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CARSNER, E.

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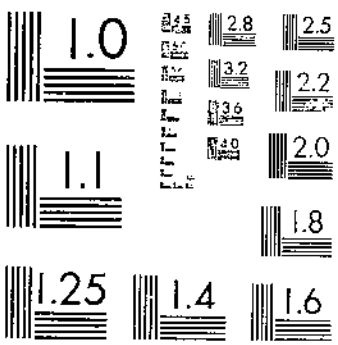

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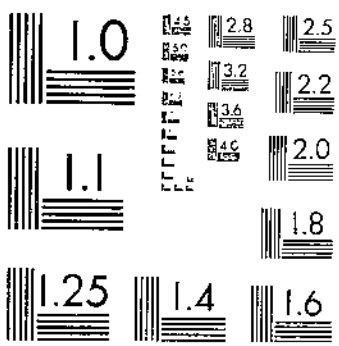

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TECHNICAL BULLETIN No. 360 MAY 1933

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

CURLY-TOP RESISTANCE IN SUGAR BEETS AND TESTS OF THE RESISTANT VARIETY U. S. No. 1

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CONTENTS

INTRODUCTION [2]

ECONOMIC IMPORTANCE OF CURLY TOP

Curly top of sugar beets (*Beta vulgaris* L.) was first recognized as a disease of major economic importance in 1899, in California. Since that time frequent and often very destructive outbreaks have occurred in practically all the sugar-beet areas west of the Rocky Mountains, except a few districts in the fog belt along the Pacific coast. Its occurrence in serious amounts east of the Continental Divide has apparently been restricted to certain sections in the Southwest, such as New Mexico, western Texas, and southern Colorado. The beet areas in northern Colorado east of the Rocky Mountains, as well as those in Nebraska, Kansas, Wyoming, and South Dakota, have been free from the disease or have shown only sporadic

[1] These contributions were made by F. A. Abegg, associate geneticist; O. E. Cormany, associate agronomist; H. A. Elcock, assistant pathologist; Wesley Keller, agent; C. J. Lowe, assistant agronomist; F. V. Owen, geneticist; D. A. Pack, associate agronomist (resigned, Nov. 30, 1929); Charles Price, associate agronomist; and A. W. Skuderna, principal agronomist. Responsibility for the various contributions is indicated in the respective sections. The agronomic tests in California, Idaho, and New Mexico were carried on under the general supervision of A. W. Skuderna. Acknowledgment is made to G. H. Coons, principal pathologist, for assistance in the preparation of the manuscript.

[2] Contributed by Eubanks Carsner.

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incidence not serious in amount. In the regions where it occurs as epidemics curly top is the most destructive of all beet diseases. In several of the important agricultural districts west of the Rocky Mountains this disease is the principal factor limiting the beet crop. Curly top is a virus disease. The causal virus is transmitted by the beet leaf hopper, *Eutettix tenellus* (Baker). The geographic distribution of the disease is therefore the same as that of the insect vector.

Investigators have emphasized direct financial losses due to curly top. Adequate recognition should be given also to the effect on western agriculture of the abandonment of the sugar-beet crop in large areas. The sugar beet is generally recognized as an important and valuable crop in the agricultural system for these regions, not alone because it is an intensively cultivated cash crop, but because through its valuable by-products, namely, beet pulp, beet tops, and

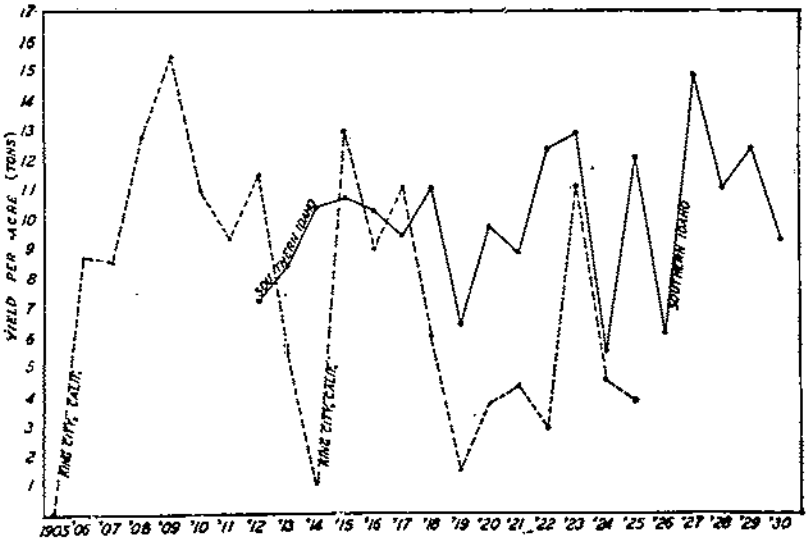

FIGURE 1.—Average yields of sugar beets in tons per acre for 1905–1930 in the King City district of California and in southern Idaho. The serious decreases in yields were caused by curly-top injury

beet molasses, it fosters the dairying and stock-feeding industries. Control of the curly-top disease will contribute greatly to a stabilization of sugar-beet growing in large areas where it is now continually menaced, and will thus have far-reaching effects upon the general farm situation in the West. If curly-top control is assured, it will be possible for the beet-sugar industry to return to districts previously abandoned because of curly top; and it will bring about, as economic conditions warrant, expansion into regions heretofore avoided because of the curly-top hazard.

Figure 1 shows the average yields of sugar beets in tons per acre for a series of years in two representative western areas where curly-top outbreaks have occurred, namely, King City, Calif., and southern Idaho. This chart indicates the decrease in yields in years of serious outbreaks and the potential production if this disease factor is over-

come. In the California district, for example, in the years 1909, 1912, 1915, and 1917, which were relatively free from curly top, the average yields were 15.6, 11.5, 13.0, and 11.3 tons per acre, respectively, in contrast with the disastrous curly-top years 1914 and 1919, when the yields were 1.0 and 1.4 tons per acre, respectively. Similarly, in southern Idaho, such years as 1923, 1925, 1927, and 1929, relatively free from curly top, and with average yields of 12.9, 12.1, 14.9, and 12.4 tons per acre, respectively, may be contrasted with the years 1924 and 1926, in which serious curly top occurred and in which the yields were 5.5 and 6.0 tons per acre, respectively. It must be remembered that even in the years classed as "relatively free from curly top" the disease caused an economically significant degree of crop reduction.

METHODS OF CONTROL

CONTROL OF THE BEET LEAF HOPPER

When it was shown that the beet leaf hopper is probably the sole natural agency of transmission of the curly-top virus, the control of the insect was suggested as a means of preventing or mitigating curly-top damage. Extended entomological research has been conducted in the effort to effect control of the insect. Attacks on the leaf hoppers with insecticides and mechanical means have, in the past, been conducted mainly in sugar-beet fields. Such methods, however, have not proved very effective in reducing curly-top damage.

The problem has also been approached, in recent years, from the standpoint of insect ecology, with the result that intensive research has developed a body of knowledge on the factors influencing the size of leaf-hopper populations in the fall, their survival through the winter, the spring increases, and the migration period (*6*).[3] From such data and from past records of beet production it is possible to predict the probable populations in the spring and the period of migration, in certain areas intensively studied. Such predictions have been valuable in making it possible to avoid planting beets in years of heavy leaf-hopper influx.

Related to this phase of control is the study of the plants that harbor the insect in the natural breeding grounds. The beet leaf hopper has been found to be strongly influenced by introduced weeds now established on the abandoned farms and in desert areas surrounding those now cultivated; this flora determines in large measure the distribution and size of populations of the insect. Reduction of the weeds in which the beet leaf hopper multiplies and which are otherwise objectionable is a procedure obviously commendable aside from its bearing on curly-top control. The possibility of developing beneficial practices through an ecological study of the weed hosts of the insect was pointed out by Carter (*6*). A study of the plant successions in these natural breeding grounds by Piemeisel (*12*) has indicated the possibility of replacing the introduced plants with the natural vegetation, which is less favorable for the leaf-hopper populations.

[3] Italic numbers in parentheses refer to Literature Cited, p. 68.

CULTURAL PRACTICES

In addition to the general measures, which involve large areas and are necessarily slow and gradual in their influence, various cultural practices are definitely applicable to curly-top control.

