay to subsoil? The results of ten tests made at this Station show an average gain of 18 per cent. in the weight of the crop as the result of subsoiling.

Is it advisable to plant the beet seed very early? The average

crop from ten plots sown between April 10th and 20th was 27.7 tons; from ten plots sown between May 1st and 10th was 24.3 tons; from ten plots sown between May 15th and 26th was 20.4 tons; and from ten plots sown between May 31st and June 10th was 15.3.

The percentage of sugar in these various crops scarcely differed at all, 0.76 of one per cent. being the maximum difference, and 3.2 was the maximum difference in purity. The difference in crop, however, is very decidedly in favor of very early planting.

The question of the distance between rows is recurred to again, and a former recommendation is repeated, *i. e.*, making the alternate spaces between rows narrower and wider. The distances advocated are eleven and twenty-seven inches. The chief advantage claimed is in irrigating, also an increase of crop.

IRRIGATING UP THE SEED.

Twelve experiments were made with irrigating up the seed, and a like number without irrigation. Of the twelve experiments with irrigation none failed, of those without irrigation two failed. The crops from the twelve irrigated at the time of planting averaged 26.3 tons to the acre. The crops from the ten plots which came up, but which were not irrigated at the time of planting, averaged 25.4 tons to the acre.

INSECTS INJURIOUS TO BEETS.

The earliest observations on this subject seem to have been made by Prof. C. P. Gillette in 1894, when he records the leaf hoppers *Gnathodus abdominalis*, *Platymetopius acutus*, and *Agallia uhleri*, as doing injury to beets in the vicinity of Grand Junction, also a mealy bug, *Dactylopius solani*, as infesting the crowns of the plant. The next mention of injury to beets by insects is in 1897, when the writer's patch of beets was seriously injured by the leaf hoppers *Agallia uhleri*, *A. sanguineolenta*, *A. cinerea*, and the striped beetle *Systena taeniata*. Later *Monoxia puncticollis*, and also the blister beetle, *Macrobases unicolor*, did some damage.

In 1899 the beet army-worm (*Laphygma flavimaculata*) made its appearance near Grand Junction, and was very destructive. It did not appear in injurious numbers in this locality in 1900. Prof. Gillette and his assistant, Mr. E. D. Ball, found but few specimens of either the first or second brood. Prof. Gillette (Thirteenth Annual Report of the Colorado Agricultural Experiment Station) says of this failure of the insect to appear the second season: The very sudden appearance of this insect, which had never before been considered injurious, in such destructive numbers, and its equally sudden disappearance, is quite remarkable. Particularly is this so from the fact that the fall brood of worms in 1899 were but little parasitized, and the moths matured in enormous numbers. The latter

must have failed, for some reason, to winter over. These worms appeared on some experimental patches of beets at Lamar and Rocky-ford in 1899, and the first brood appeared in destructive numbers in 1900. The worms began to appear during the first week in June, and were abundant by the 14th, when spraying was begun. Late planted beets were not injured by them, except where they were planted near patches of weeds or earlier beets. The poisons were effectual, especially where two sprayings were made with Paris green.

Other insects mentioned by Prof. Gillette as having been observed on beets and not already mentioned, are *Nysius angustatus* (often called false cinch bug), more or less abundant everywhere, in some cases causing beets to wilt and die. *Deilephila lineata* was found as an occasional feeder, especially where purslane was allowed to grow. (Mr. Ball's notes.)

Chemical Considerations, Bulletin No. 46.

THE EFFECTS OF ALKALI.

Sodic carbonate, or black alkali, when present in quantities equal to less than 0.1 per cent. of the weight of the dry soil, does not prevent a satisfactory germination, but a still smaller quantity, as little as 0.05 per cent. of the weight of the dry soil, will corrode the plants, both plumule and radical, causing their death. We have occasionally observed corroded plants in alkali ground, but in spots only. The ground experimented with was very strongly alkalized, the worst, in fact, that we had at our disposal.

Sodic sulfate, or white alkali, does not prevent germination when present in quantities equal to less than 0.70 per cent. of the weight of the dry soil. No corroding by this salt has been observed.

The effect of the black alkali, sodic carbonate, is not mitigated by the presence of the white alkali. The sodic salts hasten germination by 36 to 48 hours.

Magnesic sulfate, one of the constituents of our alkalies, retards but does not prevent germination.

The beet plant can endure a larger amount of white alkali in the soil after it has become established.

