The first issue of the Research Bulletin, published by the Research Department, is presented in the hope that the material it contains will be of interest and value to some of the men of our Company who cannot follow all of our activities in detail. We hope to present similar information at approximately monthly intervals, or whenever we have enough material of interest. The work of the Laboratory in Denver and the Experiment Station at Longmont, seed growing operations in all territories, and all experimental work carried on in the beet growing areas will be presented from time to time. In the next issue we will discuss the more recent developments in our breeding work.

H. W. D.

RESEARCH LABORATORY ACTIVITIES

A. R. Nees

ION EXCHANGE MATERIALS:

Ion exchange materials are now available which will remove practically all the inorganic and about 80% of the organic non-sugars from thin juice. The use of these products has not yet been adopted in the sugar industry, although a great deal of work has been done. It is said that one Michigan plant is putting in a complete installation. One or more others are installing pilot plants with a capacity of 100 tons of beets per day. The Research Laboratory has investigated the products of three different manufacturers and has still another brand to test. While there is some difference in the characteristics of the different materials, they all do essentially the same job. From a chemical standpoint the materials will do all that is claimed for them. The economic phases of the process are not so clear-cut. For our conditions, where there is excess Steffen capacity, as well as Johnstown, the earning capacity appears to be somewhat negative. However, it is possible that conditions might exist which would make the process economically feasible.

This is the first really radical change in the process of juice purification which has been proposed in many years. It does what every one has always wanted to do, viz., remove practically all the impurities from the juices before beginning crystallization. Results - high quality sugar, high extraction, low
molasses production. The process is very interesting and in time may find a place in the industry.

"BY-PRODUCTS" OF THE ION EXCHANGE MATERIALS:

There is one interesting possibility, a sort of "by-product" from the study of ion exchangers. A relatively small amount (about 4% on solids) of base exchanger will remove enough bases (sodium and potassium) and at the same time release enough acids to reduce the pH of 2nd press juice to the desired point without the use of SO₂. The ion exchanger can be regenerated with dilute sulphuric acid and reused. The cost will be higher than SO₂. Advantages - SO₂ free sugar, higher purity (0.1 to 0.2) thin juice due to removal of ash, increased extraction.

Some tests were made in the Laboratory during last campaign. The results were encouraging. Lack of time prevented further work.

COLLECTIVIT:

Collectivit is an activated carbon made by treating sawdust with sulphuric acid. It has both decolorizing and ion exchange properties. The Research Laboratory is at present testing out the possibility of making a satisfactory material from coal instead of sawdust. We have been able to make products which have two to three times the decolorizing power of activated carbon like Darco, and base exchange capacity equal to the best commercial products, but so far we have not been able to obtain the maximum value of both properties in the same product. This material has interesting possibilities. For example, it may be used as a base exchanger to replace SO₂ and at the same time remove color and colloids, as well as ash, and thus permit the production of SO₂ free sugar with all the other desirable properties of Bevrose A. It may also be possible to further reduce the lime addition at first carbonation to about 0.75% on beets and thus make a saving which will help to pay for the carbon.

We are determining the type of coal and methods of treatment which will give the most desirable product. Tests will be made on juices when campaign starts, with reference to the possibilities of defecation with low lime addition and the elimination of sulphitation.

SUGAR QUALITY:

Every year four samples of sugar, each representing one-fourth of the campaign production, are received from each factory for comparison of quality. During the first years these comparisons were made, the quality improved rapidly. The improvement now is much slower, not because of lack of effort, but because present quality is good enough to make further improvements difficult. Improvement in SO₂, foam test and acid turbidity is needed.
FERTILITY INVESTIGATIONS:

Work being carried out by factory chemists under the supervision of the Research Laboratory.

Soil and Petiole Analyses

To date there has been very little correlation between results of soil tests for P and NO₃ and results of petiole tests for the same constituents. Also the results of the tests to date indicate little correlation between the absolute values of the constituents named in either soil or petioles and the yield history of the fields from which samples were taken.

Some fields, with both high and low yield records, show high nitrates down to the two foot depth.

The few results on complete ash analyses received to date show no apparently significant differences between beets from high and low yield fields.

It is too early to attempt to draw conclusions today, since experience has shown us that past performance on a field too often does not predict the yield. However, there is some indication that the results this year will be similar to those of last year, wherein it was found that often the rapidly growing beets were definitely low in plant food elements.