Of these cultural practices the most important is timing the planting of the beets so as to get the crop advanced as far as possible before the spring influx of the beet leaf hopper. In California, Idaho, and Utah such procedure has resulted in great benefit. Associated with this measure are other desirable agronomic practices, such as the effective use of irrigation water and the application of necessary fertilizers. In general, it has been found that fields in which the size and vigor of the plants have been increased by early planting and excellent cultural practices have suffered less damage than fields in which the plants were very young or in an unthrifty condition at the time of the leaf-hopper influx.

All the measures mentioned, however, are to be regarded as palliative rather than as affording a completely satisfactory control. Nevertheless, for the present at least, it is urgent that all helpful practices be continued because of their contribution to the lessening of the injury from the curly-top disease.

USE OF RESISTANT VARIETIES

The use of resistant varieties for the control of plant diseases has long been recognized as a very desirable measure and the one to be preferred where sanitation or modified cultural practices fail to give adequate relief. In the case of curly top this method of control appears to have been the first one considered. The progress heretofore made in the development of resistant varieties may be briefly reviewed.

Townsend (*14*) began selecting sugar beets for resistance to curly top in 1902. His efforts were handicapped because the relationship of the beet leaf hopper to the disease had not then been demonstrated and therefore no way of insuring exposure of the plants to the disease was known. In one trial, however, in 1907, he reports evidence of an appreciable degree of resistance in the progeny of plants selected for resistance, as compared with 25 other varieties. The work along this line was interrupted, and no further progress was reported.

Carsner (*5*) reported selection efforts that were begun in 1918 and continued through the season of 1925. Primary emphasis was placed on securing beets resistant to the disease in the hope that, if such plants were found or developed, the required quality as to sugar content could, if necessary, be later secured by breeding. Strains varying from a moderate to a very high degree of resistance were obtained, and the fact was demonstrated that resistance to curly top is a heritable character. The extremely resistant strains proved to be very low in sugar content. No further data have been presented, but in the report of the Chief of the Bureau of Plant Industry (*13, p. 18*) issued December 3, 1929, the following statement appears: "Extensive tests demonstrated that some varieties of beets sufficiently resistant to give good yields in spite of curly top are also satisfactory from the standpoint of sugar content."

Esau (*8*) reported work on selection and breeding for curly-top resistance that had been carried on continuously from 1919 to 1929.

A strain derived from a resistant mother beet isolated in a cloth cage in 1920 was subjected to repeated tests for resistance, and attempts were made to improve it and purify it by repeated reselection. The fact was conclusively demonstrated that this strain was highly resistant and that this character was inherited. The strain was not found satisfactory for commercial use, but its value for breeding purposes was recognized. It was hybridized with another highly resistant strain (obtained from Carsner) and also with a strain (obtained from Pack) which was of high sugar quality but not highly resistant. The results indicated possibilities of progress through breeding. Mass-selection studies also demonstrated the possibility of developing by this method varieties sufficiently resistant to afford very substantial increases in yield over susceptible commercial brands. The sugar percentages in these varieties were practically the same as that of the commercial variety used for comparison. Their total sugar content was of course much greater.

Coons, Stewart, and Elcock (7) reported progress in work on the selection of resistant sugar beets and the use of such individuals either to develop inbred lines or to produce seed by being planted in groups. Progenies obtained by the latter method (mass selection) produced more than three times the yield of the commercial variety under curly-top conditions, but were regarded as not yet sufficiently resistant for commercial use under severe conditions. These investigators also reported results obtained from numerous European collections of the wild beet (*Beta maritima* L.). Individuals of *B. maritima* were found which were so nearly immune to curly top as to make it very difficult to detect symptoms on them and which were also acceptable as to percentage of sucrose. These highly resistant individuals were crossed with high-grade nonresistant commercial beets, and the hybrid material was tested. In one test the hybrid yielded approximately eight times as much as the commercial brand used as a check.

DEVELOPMENT OF RESISTANT VARIETY U. S. NO. 1[4]

This report on curly-top resistance in sugar beets as a control measure represents a continuation and expansion of the effort begun in 1918. As previously noted, the results up to 1926 have already been published. In the present report evidence is presented of an important advance in the development of a commercially desirable variety resistant to curly top (U. S. No. 1); but a very resistant variety of as high quality as is desirable has not yet been obtained, though further improvement may be expected from continued effort in this direction. From 1926 to 1929 the work was carried on through the cooperation of the contributors of this section. In 1929 the staff of investigators was enlarged and reorganized. Most of the additional workers have contributed parts of this report. The various phases of the resistance project are being continued by the several groups of workers. Selection and breeding for further improvement are being pushed by the geneticists; the agronomists are conducting the critical evaluation of the resistant varieties and studying the factors

[4] Contributed by Eubanks Carsner and Dean A. Pack.

involved in growing the seed; and the pathologists and the chemists are studying the nature of resistance in the sugar beets. Progress is being made also on an analysis of the basic physiological factors involved in seed production.

The U. S. No. 1. variety [5] is not the only resistant material that has been selected and studied in the course of the present investigation. Several lines selected from strains that were combined to produce the present variety appear to be equal or superior to it. The variety discussed herein was developed by a combination of the most promising strains available in 1928. It was thus produced as quickly as possible in order to meet promptly the emergency in the industry due to curly top and in the hope that it would afford a measure of control while resistant varieties superior to it were being developed. Because this is the first resistant variety to be released by the United States Department of Agriculture for commercial use in the curly-top areas, it has been designated "U. S No. 1."

The selections combined to produce the U. S. No. 1 variety were obtained mainly from a field of resistant strains grown at Twin Falls, Idaho, in 1928.[6] This location was chosen in order that the plants might be naturally exposed to curly-top infection. The chief purpose of the planting was to obtain from the available seed the greatest possible number of plants for extensive and critical reselection. Accordingly, men were employed to plant the seed by hand in order to spread it farther than would have been possible by the use of the beet drill. A total area of slightly over 5 acres was used for the planting. As a measure of the degree of curly-top exposure, eight 4-row plots running the full length of the field were drilled in with a commercial brand of seed. The degree of disease exposure obtained is indicated by the fact that the average yield from the test plots of the commercial brand was slightly less than 12 tons per acre as compared with a commercial yield from the same field in the preceding year of 25 tons per acre.

Included in this 1928 planting at Twin Falls were all the resistant strains and hybrids then available. Some of these, while extremely resistant, were too low in sugar content to be commercially satisfactory. They were included for selection purposes in connection with the continuing breeding program, but none of the roots selected from these strains was included in the seed-beet field of 1929, where the initial lot of seed of the U. S. No. 1 variety was grown. The history and description of the strains used to produce the U. S. No. 1 variety are given later.

The selections of resistant strains at Twin Falls were made at harvest time, October, 1928.[7] Plants were chosen first which were of satisfactory root shape and which on the basis of root size and foliage reaction appeared most resistant. The roots thus selected in the field were taken to the laboratory and individually tested by means of

[5] The term "variety" is used in conformance with common usage in sugar-beet publications and indicates in this paper a complex combination of sugar-beet types chosen on the basis of curly-top resistance and commercial qualities. It does not imply the distinct morphological uniformity which characterizes taxonomic or horticultural varieties.

[6] Albert M. Murphy, Scientific Aide, Division of Sugar Plant Investigations, assisted with the field work at Twin Falls.

[7] Thanks are due Walter Carter, at that time senior entomologist, Division of Truck Crop Insects Bureau of Entomology, for assistance in the fall and winter operations.

the refractometer. Of the 9,051 roots tested, 5,811 were retained, those reading lowest in percentage of dry substance being rejected. Of the roots saved, those which gave the higher refractometer readings were analyzed by means of the polariscope; approximately 400 beets were thus selected for further breeding work.

STRAIN 5001

Of the selected roots entering into the planting that produced the U. S. No. 1 variety, the largest lot was obtained from the strain designated in the field notes as 5001. This strain was derived from an extensive mass selection made from severely affected fields in Idaho and Utah during the curly-top epidemic of 1926. Approximately 1,500 individuals were selected on the basis of resistance and root shape, and these were planted in large groups for seed production in 1927. Strain 5001 constituted approximately one-fourth of the resistant strains planted at Twin Falls in 1928. It was thus possible to make extensive selections from this strain.