Alkalinity of soil did not effect date of ripening in a series of experiments made at the Station.

Alkali does not affect the sugar content of beets grown on soil in good, or even fair tilth.

The ripening of beets may be seriously affected by a rainfall, or untimely irrigation. The crop of 1897 showed this plainly. On September 8th the beets had already begun to ripen, from the 10th to the 14th, 0.74 inches of rain fell; on September 22nd the samples analyzed showed a lowering in the percentage of sugar present. This loss was not regained for nearly three weeks, the beets, however, increased greatly in size during this time.

The ripening in this case took place more suddenly than is probably usual, and corresponded to an increase of from 2 to 3.5 per cent. in the different plots and is equivalent to about one-third of the total yield of sugar—that is, if the yield of sugar be 6,000 pounds per acre, 2,000 pounds is formed during the period of ripening.

Beets were covered with straw and left undug until January 7, 1898, with a slight gain in percentage of sugar and purity, showing that beets under favorable conditions may remain unharvested without loss of sugar or weight of crop.

Distribution of the sugar in the beets. In bulletin No. 11, it is stated that the amount of sugar increases in the successive sections of a beet from the top downward. This is not sustained by bulletin 42, which shows that the upper third, including the crown, contains only about 0.2 of one per cent. less sugar than the lower two-thirds, and these, the lower two-thirds, cannot be said to differ at all; sometimes the second and sometimes the third third having the higher percentage of sugar, the difference always being so small that it is insignificant.

SUGAR IN THE CROWNS.

The crown as used in bulletin No. 42, is really a structural portion of the beet, and not any indefinite portion which may have chanced to grow above the ground. It is very rarely the case that sugar beets, Kleinwanzlebener or Vilmorin, grow above ground at all with us. The difference between the sugar content of the crown and the beet from which it is cut is about one per cent. The coefficient of purity is lower than that of the beet, but not necessarily poor. The example given shows beets 16.1 per cent. sugar, 88.0 purity; crowns 15.1 per cent. sugar, 82.4 purity.

EFFECT OF FREEZING ON BEETS.

Simple freezing does not cause any change in the sugar. If thawing can be prevented the crop is not necessarily lost if frozen.

DRYING OUT OF BEETS.

This takes place rapidly if the beets are exposed. Beets wrapped in paper and placed on the earth of a cellar bottom lost about five per cent. of their weight during the first twenty-four hours; from this the daily loss fell to about two per cent., at which rate the beets continued to lose up to the seventeenth day. The percentage of sugar increased.

The drying out of beets has another effect, it is accompanied by a loss of sugar. This loss varied in the experiments recorded from one-fortieth to one-sixth of the sugar present.

The suggestion is made that the loss may be materially influenced by the condition of the crop, the loss being greater in unripe beets than in riper ones.

The yields recorded range from 7.9 to 11.8 tons per acre for sugar beets, and 15.9 tons per acre for Lane's Imperial.

The ratio of the weight of the tops to that of the beets was found in two ways. First, weighing the carefully removed tops and beets gave for sugar beets of different varieties ratios varying from 1:1.087 to 1:1.274, or the weight of the tops varied from 78.5 per cent. to 92.0 per cent. of the weight of the beets. The second method was to weigh the beets as harvested and the tops as removed from them. On removing these tops no part of the crown of the beet was taken. The result was that we found the ratio to be 1:1.14. The general ratio obtained by the first method was 1:1.12. The weight of leaves as harvested in the field equalled 87.7 per cent. of the weight of the roots. The results obtained in the laboratory gave their weight as equal to 89 per cent. of that of the beets.

The tops of beets grown on alkalized ground were relatively a little heavier than in cases where the ground was practically free from alkali.

The tops increase but little in weight during the last six weeks of the growing season. The beets, on the other hand, gained 64 per cent. of their weight at the beginning of this period.

The beets ripened this season, 1897, the second week in October, and about one third of the total crop of sugar was deposited during this period.

The percentage of dry matter in sugar beets increases with the maturing of the beet. In green beets harvested September 2nd we found from 8.8 to 14.6 per cent., with an average of 12.1 per cent. In mature beets it ranges from 17.0 to 20.5 per cent., and in exceptionally favorable seasons it may be higher. Sugar forms a larger percentage of this dry matter in mature beets than in green or immature beets.

There is a little more dry matter in the top one third of the beet than in the other two thirds.