Of the seven fertilizer plots which received heavy complete fertilizer (approximately 1,000 pounds per acre of a 10-15-5 mixture), only one is showing evidence of response today. This plot was side dressed with a hand drill shortly after the beets had germinated. On all other plots the fertilizer was broadcast before planting.

Culture Solution Experiments

Greenhouse tests on culture solution investigations are showing the primary importance of climatic factors, rather than level of available nitrogen, in determining the relative top to root development and the maturation of the beet. The value of the present indoor tests is somewhat diminished because of inability to control illumination and pests at all times in a commercial greenhouse.

The outdoor variety test is progressing excellently.

In a series of small scale pot tests it was again demonstrated that when the only acid ions present in solution were nitrate, phosphate and sulphate, growth was not as rapid as when chloride was also supplied. The addition of acetic, succinic or citric acid in place of hydrochloric acid likewise stimulated growth. Manure plus chloride gave the maximum growth rate. The value of chloride in stimulating growth had been demonstrated in previous tests on a larger scale in the culture boxes.
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ACTIVITIES

Asa C. Maxson

COOPERATIVE FERTILIZER TRIALS:

In cooperation with growers 147 fertilizer trials were planted in 1941. Each factory has several of these trials which are being supervised by the local agricultural forces.

Most of the fertilizer studies are designed to answer two questions: (1) Do our soils need a nitrogen fertilizer? (2) Can the possible denitrification of our soils, due to heavy applications of strawy manure, be corrected by using a nitrogenous fertilizer early in the season?

In these trials ammonium sulphate was used as a source of nitrogen.

Observations made about thinning time, or shortly thereafter, indicate that some of our soils are probably benefited by early applications of ammonium sulphate.

To date 28 cases have been observed where ammonium sulphate alone, or in combination with phosphate or manure, has apparently increased the growth of beets early in the season. This represents about 19% of all trials planted. The fields selected for trials are supposed to fall in the medium or low yielding brackets, therefore, the per cent of response is higher than it would be if all classes of fields were studied.

Yields and per cent sugar will be determined in as many cases as are fit for such studies.

SOIL MOISTURE STUDIES:

The seasonal movement of soil moisture is being studied in 324 fields. The Colorado and Northern districts have about 20 per factory, while each Nebraska factory district has 10 fields under observation.

In this work the Bouyoucos electrical resistance method is being used. In each field weekly moisture determinations are made at 12, 24 and 36 inches below the surface at the head of the run (upper end of field) and at the end of the run.

This work was carried on on a much smaller scale last year (1940). The results of last year's work and that of the present season indicate that this method of studying soil moisture movements may be of great value in regulating the use of water. It may also result in a considerable economy in the use of water.
That there is much to be learned before we will be able to properly interpret the instrument readings and state them in terms of water needs for all soils is quite apparent. It is hoped that our soils can be placed in large groups according to type and these types be used as a guide in determining water requirements rather than to be forced to calibrate each field or small local area.

**SINGLE SEED PLANTING:**

Single seed planting this year consists quite largely of a study of the use of the so-called "cracked seed". This cracking process, which is being developed at Davis, California, consists of separating the larger seed balls into smaller units, each carrying one, or at the most 2, true seeds or germs.

As a result of this cracking process 101.75 pounds seed was reduced into the following fractions:

<table>
<thead>
<tr>
<th>Fraction</th>
<th>% Germ.</th>
<th>Ball Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncracked</td>
<td>86</td>
<td>25400</td>
</tr>
<tr>
<td>(1) Large fractions (8/64 to 12/64 In.)</td>
<td>93</td>
<td>36000</td>
</tr>
<tr>
<td>(2) Large fractions (Light weight)</td>
<td>62</td>
<td>46000</td>
</tr>
<tr>
<td>(3) Small fractions (6/64 to 8/64 In.)</td>
<td>81</td>
<td>50700</td>
</tr>
<tr>
<td>(4) Very small fractions (1/12 to 6/64 In.)</td>
<td>84</td>
<td>57800</td>
</tr>
<tr>
<td>(5) Free seeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Screenings and Dust</td>
<td></td>
<td>28.0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>101.75</td>
</tr>
</tbody>
</table>