WASHINGTON STRAIN

The next largest component of the U. S. No. 1 variety was the selection termed in the writers' notes "the Washington strain." This strain was derived from a relatively large primary mass selection made from commercial fields in the Yakima Valley, Wash., in 1923, by employees of the Utah-Idaho Sugar Co. under the direction of the company's district manager, J. W. Timpson. Under the same auspices, seed was grown from the selected roots at Toppenish, Wash., in 1924. A test of the progeny of this primary selection, as conducted at Riverside, Calif., in 1925, has been previously reported (*5*). The selections from the Riverside plots reported on here, 37 roots, were planted in a group in November, 1925. Six of the thirty-seven plants produced seed in 1926.

In connection with tests of other strains at Riverside in 1927,[8] resistance tests were made on seed from the six mother beets that bloomed in 1926. The seed was planted in single-row plots 50 feet long, alternating with check plots of a commercial brand. For one of the Washington selections there was only one plot; for four of them there was enough seed for duplicate plantings; and for one there were three replications. The beets were inoculated by caging two viruliferous beet leaf hoppers on each plant soon after thinning. At harvest the Washington selections gave average yields ranging from 69 to 102 pounds per plot, the average for the 12 plots being 81 pounds per plot. The average yield from 75 commercial check plots was 39 pounds per plot. As calculated on an acre basis, the Washington selections yielded 17.6 tons per acre; the commercial brands, 8.5 tons per acre. In the Washington plots practically no plants died after thinning, whereas 23 per cent of the commercial plants died. Curly top undoubtedly was the main factor responsible for this result. No sugar determinations were made of the commercial brand used as a check, and of the resistant strains only those roots were analyzed which had been selected for resistance. Since the

[8] Acknowledgment is due Charles F. Lackey, assistant pathologist, Division of Sugar Plant Investigations, for assistance with the experimental work at Riverside, Calif.

roots were selected mainly on the basis of size, their sugar content may have been somewhat lower than that of the beets in the plots as a whole would have run. Approximately one-third, or 213, of the Washington beets were analyzed. The six lots averaged from 13.9 to 17.0 per cent sucrose, the general average being 15.1 percent. The plants of the Washington strain in these and subsequent tests had predominantly dark-green foliage. This characteristic is useful in identifying the strain.

The group of old mother beets selected in 1925 was maintained in the same place for seed production a second year. A sufficient number of plants survived the second year to make it possible to obtain seed from 14 separate mother beets in 1927, including some that had produced seed in 1926. These lots of seed were included in the 1928 planting at Twin Falls, Idaho. Three random agronomic samples from the Washington strain at harvest, 22 roots in all, gave an average weight of 2.04 pounds per beet and an average sucrose percentage of 17.1 per beet. Three comparable samples from the commercial checks, 21 roots in all, gave averages of 1.5 pounds in weight and 16.9 per cent of sucrose per beet.

905a2 STRAIN

Another strain used in producing the U. S. No. 1 variety was the inbred line 905a2. This strain was derived from a mother beet selected by Eubanks Carsner and C. F. Stahl, entomologist, Division of Truck Crop Insects, Bureau of Entomology, from a severely exposed field of the Spreckels Sugar Co. at King City, Calif., in September, 1922. Progenies from this selection and from group plantings of subsequent reselections were tested for resistance at Riverside. In these tests, in addition to exposure by natural infestation, viruliferous beet leaf hoppers were caged on each plant. During one severe season of curly top (1926) small tests were made by natural exposure at Twin Falls, Idaho, and at Salt Lake City, Utah. This strain (905a2) consistently showed a higher sugar content than had previously been found in resistant beets, averaging about 16.5 per cent, and maintained its resistance to curly top despite loss of vigor from inbreeding. The strain possesses genetic factors that produce in many of its individuals a red stripe in the center of the upper side of the petiole. This character appears frequently in the U. S. No. 1 variety and is useful in identifying the latter. The 905a2 strain shows also an inherent tendency to bolt, that is, to develop seed stalks the first season, somewhat more readily than most commercial brands of sugar beets.

905a2 HYBRIDS

Next in order of importance among the strains combined in the U. S. No. 1 variety were several first-generation hybrids between 905a2 and other strains. The three principal hybrids resulted from crosses between 905a2 and three lines selected for high sugar quality without regard to curly-top resistance. The hybrids were 905a2 × 6A7, 905a2 × 6–4–6, and 905a2 × 202. Two other hybrids, namely, 905a2 × 7489–24 and 905a2 × 6193–24, were included in comparatively small numbers. The strains 7489–24 and 6193–24 were derived by reselection from strains first selected in northern Colorado by W. W.

Tracy, jr., formerly of the Division of Sugar Plant Investigations. Subsequent tests at Riverside and elsewhere had shown that these strains were somewhat resistant to curly top

OTHER STRAINS INCLUDED

Three other strains were combined in the U. S. No. 1 variety. These were 6677–24, 3929, and the one designated as De Rekowski. The De Rekowski strain was originally obtained by a small-scale mass selection (17 beets) made by officials of the Amalgamated Sugar Co. at Twin Falls, Idaho, in the autumn of 1924. The roots were sent to Charles W. de Rekowski at Detroit, Mich. Some of the seed produced there from these beets was sent by De Rekowski to the Riverside station. By running this strain through another generation a limited amount of seed was available for inclusion in the 1928 planting at Twin Falls. Strain 3929 resulted from inbreeding the progeny of one mother beet out of 112 beets selected for resistance at Twin Falls in the autumn of 1924. Strain 6677–24 was developed by W. W. Tracy, jr., at Fort Collins, Colo., and was later found to be somewhat

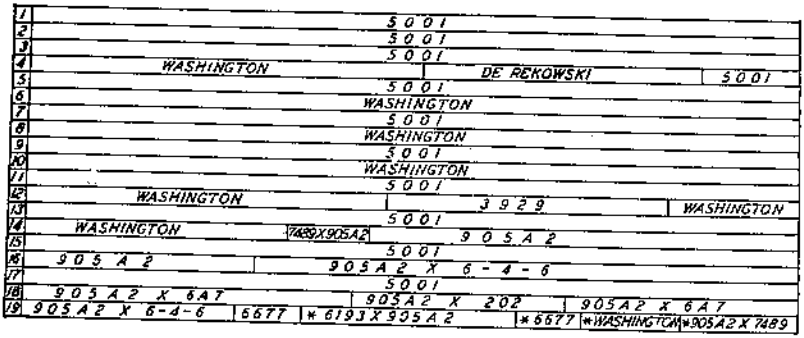

FIGURE 2.—Diagram of mother-beet planting in block A of seed-beet field at Twin Falls, Idaho, in 1929, from which the original seed of the U. S. No. 1 variety was obtained. Each horizontal line represents a row approximately 500 feet long. Rows marked * were planted with the roots from Riverside

resistant to curly top. This strain was not included in the 1928 planting at Twin Falls, but it was planted that same year under more drastic curly-top exposure at Castleford, Idaho. A small number of selected roots from that planting were included in the 1929 seed field which produced the seed of the U. S. No. 1 variety.

As shown in the chart (fig. 2), four small lots of roots grown at Riverside, Calif., during the winter of 1928–29, were also included in the seed field at Twin Falls. The relative proportion of the various strains combining to produce the U. S. No. 1 variety and their distribution in the seed-beet field are indicated on this chart. Slightly more than 4,500 mother beets were included in the plot. Of these, about 2,500 were of the strain 5001; about 1,200 were of the Washington strain; and the other strains were represented in smaller proportions.

The seed from this group planting at Twin Falls, in 1929, constituted the original seed supply of the U. S. No. 1 variety. With seed of this original lot agronomic evaluation tests were conducted on a comparatively limited scale in three localities in 1930. The results of these tests are reported in other sections of this bulletin.