Stock beets contain less dry matter than sugar beets. We found the dry matter ranging from 12.25 to 14.63 per cent. in mature beets.

The marc or pulp, the portion left after the sugar and soluble matters have been washed out, ranged from 4.21 to 5.25 per cent. The average is about five per cent.

For fodder analyses of sugar beets grown on alkali soil and soil free from alkali, of stock beets, beet tops, and marc or pulp, see bulletin No. 46, page 37.

Alkali in the soil tends to increase the percentages of ash and albuminoids.

The feeding value of dry pulp may safely be estimated as equal, pound for pound, to the dry sugar beet.

One ton of sugar beets yields about four hundred pounds of dry matter, and only one hundred pounds of dry pulp. One ton of stock beets yields about two hundred and forty pounds of dry matter, which is richer in albuminoids and nitrogen-free extract than the pulp is; the pulp, however, is a by-product and the stock beets are not.

The percentage of crude fiber in beets is quite irregular, but uniformly higher in beets from alkalized ground than others.

Alkali affects the composition of the beets more than that of the leaves.

The percentage of ash in the beet ranged from 0.79 to 1.33 per cent. in immature beets, samples harvested September 2nd, to from 0.95 to 1.39 per cent. in mature beets harvested October 13th. The average is 1.10 per cent. of ash in the fresh beet.

Fifty-eight per cent. of the total ash constituents removed from the soil by the roots, and 70 per cent. of all the mineral constituents removed by the leaves, had been gathered by September 2nd. The accumulation of ash constituents continues until the period of ripening.

The slight decrease in the percentage of ash as the roots approach maturity is due to the rapid increase in the weight of the beets. There is no diminution in the amount of ash constituents in the crop.

The influence of alkali, present in large quantities, is to increase the ash by about two per cent., reckoned on the dry matter.

The ash is quite evenly distributed throughout the beet, with a slightly larger amount in the top one-third, but the percentage of ash is higher in the dry matter of the bottom third.

The ash of the beet has a pretty uniform composition, generally showing about 3.5 per cent. sulfuric acid, 7 to 9 (usually about 8.5) per cent. phosphoric acid, 48 to 52 per cent. of alkalies, 2 to 3 per cent. of lime, about 6 per cent. of magnesia, 11.5 to 14.5 per cent. of chlorin, and about 15 per cent. of carbonic acid in the fine ash. When the carbonic acid is higher than 15 per cent. either the phosphoric acid or the chlorin is correspondingly lowered.

The composition of the ash of the leaves is quite different from the composition of the ash of the roots. The ash of the leaves contains from 3.5 to 3.9 per cent. of sulfuric acid, 1.8 to 2.3 per cent. of phosphoric acid, 23.7 to 25.7 per cent. of potash, 22.3 to 25.5 per cent. of soda, 1.5 to 2.5 per cent. of lime, 6 per cent. of magnesia, 23.3 to 28.5 per cent. of chlorin, and from 10.6 to 15.0 per cent. of carbonic acid.

The composition of the ash of immature beets is the same as that of mature beets. The only exception to this statement seems to be the percentage of chlorin in the ash of the leaves, which increases so generally and uniformly that it suggests a relation between the degree of maturity and the quantity of chlorin.

The soil, repeatedly referred to as alkalized, contained chlorid of sodium, or salt, equal to 0.025 per cent. of the weight of the air dried soil. This gives us 2,800 pounds of salt in each acre of soil, taken to a depth of two feet. The total water soluble in this soil varies from 0.09 to 1.4 per cent. of the weight of the air dried soil, taken also to a depth of two feet. The higher figure gives us the immense quantity of 49.0 tons of alkali per acre, consisting of 16.33 tons of sodic sulfate, 17.64 tons calcic sulfate, 10.27 tons of magnesic sulfate, and 1.25 tons of ordinary salt.

Continued cropping to beets would soon show a perceptible reduction in this quantity of sodic chlorid, especially if the leaves were carefully removed, but the ground water is rich in salts, and is capable of replacing this, as well as the other "alkali" salts removed.

Stock beets, including leaves, remove, crop for crop, more soda salts than sugar beets do, but not ton for ton.

The chemical work of 1898 and 1899 is recorded in bulletin No. 58, which continues the study of the effect of soil conditions on the stand and quality of the beets, and the chemistry of the beet itself.