The germination and unit count per pound for the original seed and fractions (1) to (4) was as follows:

<table>
<thead>
<tr>
<th>Fraction</th>
<th>% Germ.</th>
<th>Ball Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncracked</td>
<td>86</td>
<td>25400</td>
</tr>
<tr>
<td>(1)</td>
<td>93</td>
<td>36000</td>
</tr>
<tr>
<td>(2)</td>
<td>62</td>
<td>46000</td>
</tr>
<tr>
<td>(3)</td>
<td>81</td>
<td>50700</td>
</tr>
<tr>
<td>(4)</td>
<td>84</td>
<td>57800</td>
</tr>
</tbody>
</table>

The study at Windsor consists of 3 plantings of (1) grade seed, using the 82 hole plate developed at Windsor and sowing at 5.43, 5.79, and 7.47 per acre.

Grade (3) seed was used with the 82 hole plate, sowing an average of 6.67 per acre (3 plots) and 6.74 (average of 2 plots) per acre.

Germination stands ranging from 23.7% to 34.3% were secured from plantings of grade (1) seed and from 32% to 36.5% where grade (3) seed was planted. These plantings were thinned in 5 ways: (1) by hand hoe; (2) cotton chopper, old 10" knives; (3) cotton chopper, new 10" knives; (4) old 6" knives; and (5) new 6" knives.

Thinned stands ranged from 108 with the hand hoe to 74.5% with 10" knives and 82% with the 6" knives. The number of single plant hills exceeded multiple plant hills in all cases.
Thinning by the cross blocking method was also studied, using 7" cut - 3" block and a 5" cut - 3" block. Thinned stands were as follows: 65% with the 7" cut - 3" block and grade (1) seed, and 54% where grade (3) seed was used. With the 5" cut and 3" block, grade (1) seed gave 89% stand and grade (3) seed gave a 94% stand. On the average, single plant hills exceeded multiple plant hills after thinning. The average percentages were 27% and 32% single plant hills for the grade (1) and grade (3) seeds and 7" cut - 3" block thinning respectively. With the 5" cut - 3" block grades (1) and (3) gave 36% and 42% single plant hills respectively.

Additional plantings were made July 29th using a different lot of cracked seed and a greater range of planting rates and additional types of distribution plates in the drills.

PLANTING METHODS:

Three planting methods are also being studied at Windsor. (1) Planting 1.5" deep and covering with 1" of soil after planting, thus having a 2.5" covering over the seed; (2) planting 2.5" deep, hoping to be able to remove 1" of soil after the seed had sprouted; (3) removing 1" of dry soil before planting, then planting the seed 1.5" deep in the bottom of the shallow furrow produced by removing the top soil; (4) ordinary ordinary 1.5" planting.

Due to abnormal conditions, such as summer planting and adverse soil conditions, further study under normal planting conditions is needed before conclusions can be drawn. At present it appears that method (3) may prove valuable in dry springs.

DISEASES:

The work of the Experiment Station on beet diseases falls under two headings: (1) Breeding for disease resistance; and (2) Determination of the cause of existing diseases and their prevention by means other than breeding.

Recent studies have shown that during the last 3 years diseases have caused almost 40% of all losses in stand after blocking and thinning.

The most active diseases are Rhizoctonia, Blackroot and Girdle scurf when named in the order of their severity.

There is some evidence that Rhizoctonia may be prevented to some extent by proper rotation of crops. It also seems probable that a strain of beets resistant to the attack of this disease may be produced by selection.

At Wheatland the possibility of reducing Rhizoctonia by seed treatment is being studied. So far there is no indication that Ceresan seed treatment has any effect upon this disease. On the other hand, when seedling losses are due largely to Phoma, treatment with this material has given very satisfactory results on a field in the Wheatland territory.
In connection with the work at Wheatland, it has been observed that there is a difference in lots of seed and the effect of Cereasan treatment. Some lots appear to carry much more Phoma than others and greater reduction in seedling mortality results when such infected lots are treated. This suggests the possibility of determining the presence of Phoma on seed and using this as a means of determining the need of treatment.

Samples of diseased beets are received throughout the season. These are examined and the cause of injury reported to the sender.