An augmented supply of seed of the U. S. No. 1 variety was produced in 1930 by the overwintering-in-the-field method of seed growing developed by the United States Department of Agriculture (*11*). The production of this seed was carried out by H. A. Elcock and J. C. Overpeck, at State College, N. Mex.; by Charles Price, at Beaumont, Calif.; and by F. V. Owen and D. A. Pack, at St. George, Utah. The increased amount of seed of the variety made possible extensive agronomic evaluation tests in 1931. Critical tests were conducted in controlled agronomic plots, and plots known as grower-test plantings were planted in the fields of farmers. The localities chosen for these tests were distributed throughout the curly-top areas in Idaho, Utah, Colorado, California, and New Mexico. This distribution afforded a wide range of soil and of climatic and cultural conditions, as well as of degrees of disease exposure. The distribution of the places where the testing was conducted is shown in Figure 3. The detailed results of these tests are reported in the following sections of this bulletin.[9]

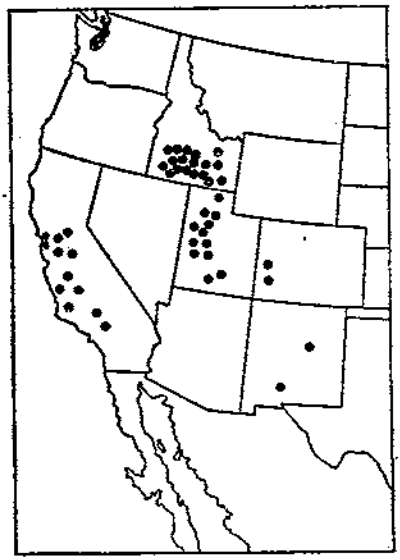

FIGURE 3.—Location of test plantings of the U. S. No. 1 variety, in 1931, in Idaho, Utah, Colorado, California, and New Mexico

EVALUATION TESTS OF RESISTANT VARIETY U. S. NO. 1

TESTS IN IDAHO [10]

In Idaho agronomic tests were made to determine the performance of the U. S. No. 1 variety of sugar beets as compared with that of the commercial brands commonly used in the Idaho area. The tests were of three types: (1) Intensive agronomic tests on small plots replicated many times; (2) grower-test plantings, made under ordinary field conditions; and 3) comparative studies of the rate of development of the resistant and susceptible plants.

INTENSIVE AGRONOMIC TESTS

TESTS AT CASTLEFORD

In 1930 intensive agronomic tests of the U. S. No. 1 variety were begun on the experimental farm at Castleford. In these tests the original seed stock obtained from selected mothers (p. 5–9) was used. The tests were continued at Castleford in 1931 with the first multiplication of the original seed (p. 9).

The experimental farm at Castleford was selected [11] for the intensive agronomic work because of the long history of sugar-beet failures in this district. The farm chosen had not produced a profitable crop of

[9] Details as to materials and methods, where these were identical in several consecutive sections, have not been repeated.

[10] Contributed by C. E. Cormany and C. C. Lowe.

[11] The experimental work in the Castleford and Twin Falls area was carried on in cooperation with the Amalgamated Sugar Co., which provided land and other facilities for these experiments.

sugar beets during recent years, and sugar-beet growing had been almost entirely abandoned by the farmers in the Castleford area as being too hazardous because of the curly-top menace. In 1930 and 1931 conditions in the Castleford district fully conformed to past experience. Nearly maximum curly-top exposure was obtained in 1930; in 1931 curly top, while not doing maximum damage, seriously affected the beet crop.

In 1930 the U. S. No. 1 variety was planted on the experimental farm in six plots, each four rows wide and 90 feet long, alternating with similar plots of a commercial brand (Pioneer).[12] These plots were part of a large series planted with different varieties and strains in systematic replications. As has been noted, 1930 was one of the most severe curly-top years experienced in Idaho; the Castleford district, being close to the breeding areas of the insect, was particularly affected. The plots of resistant sugar beets were conspicuous in the latter part of the season as islands of dark-green growing plants

FIGURE 4.—Curly-top-resistance tests in agronomic plots at Castleford, Idaho. At the left in the foreground (plot 1703) are four rows of the U. S. No. 1 variety. Adjacent to this on the right (plot 1704) are four rows of the commerical brand (Pioneer) which are continuous through the field. The photograph shows also replicated plots of the U. S. No. 1 variety and those of three other resistant strains being tested. Photographed September 19, 1930

(fig. 4.) surrounded by plots of dwarfed yellowish-green plants of the commercial brand. Although there was evidence of practically 100 per cent infection in the plots of the U. S. No. 1 variety and the disease had killed or rendered worthless a certain percentage of the plants, those which remained showed definite curly-top resistance.

The somewhat unfavorable soil conditions in the experimental field and the late planting undoubtedly affected yields and sucrose percentages of both the resistant variety under test and the commercial brand used as a check; these conditions, on the other hand, provided as severe a curly-top test as could be desired.

The results here given as averages (Table 1) were overwhelmingly in favor of the resistant variety (U. S. No. 1) in yields of beets and of sugar per acre, and demonstrated the curly-top resistance of the variety as a whole. It is evident, however, that the variety does not consist of uniformly reacting individuals but of individuals of various degrees of resistance. The average sucrose percentage and coefficient

[12] Produced by the Kleinwanzleben Zuckerfabrik, Kleinwanzleben, Germany.

of purity, obtained in the comparative analyses, were likewise in favor of the U. S. No. 1 variety.

TABLE 1.—*Comparison of the U. S. No. 1 variety with a commercial brand (Pioneer), planted April 22, 1930, at Castleford, Idaho*

[Data represent averages from 6 plots, each 90 feet long and 4 rows wide]

Variety	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre	
				Gross [1]	Indicated available [2]
	Pounds	*Per cent*		*Pounds*	*Pounds*
U. S. No. 1	10,930	13.53	88.78	1,479	1,313
Commerical (Pioneer)	1,930	11.55	83.38	224	187
Difference	8,991	1.98	5.40	1,255	1,126
Odds of significance [3]	[4] 1,572:1	[4] 2,499:1	[4] 158:1	[4] 1,249:1	[4] 1,188:1

[1] Gross sugar per acre=yield per acre (in pounds) × sucrose percentage.

[2] Indicated-available sugar per acre=$\frac{\text{yield per acre (in pounds)} \times \text{proportional-value coefficient}}{100}$.

(Proportional-value coefficient=$\frac{\text{sucrose percentage} \times \text{coefficient of apparent purity}}{100}$).

[3] Determined by Student's Method (*1, 2*); odds of 30 : 1 are considered significant.

[4] Odds of significance in favor of the U. S. No. 1 variety.

In obtaining these data, each plot was harvested and one 10-beet sample was taken at random for determining sucrose and purity. The determination of the coefficient of apparent purity was made in the standard manner (*4*), and the sucrose percentage was computed by multiplying the amount of sucrose in the juice by 0.95, to allow for an assumed marc of 5 per cent.

In 1931 a test was conducted at Castleford for the purpose of comparing the three seed increases of the original U. S. No. 1 selection with two standard commercial brands. The seed of the U. S. No. 1 variety was produced at Beaumont, Calif. (A); St. George, Utah (B); Las Cruces, N. Mex. (C); the seed of the commercial brands used, namely, Old Type (D)[13] and Pioneer (E),[13] was ordinary commercial seed. The plots were arranged in a Latin square so that the comparative data on yield, sucrose percentage, coefficient of apparent purity, and sugar per acre might be subjected to statistical analysis (*9*).

On April 11, 23 pounds of seed per acre was planted in plots, each $\frac{1}{96.6}$ of an acre in harvestable area and consisting of eight rows 22 inches apart, replicated five times in restricted random arrangement. The inner six rows of each plot were harvested October 19 on a normally competitive-beet basis,[14] and the data were computed on the basis of a 100 per cent stand of beets. Determinations of sucrose percentage and of the coefficient of apparent purity were made on three 20-beet samples of normally competitive beets from each plot. Sucrose was determined by the Sachs-Le Docte cold-water-digestion method. The coefficient of apparent purity was determined from the Brix reading of the expressed juice and the saccharimeter reading of sucrose in the clarified, undiluted juice by means of Schmitz's tables (*4*). The data (Table 2) have been analyzed according to accepted

[13] Produced by the Kleinwanzleben Zuckerfabrik, Kleinwanzleben, Germany.