There were certain spots in which the seed failed to germinate, and the cause of this was not discovered. It was not explained by either a lack or an excess of moisture, nor was the alkali as excessive as in some other places.

The plot experimented with was the same as that used in 1897, the results of which appear in bulletin No. 42.

The rainfall for the months of July, August, September and October was 2.8 inches, the total amount received by the crop from the time of planting till harvested was about eight inches. The ground at the time of planting was wet, and the water plane was about two feet below the surface. The water fell about a foot in the next thirty days. An irrigation given July 8th to 11th did not suffice to raise the water to its earlier level, and it fell two feet in eleven days. The level of the ground water was not sensibly affected two hundred feet east of my plot by this irrigation. The water plane fell slowly from July 25th until early in October, when it reached its lowest point. The water plane from July 15th to October 10th ranged from three to four and one half feet below the surface at the east end of the plot, and there were but few beets in this section. At the upper and higher end of the plot the plane varied from 5.2 to 6 feet below, and the crop was excellent. In an intermediate section the water plane varied from 3.5 to 4.5 feet below the surface, with an abundance of alkali, and it yielded a good crop. The crop showed the need of water during the later part of the season, notwithstanding the high water plane. The ground had been kept as mellow as possible, and clean, having received five hoeings and five cultivatings. This plot of ground was put in beets in 1899, and needed no irrigating, it having been sub-irrigated this season from higher ground lying to the west of it. The wetness of the ground interfered with the cultivation of the crop, but the mechanical condition of the soil was so much improved over that of previous years that the cultivation was much easier. In 1899 this plot was soaked, August 31st to September 2nd, and the crop left to itself. The crop from this plot in 1897 was, taking an average of all varieties of sugar beets, about nine tons; in 1898, thirteen tons; in 1899, fourteen and one half tons to the acre. The increase in the crop is due to the betterment in the condition of the soil and a rather better stand.

Application of manure, sheep manure in this case, improved the stand by at least ten per cent.

The ripening of the crop of 1898 was entirely different from that of the crop of 1897. In 1897 there was a rainfall in September, on the 14th, which interrupted the ripening. In 1898 the crop developed continuously up to maturing. No sudden increase in the percentage of sugar was observed as in the preceding year, when the

increase was from 2 to 3.5 per cent. In 1898 the greatest gain observed, which could be attributed to ripening, was 1.4 per cent. The varieties grown by the Farm Department remained almost constant from October 3rd till October 22nd, in only one variety was there a gain of as much as one per cent. The ripening of the crop is much more gradual some seasons than others. The same observations were made in regard to the effect of the alkali upon the quantity of sugar, coefficient of purity, and time of maturing as were recorded in bulletin No. 46, namely, that the effect of the alkali is not detrimental.

The effect of the manure upon the sugar content and coefficient of purity, considering all of the tests, which, however, are not concordant with one another, is to lower both the sugar content by from 0.5 to 1.2 per cent. and the coefficient of purity by from 0.1 to 3.1 per cent.

The effect of the manure on the shape of the beet was bad, and this effect was uniform in the six comparative experiments which were conducted.

These effects of the manure were noticeable the second year after its application, but not in so marked a degree as they were the first year.

The result the second year is probably due to the failure of the manure to thoroughly rot and become incorporated with the soil.

Cut straw was also used as a dressing. Its effects were beneficial to the soil, but less in degree than those of the manure. Its effects upon the beets were not pronounced enough to permit the expression of a positive judgment. The results of this experiment are taken as corroborative of the opinion expressed elsewhere, that it is the mechanical condition of our alkali soils that preeminently needs improvement. That section of the plot which has been in the worst mechanical condition shows more alkali on the surface than the others. The water soluble in the soil, however, is greater in other portions of the plot. No attempt is made to formulate the relation existing between the mechanical condition of the soil and the amount of alkali present. These two factors are spoken of together as producing certain effects on the crop, but the opinion is expressed that the alkali, *per se*, is not the cause of these effects. This opinion is based upon the observation of spots where there is an abundance of alkali, but where the mechanical condition of the soil is better. No statement is made as to the extent of the influence of the alkali upon the mechanical condition of the soil. This point is left as an open question. The crops have improved each year, showing a mitigation of these conditions due to cultiva-

tion. This improvement is not due to drainage, for the water table has not been lowered and is seldom low enough to prevent capillarity from bringing moisture, and consequently salts, to the surface. An attempt was made to determine the direction and rate of the flow by introducing lithia salts into one of the wells, but it was found upon examination that the ground water contained lithia at all times.