To date 26 disease samples have been studied and reported this season. The several diseases occurred as follows:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhizoctonia</td>
<td>9</td>
</tr>
<tr>
<td>Fusarium</td>
<td>8</td>
</tr>
<tr>
<td>Pythium</td>
<td>2</td>
</tr>
<tr>
<td>Phoma</td>
<td>1</td>
</tr>
<tr>
<td>Girdle scurf</td>
<td>2</td>
</tr>
<tr>
<td>Lightning Injury</td>
<td>1</td>
</tr>
<tr>
<td>Unidentifiable</td>
<td>3</td>
</tr>
</tbody>
</table>

One case of curly-top has been reported. Leaf spot is developing quite rapidly in some parts of the Great Western territory, especially in Eastern Colorado.

**INSECTS:**

Web worm infestations have been studied since 1918. It has been found that if the current year has a heavier per cent of harvested acres infestation than the preceding year, the year following will usually have a lower per cent infestation than the current one. 1940 exceeded 1939, therefore 1941 should have a smaller acreage infested than 1940. First brood figures only are available at this time.

The acreage covered by the first brood in 1941 exceeds the first in 1940 by 2840 acres. Therefore, 1941 seems to be one of the very few when the rule stated above will not hold. However, a low second brood infestation is anticipated.

Alfalfa and clover cut worms appeared in rather large numbers this spring. The alfalfa web worm was reported on 284 acres in the Lovell district.

Pyrocide and a new type of Paris Green have proven effective against the sugar beet web worm. The latter is somewhat stronger than the ordinary Paris Green and promises to reduce the cost of spraying, since a smaller quantity per acre can be used.
PRE-HARVESTING SAMPLING

H. E. Brewbaker and H. L. Bush

A new method for securing pre-harvest estimates of yield and per cent sugar has been developed at the Great Western Experiment Station and will be tried out in Northern Colorado and part of Nebraska this fall. This method presumes complete randomization of the samples to be taken, the actual yields and sugars to be reported as taken for each field.

Fields will be sampled on the basis of 100 farms per 10,000 acres of beets, 2 samples being taken at pre-determined locations in the fields chosen for sampling. Samples will be taken at two dates a little over two weeks apart in September. The change recorded for this period will provide some basis of estimate for the anticipated change during the harvest period.

The method, as outlined, is based on sound sampling principles such as used by the United States Government in wheat forecasting, and modern polls of public opinion, and it is confidently anticipated that they will prove useful in this attempt to estimate with considerable accuracy the bags of sugar which may be harvested.

EXPERIMENTAL DESIGNS INCREASE ACCURACY

H. L. Bush

In the past agricultural field experiments which were conducted to compare different varieties or fertilizers or other variations in cultural practice often gave unsatisfactory results.

Statistics was long regarded as a branch of economics and it was not until about 30 years ago before much attempt was made to apply statistical analysis to biologic data. In 1912 Dr. R. A. Fisher, who was then at the Rothamsted Experimental Station in England, published "On an absolute criterion for fitting frequency curves". He had several publications in the intervening years, but it was the ideas contained in his book "Statistical Methods for Research Workers", first published in 1925, which has laid the groundwork for modern statistics. Dr. Fisher says that the average values or variations in themselves are not so important as the cause of those variations.

With Dr. Fisher's ideas as a basis, progress has been rapid in the application of statistics to the various phases of biology. Types of improved designs recommended have changed rapidly as mathematicians have evolved proofs for the various theories advanced. These theories have all been based on the theory of random sampling and the variance of the mean values of the samples from the Normal Distribution. The simplest scheme is the replicated block design. In this case
one of each of the varieties or treatments is assigned at random to equivalent plots which together form a compact block. Each complete replication constitutes a block and it is a requirement that the size of the block be kept within such limits as to insure uniform conditions within the block. It has been the chief aim of statisticians to evolve designs whereby these blocks could be maintained at a sufficiently small size so that uniformity would exist within the block and still maintain a valid estimate of the variation between samples where a large number of varieties or treatments must necessarily be included in one replication. The result has been that there are now reliable types of designs available to statisticians in all phases of work, as well as in the field of biology.