[14] By "normally competitive beet" is meant a beet which has grown surrounded on all four sides by beets at approximately the right distance to conform to the requirements of the test. The value for weight per beet has been computed from the data from the competitive-beet samples, and this value multiplied by the appropriate number of beets per acre has given the value for yield in terms of 100 per cent stand for beets under the conditions of the experiment.

statistical methods, and the value of z has been used as a convenient measure of the significance of the test for the attribute measured. In all cases in which the value of z equaled or exceeded either the 5 per cent or the 1 per cent point as given in Fisher's tables (*9*), the standard errors of the means have been computed in order to determine the difference required for significance.

TABLE 2.—*Comparison of three increases of the U. S. No. 1 variety with two commercial brands, planted April 11, 1931, at Castleford, Idaho*

[Data represent averages of five plots, each $\frac{1}{160}$ of an acre in area and consisting of the six inner 22-inch rows of the original plot]

Variety	Yield		Sucrose [1]	Coefficient of apparent purity [2]	Sugar production [3]			
					Per plot		Per acre	
	Per plot	Per acre			Gross	Indicated available	Gross	Indicated available
U. S. No. 1 increase from—	*Pounds*	*Tons*	*Per cent*		*Pounds*	*Pounds*	*Pounds*	*Pounds*
Beaumont, Calif.	350.78	16.943	19.16	92.62	67.16	62.21	6,488	6,009
St. George, Utah	337.48	16.300	19.24	92.26	64.92	59.91	6,271	5,787
Las Cruces, N. Mex.	373.92	18.060	18.56	92.62	69.40	63.97	6,675	6,179
Average	354.06	17.101	18.99	92.50	67.16	62.03	6,478	5,991
Commercial:								
Old Type	190.38	9.195	18.82	91.70	35.45	32.47	3,424	3,137
Pioneer	204.18	9.862	19.10	92.06	39.16	36.13	3,783	3,490
Average	197.28	9.528	18.86	91.88	37.30	34.30	3,603	3,313
Difference	156.78	7.573	.13	.62	29.80	27.73	2,875	2,678
z [4]	1.6956	1.6956	[5] .3418	[6]	1.7711	1.7975	1.7711	1.7975
Standard error	35.22	1.701			6.2449	5.6781	603.7	547.8
Standard error of mean	15.752	.761			2.7929	2.5394	270	245
Standard error of difference	22.273	1.076			3.9492	3.5907	382	346
Difference required for significance	44.55	2.152			7.8984	7.1814	764	692

[1] Determined on three 20-beet samples of normally competitive beets per plot.
[2] Determined by direct reading of the Brix of the expressed juice and direct polariscopic determination of sucrose in the clarified, undiluted juice.
[3] Obtained by averaging of individual plot values; hence it differs slightly from product of the means given in this table.
[4] z=one-half the difference between the natural logarithms of the variances for variety and error. The 5 per cent point for z=0.5907; 1 per cent point=0.8413.
[5] Difference found was not significant by z test.
[6] Variance assignable to error was greater than variance assignable to effect of variety.

There were no significant differences in yield among the three seed increases of the U. S. No. 1 variety nor between the two commercial brands used for comparison. Each of the U. S. No. 1 seed increases, however, showed a much larger yield per plot than did either of the commercial brands, and there was a significant difference between the average yield of the U. S. No. 1 lots and the average yield of the commercial brands.

In sucrose percentage the results were not significant according to the z test. For the coefficient of apparent purity no significant differences were obtained, as the variance due to error was greater than that due to the effect of variety.

In sugar production no significant differences were found among the three U. S. No. 1 seed lots nor between the two commercial brands. In both gross and indicated-available sugar, however, the average of

the U. S. No. 1 lots was significantly greater than the average of the commercial brands.

The test as a whole indicates that there were no significant differences among the three seed increases of the U. S. No. 1 variety and that each of these showed marked superiority to the two commercial brands used for comparison.

Counts of plants affected with "obvious [15] curly top" (Table 3) show no large differences among the three seed increases of the U. S. No. 1 variety, regardless of whether the readings were made early or late in the season. On each of the dates when readings were made, except the first date, the average percentage of obvious curly top for each of the three U. S. No. 1 lots was strikingly lower than that of either of the commercial brands. This is entirely consistent with the results given later for the grower-test plantings and the comparative-development studies.

TABLE 3.—*Percentage* [1] *of plants showing obvious curly top in each of three seed increases of the U. S. No. 1 variety as compared with that in two commercial brands, planted April 11, 1931, at Castleford, Idaho*

Variety	Percentage of plants showing obvious curly top on—					
	June 20	July 1	July 14	July 31	Aug. 11	Aug. 28
U. S. No. 1 increase from—						
Beaumont, Calif.	3.0	8.5	24.2	41.0	54.0	45.8
St. George, Utah	2.2	11.3	24.8	45.4	56.2	44.4
Las Cruces, N. Mex.	2.2	11.6	24.6	38.6	58.0	37.8
Commercial:						
Old Type	8.4	25.4	56.2	87.4	93.2	98.2
Pioneer	3.0	22.0	51.8	84.4	92.8	99.2

[1] Counts were made on all the beets in the center two rows of each plot; each reading is an average of 5 plots.

TEST AT TWIN FALLS

A companion test to the one conducted at Castleford—an area where severe outbreaks of curly top prevail—was undertaken at Twin Falls—an area in which curly-top outbreaks are not usually so severe—in order to compare the behavior of the three increases of the U. S. No. 1 variety with that of the two commercial brands used as checks. The planting plan used at Castleford was followed.

Twenty-three pounds of seed per acre was planted April 16 in plots, each one two-hundred-and-fourth of an acre in harvestable area and consisting of four rows, 20 inches apart, replicated five times in restricted random arrangement. The two center rows of each plot were harvested November 6 on a normally competitive-beet basis, and the data were computed on the basis of a 100 per cent stand. Determinations of sucrose percentage and coefficient of apparent purity were made on three 20-beet samples of normally competitive beets from each plot, in the manner previously described.

The data presented in Table 4 show that in yield per plot the results are not significant according to the *z* test. There were no large differences in yield between the U. S. No. 1 variety and the two commercial brands used as checks. Likewise there were no large differences in

[15] The term "obvious curly top" signifies that degree of curly-top reaction by which the disease can be detected in a rapid examination of the foliage as a whole and which does not require a close examination of the inner leaves. The conception of what constitutes obvious curly top might vary with different workers, but as all these counts were made by one person (Lowe) the records are closely comparable.

yield among the three lots of the U. S. No. 1 variety, nor were the commercial brands appreciably different from each other. In sucrose percentage the results are not significant according to the z test. Aside from the lower sucrose percentage for the St. George seed increase, which must be considered, according to the z test, as a chance occurrence, the average sucrose percentage of the three lots of the U. S. No. 1 variety was 18.29, as compared with 18.47 for the commercial brands, both values being commercially acceptable.

TABLE 4.—*Comparison of the U. S. No. 1 variety with two commercial brands, planted April 16, 1931, at Twin Falls, Idaho*

[Data represent averages from five plots, each 1/264 of an acre in area and consisting of the two inner 20-inch rows of the original plot]

Variety	Yield		Sucrose	Coefficient of apparent purity	Sugar production [1]			
					Per plot		Per acre	
	Per plot	Per acre			Gross	Indicated-available	Gross	Indicated-available
U. S. No. 1 increase from—	*Pounds*	*Tons*	*Per cent*		*Pounds*	*Pounds*	*Pounds*	*Pounds*
Beaumont, Calif.	186.36	19.009	18.42	83.58	34.35	28.73	7,007	5,861
St. George, Utah	205.30	20.941	17.82	83.44	36.56	30.55	7,458	6,232
Las Cruces, N. Mex.	202.22	20.626	18.62	83.24	37.54	31.23	7,658	6,371
Commercial:								
Old Type	191.24	19.506	18.44	83.38	35.22	29.37	7,185	5,991
Pioneer	178.94	18.252	18.50	83.66	33.05	27.65	6,742	5,641
z [2]	[3].0807	[3].0807	[3].0575	(4)	[3].1889	[3].1725	[3].1889	[3].1725

[1] Obtained by averaging individual plot values; hence differing slightly from product of the means given in this table.