The effect of seasonal differences upon the crop was noticed in the greater amount of dry matter in the beets in 1898 than in 1897. The difference in the percentage of dry matter attributable to the seasons was from 3.0 to 3.75 per cent., about one sixth of the total dry matter in the beets.

The question of the rate of drying out was taken up again with more care than in previous years, with about the same results, *i. e.*, that the loss for the first twenty-four hours was about five per cent. In this case, with a temperature of 57 to 66 degrees, the loss was 4.39 per cent. It fell to two per cent. in a few days, and remained at this figure for twelve days. The effect of drying out is shown in its effect on the average sugar percentage in 1898. In this year we analyzed 813 samples. The average percentage of sugar is found to be 15.12, without making any allowance for the drying out. We succeeded in obtaining fairly reliable data in 336 instances on which to base the deduction which should be made, and find it to be 1.5 per cent., which gives us an average of 13.62 per cent. for the crop.

The conclusions arrived at, as the result of many experiments to determine the relation existing between the size of the beets and their sugar content, are: That beets to be compared must be grown under the same conditions; that the conditions determining the percentage of sugar are so complex that no given weight can be accepted as a limit which, if exceeded, will indicate that the beet is not of proper richness and quality for the manufacture of sugar; that when the large size is due to an excessive supply of plant food, or an unduly large feeding ground and a constant and very abundant water supply, the beet is quite certain to be low in sugar, but this will be true of all beets, large or small, grown under such conditions.

Eight experiments, in which beets weighing less than one half a pound are compared with beets weighing more than two pounds, showed that the smaller beets were richer in seven instances and poorer in one. The maximum difference in favor of the smaller beets is one per cent., the least difference is 0.19 per cent. The average difference is 0.50 per cent. The beets above one half pound in weight make the crop. The coefficient of purity is better in the

larger beets, or at least as high as in the smaller ones. The conclusion drawn from another experiment is that too great a width between the rows tends to have the same effect as permitting beets to grow singly.

In 1898 it was observed that certain over-irrigated spots had turned yellow. Analysis showed that these beets were richer in sugar than the beets growing adjacent to them, but which had not been over-irrigated, by upwards of three per cent., and the coefficient of purity was much better, ten per cent. This clue was followed in 1899 with excellent results. The average percentage of sugar for beets grown by the Chemical Department in 1898 was 13.65. The average for all samples analyzed that season, 1898, was 13.62 per cent. The average for the season of 1899 was 14.69 per cent.* The effect upon the tonnage of the crop was not determined, but it was not materially affected in any observed case.

This is unlike the effects of a late and inopportune rainfall. The bad effects of this are probably due to the condition of the crop at the time of the rainfall, and not particularly to the amount of water that falls.

Cultivation and manuring increased the amount of phosphoric acid taken up, but did not increase the percentage of ash in the fresh beet. The greatest effect seems to have been on the percentage of chlorin taken up, it having been lowered.

The percentages of phosphoric acid, lime and magnesia in the ashes of the samples of 1897 and 1898 were very nearly the same, but in 1899 the percentages of the two latter substances increased by one per cent. each.

The changes produced tend to bring the composition of the ashes more into harmony with the results of other observers, and indicate the tendency of cultivation and continued cropping to ameliorate the soil conditions and modify their effects upon the mineral matters taken up by the plants.

The effect of the manure was of two characters, mechanical and as a fertilizer.

The nitric acid in the ground waters was more variable and higher after than before the application of the manure.

The total solids were also higher during the season immediately following its application.

Heavy rains or an irrigation increase the amount of chlorin in

* The average of all varieties, manured and not manured. The average for the not manured sections was 15.34 per cent.

the ground water. The increase was more pronounced and of longer duration after the manure was applied. The effects of the straw upon the soil lead the writer to attribute the effects of the manure principally to the organic matter in it, improving the mechanical condition of the soil and bettering its biological conditions, as indicated by the increased amount of nitric acid formed.

Experiments made in 1897, 1898 and 1899 upon the effect of soaking beets in water at a temperature of about 42 degrees Fahrenheit for a period of seven days, resulted uniformly in showing an increase in the amount of sugar present, and also in the coefficient of purity.