An attempt has been made at the Great Western Experiment Station to make use of these newer designs as they have been evolved, so that we might gain the maximum precision in our results. The newer designs are known as "Quasi-factorials" and there are several such designs available. Such designs are especially adapted in our work to variety testing, since we must test a large number of varieties at two or more locations, which makes it imperative that we use an experimental design whereby we can test a variety at as many locations as possible with a minimum of expenditure of funds. Justification for the use of these designs is shown by the fact that our 1940 Variety Test results at four locations show an increase in precision in yield estimate of from 9% to 87% with a mean of 35%. In other words, 35% more information was gained for the same expenditure of funds than if an older design had been used. A newer method of calculation has just recently been evolved whereby we should show an even greater precision in our results.

LEAF SPOT OBSERVATIONS

September 9, 1941

During the past week Mr. Maxson and the writer observed leaf spot conditions in many fields in the Sterling, Brush, Fort Morgan districts, and in the McCook, Nebraska area. The latter area has had a rather severe attack, but on September 5th most of the fields were recovering and there was not much evidence of new attacks, either there or in the Sterling territory. A certain proportion of partially resistant seed was used in eastern Colorado and it is quite evident that this is reducing the severity of attack. The more resistant individuals in the field are lightly attacked, while the more susceptible individuals show rather severe burning. As usual, the disease has done the most damage in second year beet fields and in fields not far from streams, where humidity conditions are favorable.

Mr. Maxson reported only light leaf spot in the Nebraska district on August 29th. There may have been some further development since that date. Up to the present time the Sterling district has more of the disease than any other territory. Northern Colorado has many scattered fields with more or less leaf spot.

H.W.D.
The 1941 crop of Great Western seed is now being cleaned in Arizona, New Mexico and Northern California. Threshing of seed is still in progress in Oregon. The crop is good as to germination and there is a normal yield per acre. Yields in Arizona were somewhat reduced by a series of heavy showers, while 800 acres had seed lying in the windrow. The total crop is estimated at about 3,700,000 pounds. This will give us nearly two years' requirements on hand this fall.

Acreage for next year is being increased in order to meet any possible demands resulting from increased beet acreages. The following acreages are now planned, although we are not sure that we will secure all of the desired acreage in Oregon.

<table>
<thead>
<tr>
<th>State</th>
<th>Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>2600</td>
</tr>
<tr>
<td>New Mexico</td>
<td>375</td>
</tr>
<tr>
<td>Oregon</td>
<td>750</td>
</tr>
<tr>
<td>Colorado (Windsor Farm)</td>
<td>250</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3975</strong></td>
</tr>
</tbody>
</table>

Varieties being planted are predominantly G.W. 1053 and G.W. 49, both excellent tonnage varieties. Approximately 200 acres of G.W. 8, a variety with similar leaf spot resistance to G.W. 9, and better tonnage performance than the latter, is being planted for use in leaf spot areas. 32 acres of G.W. 1078 is being planted in New Mexico in order to supply future planting stock and also to have available for areas subject to severe leaf spot attack, such as the McCook area. This variety is the most promising resistant variety we now have in sufficient volume to make a large commercial increase. It is being very thoroughly tested for performance in the "General Variety Test" in the four states in which we operate, and in the Brush field it is showing fine leaf spot resistance. It is hoped that in the fall of 1942 either G.W. 1078 or a highly resistant sister variety may be multiplied to the extent of several hundred acres.

Up to the present time our resistant varieties have been very poor seed producers in Arizona and show a definite need for a colder winter. We can doubtless overcome this undesirable character by planting these particular varieties in Oregon.

The matter of poor seed production from Great Western varieties grown in the Southwest is one which has given us considerable concern for the past four years. Our high tonnage types include among their other characters the character of late and incomplete bolting under mild winter conditions and this very materially reduces the average yield of seed per acre in certain years. All of the U.S. curly top varieties show the characters of early and complete bolting, giving good seed production, but in turn they give very much less tonnage per acre.
of commercial beets than do our G.W. varieties. The same trend is shown by American Crystal No. 1, which is a splendid seed producer, but does not give satisfactory tonnage when tested in Northern Colorado. One of our varieties, G.W. 2, is an excellent seed producer in the Southwest, but we are not fully satisfied with its tonnage performance. This fall we plan to make a definite selection for tonnage types from this variety to see if we can build up tonnage while still retaining the character of good seed production. We are also making a careful comparison of the seed producing ability of varieties G.W. 1053 and G.W. 49 by growing them in replicated seed plots in Arizona. Varieties of the other companies interested in the Western Seed Production Corporation will also be under observation in the same field.

H.W.D.