[2] z=one-half the difference between the natural logarithms of the variances for variety and error. The 5 per cent point for z=0.5067; 1 per cent point for z=0.8443.

[3] Difference found was not significant by z test.

[4] Variance assignable to error was greater than variance assignable to effect of variety.

For the coefficient of apparent purity, no reliable differences were obtained, inasmuch as the variance due to error was greater than that due to effect of variety.

In pounds of sugar per acre, the differences, according to the z test, are not significant. On comparing the three seed lots of the U. S. No. 1 variety among themselves, no appreciably large difference was found. In gross and indicated-available sugar an appreciably large difference was found between the Las Cruces seed increase of the U. S. No. 1 variety and the Pioneer commercial brand. Although this difference exceeds the amount required for significance, it must, according to the z test, be considered a chance occurrence.

Counts made of plants affected with obvious curly top (Table 5) show that for the period during which the observations were made the percentage of affected plants was relatively small. In each case the number of plants affected was less in the U. S. No. 1 variety than in the commercial brands used as checks.

This test as a whole indicates that under relatively light outbreaks of curly top the U. S. No. 1 variety approached in yields and in other attributes the two standard commercial brands with which it was compared.

TABLE 5.—*Percentage* [1] *of plants showing obvious curly top in each of the three seed increases of the U. S. No. 1 variety as compared with two commercial brands, planted April 16, 1931, at Twin Falls, Idaho*

Variety	Percentage of plants showing obvious curly top on—			
	June 29	July 13	July 28	Aug. 15
U. S. No. 1 increase from—				
Beaumont, Calif.	3.0	9.2	13.0	21.6
St. George, Utah	2.2	8.6	16.6	24.4
Las Cruces, N. Mex.	2.0	10.2	16.8	26.4
Commercial:				
Old Type	5.9	25.8	50.4	70.0
Pioneer	7.6	22.2	45.0	62.6

[1] Counts were made on all the beets in the center 2 rows of each plot; each reading is an average of 5 plots

GROWER-TEST PLANTINGS

In 1931 grower-test plantings were made throughout the affected sugar-beet areas of Idaho. The season was characterized by a serious outbreak of curly top. The amount of damage resulting from curly top each season from 1927 to 1931, inclusive, is shown in Table 6, in which comparative data are given on acreages and average yields in the Jerome, Twin Falls, and Burley-Paul areas. These data indicate that the tests of 1930, described in the preceding section, were conducted under conditions that probably represent a maximum of curly-top exposure for the Idaho beet-growing district and that those of 1931 were made under conditions of a moderately severe curly-top epidemic. Although the influx of beet leaf hoppers began at approximately the same date in 1931 as in 1930 and continued over a considerable period,[16] the number of insects was apparently smaller.

TABLE 6.—*Acreages and average yields for the Twin Falls, Jerome, and Burley-Paul, Idaho, areas from 1927 to 1931*

Year	Number of acres						Average yield per acre based on—					
	Thinned			Harvested			Acres harvested			Acres thinned		
	Jerome	Twin Falls	Burley-Paul	Jerome	Twin Falls	Burley-Paul	Jerome	Twin Falls	Burley-Paul	Jerome	Twin Falls	Burley-Paul
							Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1927 [a]	1,980	4,966	3,945	1,479.51	4,887.12	3,533	11.95	16.35	14.46	8.90	15.44	12.95
1928 [b]	[c] 206	[c] 152	[c] 1,633	61.81	110.66	1,644.5	4.63	8.39	11.46	1.30	6.11	10.84
1929 [a]	2,009	7,004	4,849	1,251.58	6,307.85	4,795.5	9.92	12.99	12.68	6.18	11.70	12.54
1930 [b]	1,171	3,764	6,822	761.50	2,221.24	6,329	7.13	8.70	9.69	4.76	5.14	8.90
1931 [a]	317.4	1,125.4	3,198	270.50	1,061.50	2,958	8.92	7.13	9.35	7.61	6.72	8.65

[a] Curly top not serious.
[b] Curly top serious.
[c] The drop in acreage in 1928 was due primarily to the effect of the forecast by the Bureau of Entomology that the numbers of leaf hoppers in the breeding grounds indicated decidedly unfavorable prospects for the beet crop.

[16] P. N. Annand, entomologist in charge of the sugar-beet insect field laboratory at Twin Falls, has furnished the following statement: "The influx began on May 24, the same date as in 1930, and continued over a period of five weeks. The flight was smaller than in 1930 as indicated by the numbers of leaf hoppers per beet and by numbers intercepted by flight traps."

In the grower-test plantings of 1931, a special effort was made to select localities where different degrees of curly-top exposure might be expected. Nineteen plantings were made in the sugar-beet area from Filer, on the west, to McCammon, on the east, as follows: Two fields at Filer, 2 at Twin Falls, 3 at Jerome, 2 at Kimberley, 2 at Hansen, 2 at Murtaugh, and 1 each at Burley, Paul, Rupert, Aberdeen, Fort Hall, and McCammon.[17] The planting at Fort Hall and one of those at Jerome were lost shortly after they were made, so that this report concerns itself with 17 plantings, as listed in Table 7.

In order to test the performance of the U. S. No. 1 variety under average farm conditions, an extensive series of plantings was made of the first multiplication of the seed used in the 1930 tests. Representative farms were chosen where, in the opinion of factory managers and agriculturists [18] consulted, the crop would receive proper handling. These farms were so distributed as to give a representative cross section of the whole beet acreage in Idaho, where curly top is regularly a serious factor. The plan used was to plant the seed of the U. S. No. 1 variety and that of a commercial brand in alternate strips 16 rows wide. The number of such strips varied from two to four sets for each field, depending on the size of the field and the supply of the seed. In every case, as nearly as could be judged at planting time, these strips were so located that neither the U. S. No. 1 nor its commercial check was unfavorably placed; all the plantings were made under the supervision of the writers, and the boundaries of the plots were carefully staked and recorded to prevent errors when the plots were harvested. The areas involved in these comparisons were approximately 1 acre for the U. S. No. 1 variety and a similar area for the commercial check. During the growing season, inspection trips were made at intervals of two weeks to observe closely the differences in these 17 grower-test plantings in regard to growth, degree of curly-top infestation, and progressive development of the U. S. No. 1 variety and the commercial brand. By doing this, it was possible to insure identical treatment of the comparison strips in regard to timeliness of thinning, uniform irrigation, and other cultural operations.

At the time of planting it was noticed that the seed balls of the U. S. No. 1 variety were, on an average, larger than the seed balls of the commercial brand. This difference in size necessitated the adjustment of the drill to insure that approximately the same weight of both lots of seed was used in the comparison strips. When viewed along the row, the seedlings of the U. S. No. 1 variety appeared slightly darker than the seedlings of the commercial brands. Close examination showed that the foliage of the U. S. No. 1 variety was a darker green than that of the commercial brands and that a fairly high percentage of the U. S. No. 1 plants had red coloration in the petioles.

[17] Acknowledgment is made of the helpful cooperation given by the following farmers in whose fields the tests were conducted: Martin Meier and H. F. McKay, of Twin Falls; W. H. Newman and S. D. Perrine, of Kimberley; J. Mason and V. Naylor, of Hansen; J. Priest and J. Sackett, of Filer; R. C. May, of Rupert; D. B. Hardin, of Paul; J. H. Bodily, of Burley; D. F. Turner and Francis Johnson, of Murtaugh; E. J. Netz, W. H. Stoddard, and M. Reich, of Jerome; W. R. Christensen, of McCammon; G. Becker, of Aberdeen; and S. A. Dunn, of Fort Hall. Acknowledgment is also due the Amalgamated Sugar Co. and the Utah-Idaho Sugar Co. for advice and assistance in securing the test fields in their respective operating districts.

[18] Acknowledgment is made of the assistance and continued interest throughout these experiments of A. R. Hagar, R. C. May, and R. H. Tallman, of the Amalgamated Sugar Co., and W. Y. Cannon, of the Utah-Idaho Sugar Co.