The reducing power of beet pulp was determined by extracting the beets with 80 per cent. alcohol until the extract no longer reacted for sugar, then boiling with dilute hydrochloric acid and determining the reducing sugar thus formed and calculating it as pentose. The pentoses, or, as it is expressed in the bulletin, the reducing power, did not decrease as the beet matured. The rich beets showed higher percentages of pentoses than those showing lower percentages of sugar. The quantity of pentoses in stock beets is quite as great as that in sugar beets.

Soaking seemed to diminish the quantity of pentoses present.

The sugars present in the leaves of sugar beets in largest quantities are glucose and maltose. Cane sugar is present in small quantities only, or is entirely absent.

CONCLUSIONS RELATIVE TO THE CULTURE OF SUGAR BEETS.

A rich, loamy soil is best adapted to the growing of sugar beets, but any soil that will produce good crops of grain will grow beets, and even soils too alkali to grow grains will grow beets.

Plowing is best done in the fall, subsoiling to fifteen or eighteen inches. Plowing may be done in the spring; in this case it is best to plow immediately before planting. In either case harrow quite smooth and even.

Results at this Station show a gain of 18 per cent. in weight of crop, in favor of subsoiling.

The time to plant will vary with locality and soil. Early planting gives largest crops. Good results have been obtained with plantings as late as June 13th at this Station, and June 15th at Rockyford, but four series of tests of ten experiments each, made in different sections of the State, show an average excess of 3.4 tons of beets for the plots planted from April 10th to 20th over similar plots planted from May 1st to 10th; 7.3 tons over those planted May 15th to 26th, and 12.4 tons over those planted between May 31st and June 10th.

If the soil is wet, very shallow planting will give good results, but the best results are generally obtained by planting from one inch to an inch and a half. Deeper planting is not advisable.

The distance between rows should be from 18 to 20 inches if in single rows. Mr. Watrous, in bulletin No. 21, recommends double rows 12 inches apart and 24 inches between rows. He claims that they are more easily irrigated. Prof. Cooke, in bulletin No. 57, recommends double rows 11 inches apart and 27 inches between rows.

Good crops have been raised by planting small quantities, three to five pounds of seed to the acre, but it is advisable to sow eighteen or twenty pounds to the acre. One of the most difficult things in beet growing in Colorado is to get a good stand.

In order to get a satisfactory germination of the seed, one or other of the following methods have given the best results: Either plant on freshly plowed soil with a good supply of moisture, or irrigate up.

Cultivation should begin as soon as the plants show the drills distinctly enough to be easily followed, when the surface should be thoroughly stirred to kill the young weeds. The young beet plants must not be covered.

Thinning may be begun as soon as the plants have gotten big enough, when they have four leaves, and may be extended over a period of two weeks. As the plants get larger, more care must be exercised on the part of the persons thinning, to avoid injury to the remaining plants.

The distance between the beets in the row may vary from six to ten inches —eight inches on an average gives a satisfactory crop. There is but little

difference in the weight of the crop when the beets stand six, eight or ten inches apart. At twelve inches apart the beets are apt to attain an undesirably large size.

The cultivation of the crop must be varied according to the character of the soil. Any instrument, the plow, the cultivator or special beet cultivating implement, which will put the soil in good condition without covering or otherwise injuring the plant, may be used. During the growing season the beets should be cultivated as soon after an irrigation as is practicable, to prevent encrusting of the surface, to level the ground, and to make a mulch of fine earth.

The number of irrigations necessary to raise a good crop will vary with the seasons. Mr. Watrous, in bulletin No. 21, says that in ordinary seasons, with an average rainfall of 13.89 inches, one irrigation during the growing season is sufficient to produce the best results. Some experiments made at Rockyford under Prof. Cooke gave the same result. The rainfall of that season was unusually heavy. If the water is at the command of the grower, the beets should be irrigated often enough to keep them growing continuously from the beginning of the season until the time of harvesting. Under this condition it pays to irrigate until late in the season. The difference in the halves of six plots, one half receiving no water after August 20th and the other receiving two irrigations after this date, was one seventh of the crop, in favor of the later irrigation.

It would be difficult to designate the best variety. The various strains of Kleinwanzlebener and Vilmorin probably take precedence. The Lion Brand, Mangold and Zehringen have given excellent results.

The plots grown under the direction of this Station or on the College Farm have given large yields. The average for ten counties of the State in 1898 is given as 19.9 tons. In 1899 the averages for eight series of twelve plots each ranged from 15.3 tons to 27.7 tons per acre. The writer's experience and observation would lead him to put the average crop for this section of the State at from 10 to 14 tons, ranging from six to thirty tons per acre.