In the various grower-test plantings no consistent differences in relative stand or size were noted, prior to thinning, between the U. S. No. 1 plots and the adjoining plots planted with the commercial brand. After thinning, the plants in the comparison strips continued growth without noticeable differences in stand or size until after the leaf-hopper attack began. In most cases the beet leaf hoppers appeared in the fields during the latter part of May, and curly-top symptoms became evident the first week in June, little damage appearing until after June 20. At that time the beet fields (located under the Twin Falls irrigation system) began to show rather pronounced curly-top damage in the commercial strips and only slight damage in the adjacent strips planted with the U. S. No. 1 variety. The progressive development of the disease is shown in Table 7, in which the field records for obvious curly top are arranged according to districts. These detailed records are based upon readings obtained from a large number of rows selected at random. Each reading given is an average based upon at least 10 sets of 100 consecutive beet plants in each comparison strip. The table shows also the obvious curly top occurring in portions of the rows selected at random. In all the grower-test plantings the counts were taken at intervals of approximately two weeks throughout the season, beginning June 17 to 26, and show that curly top became severe before the close of August. At the close of the season all but 1 of the commercial plots in the 17 test fields showed nearly 100 per cent obvious curly top, the exception (field 16) showing 50 per cent. The U. S. No. 1 variety, on the other hand, had shown in many cases a tendency apparently to recover from the disease; in 14 of the fields the obvious curly top ranged from 37 to 72 per cent, and 3 of the fields (16, 5, and 9) showed only 19, 27, and 24 per cent of curly top, respectively. A detailed account of these results is given in Table 7.

TABLE 7.—*Percentage* [1] *of plants showing obvious curly top in the grower-test plantings of the U. S. No. 1 variety and commercial brands in Idaho in 1931*

[Data represent averages of a minimum of 10 counts of 100 beets for each planting]

Area and locality	Field No.	Variety [2]	Percentage of plants showing obvious curly top on—									
			June 17–26	July 2–8	July 17–24	Aug. 3–7	Aug. 17–22	Aug. 31 to Sept. 4	Sept. 14–18	Sept. 25	Oct. 10	
											Foliage mildly affected	Foliage severely affected
Twin Falls area:												
Twin Falls	1	U. S. No. 1	7	16	18	24	54	39	35	37	30	7
		Commercial	17	55	61	82	100	100	95	96	42	54
	2	U. S. No. 1	12	13	28	30	66	63	63	61	39	21
		Commercial	27	48	57	80	97	100	95	98	26	72
Kimberley	3	U. S. No. 1	9	19	28	42	72	60	61	72	57	15
		Commercial	20	65	86	98	100	100	100	97	25	72
	4	U. S. No. 1	19	21	42	57	74	59	63	------	------	------
		Commercial	51	69	91	100	100	100	100	------	------	------

[1] The rows in which the counts were made were selected at random for each comparison-strip planting.

[2] In the grower-test plantings the following commercial brands were used: Fields 1, 2, 6, and 13, Old Type; field 16, Pioneer, both brands of the Zuckerfabrik Kleinwanzleben; in fields 7, 8, 11, 12, and 15, seed from the same firm was used, but the particular brand was not available from factory records; fields 3, 5, and 10, Elite (Schreiber & Son); fields 4, 14, and 17, Elite (C. Braune); field 9, F. F. (E. Frederiksen).

TABLE 7.—*Percentage of plants showing obvious curly top in the grower-test plantings of the U. S. No. 1 variety and commercial brands in Idaho in 1931*—Con.

Area and locality	Field No.	Variety	Percentage of plants showing obvious curly top on—								Oct. 10	
			June 17–20	July 2–8	July 17–24	Aug. 3–7	Aug. 17–22	Aug. 31 to Sept. 4	Sept. 14–18	Sept. 25	Foliage mildly affected	Foliage severely affected
Twin Falls area—Con.												
Hansen	5	U. S. No. 1	7	11	30	39	69	53	68	26	21	6
		Commercial	27	44	82	97	100	100	100	98	53	47
	6	U. S. No. 1	8	9	22	27	60	48	52	39	28	10
		Commercial	24	32	71	92	100	100	97	98	42	56
Filer	7	U. S. No. 1	5	5	7	20	46	38	31	40	32	8
		Commercial	27	25	39	77	89	94	88	96	39	57
	8	U. S. No. 1	3	13	28	46	70	60	54	33	22	11
		Commercial	17	33	74	96	100	100	100	99	48	51
Burley area: Rupert	9	U. S. No. 1	3	7	10	13	21	27	23	25	19	5
		Commercial	11	28	36	56	91	100	90	94	59	36
Paul	10	U. S. No. 1	3	13	31	30	42	50	52	47	38	9
		Commercial	7	26	60	83	96	100	100	96	61	35
Burley	11	U. S. No. 1		11	21	31	54	51	39	49	33	16
		Commercial		21	46	70	100	100	92	97	30	66
Murtaugh	12	U. S. No. 1	12	19	36	50	57	62	64	51	37	14
		Commercial	38	59	84	100	100	100	100	99	18	81
	13	U. S. No. 1	7	11	20	40	54	51	54	49	31	18
		Commercial	26	43	68	93	100	100	100	98	23	75
Jerome area: Jerome	14	U. S. No. 1	2	11	22	40	66	60	48	59	38	21
		Commercial	5	21	44	80	100	100	93	96	29	67
	15	U. S. No. 1	2	4	14	35	58	54	56	59	40	19
		Commercial	3	10	34	79	100	100	89	89	35	54
Eastern area: McCammon	16	U. S. No. 1	0	3	7	12	14	22	24	19	14	5
		Commercial	0	7	19	27	46	59	61	50	27	23
Aberdeen	17	U. S. No. 1	4	17	32	53	42	51	42	38	27	11
		Commercial	9	29	68	85	92	100	93	94	50	44
Average		U. S. No. 1	6.4	11.9	23.2	34.6	54.4	49.8	48.6	43.8	31.6	12.2
		Commercial	19.2	36.5	59.9	82.0	94.8	97.2	93.7	93.3	37.8	55.5

In taking the last count of beets affected with obvious curly top just before harvest, the effects of the disease on the foliage were classified as either mild or severe. The commercial brands used as checks usually showed a greater proportion of severe cases than mild ones. In the U. S. No. 1 variety, however, the mild type of disease constituted nearly three-fourths of the obvious curly top. In the commercial brands the percentages of severe curly top ranged from 23 to 81, whereas in the resistant variety the range was 5 to 21 per cent.

The data in Table 7 show that in all the fields but one the disease in the commercial beets had practically reached the maximum of incidence by the last of August and that throughout the season the U. S. No. 1 variety showed a marked degree of resistance to curly-top infection. In view of the severity of the disease in these areas, it is obvious that the season afforded for nearly all fields a fairly severe test of the U. S. No. 1 variety. (Fig. 5.)

The harvest results of the 17 grower-test plantings are given in Table 8. The methods used in securing the data were as follows: From each strip constituting a part of the grower-test planting, twenty 20-beet samples of normally competitive beets were selected at random. These beets were put in moisture-proof sacks and taken to the laboratory, where they were washed, weighed, and analyzed.

Determinations of sucrose percentage and of the coefficient of apparent purity were made separately for each 20-beet sample of normally competitive beets in the manner previously described.