The average percentage of sugar in the beet will probably be not far from 13 per cent., taken for a series of years; the range in the different crops will be between 10 and 20 per cent.

The average coefficient of purity will be between 79 and 81; in very favorable years possibly 82, in unfavorable years 77 or 78.

The date of ripening will vary with time of planting, soil, season and treatment of the crop. The earliest harvesting of workable beets of which I have record for Larimer county is September 15th; sugar 14.71 per cent., purity 80.4.

Our experience with transplanting beets is that the beets produced are of very ill shape, but may be rich in sugar, and yield well.

The application of a liberal dressing of well rotted manure will lower the percentage of sugar and coefficient of purity a little, but the crop will be increased more than enough to compensate for this.

Beets should not be permitted to dry out after being dug, as there is a loss of sugar.

Freezing does not destroy the sugar in beets, but freezing and thawing injures the beets for sugar making.

The beet is a vigorous feeder. A crop of 14 tons of beets would remove 300 pounds of mineral matter, about one half of which, or 150 pounds, is potash, and 25 pounds is phosphoric acid. If the tops are taken off the field there will be a still larger quantity of these substances removed. The fertility of the soil may be maintained by the application of well rotted manure, and by a judicious rotation of crops.

The trimmings of the beets make good fodder for cattle. The fresh tops, however, are apt to have a laxative effect.

The dry matter in the beet pulp is of rather more value, pound for pound, than the dry matter from the fresh beet. The pulp as obtained from the silo contains 90 to 92 per cent. of water. Slight fermentation is said to improve it.

We have grown beets carrying as high as 19 per cent. of sugar in soil rich in "alkali" salts. The average percentages of sugar for the crops of 1898 and 1899, grown in such soil, were 13.65 and 15.34 respectively. The coefficients of purity were 84.6 and 80.8.

As a rule medium sized beets are richer than either small or large beets. By medium sized beets is meant such as weigh from one to two pounds. Large beets, beets weighing from two to four or even many more pounds, may be as rich in sugar and have as high a coefficient of purity as beets of one pound or less, if grown under the same conditions. If not grown under the same conditions they cannot be compared. Even big beets grown under different conditions cannot be compared. Two beets, weighing respectively 2.88 and 2.90 pounds, grown in the same plot of ground within two hundred feet of one another, but under different conditions in regard to water supply, showed 10.45 per cent. sugar, 67.0 per cent. purity, and 16.06 per cent. sugar and 85.1 purity. Big beets *may be* rich beets, the size alone is not determinative.

It has been stated that one irrigation may, under certain seasonal conditions, suffice to produce the best results in regard to crop and quality of beets. Under other conditions of the season or soil, or both, more irrigations will be necessary. The condition of the crop will determine how late in the season irrigation may be profitably practiced. If the crop has already begun to ripen either a rainfall or an irrigation which causes a second growth will prove detrimental, but if the crop is in such condition that a second growth is not produced a late irrigation may do good.

A late over-irrigation ofter does good, hastening the ripening and increasing the sugar. It has not been determined that it will uniformly produce this result. The character of the soil will probably modify the effect.

The higher parks of the State are not adapted to this culture, but good crops of rich beets have been grown in the San Luis valley at an altitude of rather more than seventy-five hundred feet.

The beet growing almost wholly under ground in this State, the loss in trimming is reduced to a minimum. Experiments indicate about 13 per cent. loss.

The amount of sugar in the crown of the beet, as it grows with us, is about one per cent. less than there is in the beet.

The cost of growing and harvesting an acre of beets will, of course, vary, but it is not far from thirty dollars per acre, exclusive of ground rent.

The growing of this crop will be more successful and the cost often materially lessened by the exercise of good judgment on the part of the cultivator. Specific rules for its culture, applicable to every case, cannot be laid down, and it must furthermore be remembered that even the very best rule can be so indifferently carried out that it may produce very poor results. No amount of experimentation can eliminate the difference between an intelligent, observing cultivator and one lacking these characteristics. Some land needs to be treated in a manner which would be wholly inapplicable in another case. Men who have tilled and irrigated their farm lands for years have learned how to treat each separate part of their farms. This knowledge is probably the secret of their success. No general statement regarding the culture of beets can be properly interpreted without taking these special facts into consideration.

INDEX.

THE COLORADO AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

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