FIGURE 5.—Grower-test planting on the Newman farm, at Kimberley, near Twin Falls, Idaho, showing the U. S. No. 1 variety at the right and a commercial brand (Schreiber & Son's Elite) at the left. Planted March 11, 1931; photographed July 26, 1931

TABLE 8.—*Results of grower-test plantings of the U. S. No. 1 variety and commercial brands in Idaho in 1931*

Area and locality	Field No.	Planting date	Yield per acre [1]			Sucrose			Coefficient of apparent purity		
			U. S. No. 1	Commercial	Difference	U. S. No. 1	Commercial	Difference [2]	U. S. No. 1	Commercial	Difference [2]
Twin Falls area:			*Tons*	*Tons*	*Tons*	*Per ct.*	*Per ct.*	*Per ct.*			
Twin Falls	1	Mar. 23	17.906	13.038	4.868	18.35	18.38	—0.03	94.98	95.69	—0.71
	2	Apr. 27	21.424	14.694	6.730	16.84	16.89	—.05	92.22	91.48	.74
Kimberley	3	Mar. 11	12.741	7.282	5.459	18.58	17.90	.68	92.13	90.69	1.44
	4	Mar. 20	10.002	6.527	3.535	16.30	16.41	—.11	97.69	95.26	2.43
Hansen	5	Apr. 4	8.115	4.257	3.858	18.18	18.11	.07	93.32	91.87	1.45
	6	Mar. 23	8.200	5.740	2.460	18.42	18.37	.05	94.41	93.57	.84
Filer	7	Apr. 3	17.828	14.244	3.584	19.20	19.20	0	93.85	94.16	—.31
	8	do	12.071	5.697	6.374	19.06	18.23	.83	94.18	90.90	3.28
Burley area:											
Rupert	9	Apr. 4	18.814	14.208	4.606	16.98	17.52	—.54	94.17	95.60	—1.43
Paul	10	Apr. 10	24.417	17.410	7.007	16.19	16.97	—.78	94.90	95.00	—.10
Burley	11	do	11.728	7.331	4.397	17.83	17.75	.08	96.35	96.69	—.34
Murtaugh	12	Apr. 4	11.627	6.766	4.861	19.19	18.34	.85	94.96	93.11	1.85
	13	Apr. 3	10.941	8.331	2.610	18.84	18.49	.35	96.25	95.92	.33
Jerome area:											
Jerome	14	Mar. 30	16.668	11.731	4.937	17.84	17.48	.36	93.97	94.21	—.24
	15	Apr. 8	14.361	11.015	3.346	18.04	18.37	—.33	94.71	94.12	.59
Eastern area:											
McCammon	16	Apr. 28	11.385	9.085	2.300	18.37	18.83	—.46	92.10	90.77	1.33
Aberdeen	17	Apr. 21	14.927	6.707	8.220	18.16	17.65	.51	90.13	88.89	1.24
Average			14.307	9.651	[3]4.656	18.02	17.93	[4].09	94.14	93.41	[4].73

[1] Yield values were obtained from normally competitive beets and were computed on the basis of a 100 per cent stand.
[2] When the commercial exceeds U. S. No. 1, a minus sign is used.
[3] Odds 9999 to 1 that difference as great as shown was not due to chance alone (2).
[4] Odds less than 30 to 1 that difference as great as shown was not due to chance alone.

TABLE 8.—*Results of grower-test plantings of the U. S. No. 1 variety and commercial brands in Idaho in 1931*—Continued

Area and locality	Field No.	Planting date	Sugar per acre					
			Gross			Indicated available		
			U. S. No. 1	Commercial	Difference	U. S. No. 1	Commercial	Difference
			Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Twin Falls area:								
Twin Falls	1	Mar. 23	6,572	4,793	1,779	6,242	4,586	1,656
	2	Apr. 27	7,210	4,954	2,252	6,654	4,541	2,113
Kimberley	3	Mar. 11	5,735	2,607	2,128	4,362	2,364	1,998
	4	Mar. 20	3,280	2,142	1,138	3,204	2,041	1,163
Hansen	5	Apr. 4	2,951	1,542	1,409	2,749	1,417	1,332
	6	Mar. 23	3,024	2,112	912	2,855	1,977	878
Filer	7	Apr. 3	6,846	5,470	1,376	6,425	5,150	1,274
	8	do	4,602	2,077	2,525	4,334	1,888	2,446
Burley area:								
Rupert	9	Apr. 4	6,389	4,979	1,410	6,017	4,759	1,258
Paul	10	Apr. 10	7,006	5,009	1,997	7,503	5,614	1,889
Burley	11	do	4,182	2,603	1,579	4,030	2,516	1,514
Murtaugh	12	Apr. 4	4,402	2,482	1,980	4,238	2,311	1,927
	13	Apr. 3	4,123	3,073	1,050	3,908	2,948	1,020
Jerome area:								
Jerome	14	Mar. 30	5,947	4,101	1,846	5,589	3,864	1,725
	15	Apr. 8	5,182	4,047	1,135	4,908	3,809	1,099
Eastern area:								
McCammon	16	Apr. 28	4,183	3,422	761	3,853	3,106	747
Aberdeen	17	Apr. 21	5,422	2,368	3,054	4,880	2,105	2,781
Average			[3] 5,110	[3] 3,452	[3] 1,667	[3] 4,813	[3] 3,235	[3] 1,578

[2] Odds 9999 to 1 that difference as great as shown was not due to chance alone (2).
[3] Obtained by averaging the sugar-per-acre values computed for the individual fields; hence it differs slightly from the product of the means given in this table.

The results from the 17 fields show that the U. S. No. 1 variety outyielded the commercial brand in every case. The difference in favor of the U. S. No. 1 variety was 2.3 tons per acre in the field (16) showing the lowest difference, which was the field where obvious curly top occurred in the lowest percentage. The average gain for all 17 fields was 4.66 tons per acre, a significant difference. The individual gains, as calculated by this method, ranged from 2.3 tons to 8.2 tons per acre. In seven fields the commercial brand showed the higher average sucrose percentage per beet, and in nine fields the U. S. No. 1 variety was the higher. In no case did the difference exceed 0.85, which was too small to be significant. Six fields showed a higher average coefficient of apparent purity per sample for the commercial beets, and 11 fields showed a higher average purity for the U. S. No. 1 variety. In no case did the difference exceed 3.28, and the average difference (0.73) was too small to be significant. In the calculated yield of sugar (pounds per acre) the U. S. No. 1 variety exceeded the commercial brand in every case. The difference in favor of the U. S. No. 1 variety was 761 pounds of gross sugar and 747 pounds of indicated-available sugar in the field (16) showing the lowest difference, which, as noted previously, was the field where the obvious curly top was the lowest. The average difference in favor of the U. S. No. 1 variety in all 17 fields was 1,667 pounds of gross sugar per acre and 1,578 pounds of indicated-available sugar. The individual differences ranged from 761 to 3,054 pounds of gross sugar per acre, and from 747 to 2,781 pounds of indicated-available sugar per acre.

It must be borne in mind that these yields in tons of beets and pounds of sugar produced are based on the average individual root

weight for the contrasted types, resistant and nonresistant, and have been computed uniformly on a 100-per-cent-stand basis. Actual yields per acre were less, since stands were not perfect, but this consideration does not affect the relations shown by the differences, except, perhaps, to handicap the resistant variety.

The comparisons as made show the essential differences in weight and quality that may exist among beets growing under uniform conditions of competition. In such a consideration of the data, the influence of the stand factor as it might affect yield per acre is eliminated. The fact that the stand relations are eliminated influences the results obtainable by this method in those cases where some factor affects the stand in the check and tested plots differently. The curly-top disease, for instance, may and often does decrease the stand in the check more than it does that of a resistant variety. Obviously a decrease in stand due to the disease must be recognized as a part of the damage, and when this consideration is left out of the evaluation the resistant variety is to that extent handicapped. There are, however, certain practical advantages in the method. Extensive samples from the comparison strips may be taken in advance of the regular harvest, thereby affording a precise comparison as to sucrose percentage and coefficient of apparent purity and also some measure of yields, whereas it is often impossible to get satisfactory records of quality and yields at the time a whole field is harvested. It seems that under curly-top conditions a fairly representative value for actual yield per acre may be arrived at by applying the harvest-stand count to the data obtained from the normally competitive-beet samples.

In five of these tests the actual yields produced on measured areas planted to the two contrasted beet types were obtained as a check on the method employed. (Table 9.) The table gives the actual yields obtained from the resistant and nonresistant beets under the conditions of the particular field. These are compared with the yields computed from the individual beet weight as determined from the normally competitive-beet samples, assuming the stand to be 100 per cent.

TABLE 9.—*Yield computed on basis of 100 per cent stand of normally competitive beets as compared with actual yields from grower-test plantings in Idaho in 1931*

Locality	Field No.	Actual yield per acre				Yield per acre on basis of 100 per cent stand of normally competitive beets			
		U. S. No. 1	Commercial	Difference		U. S. No. 1	Commercial	Difference	
		Pounds	*Pounds*	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Pounds*	*Per cent*
McCammon	10	15,964	8,150	7,814	95.9	22,771	18,171	4,600	25.3
Rupert	9	30,300	20,200	10,100	50.0	37,629	28,416	9,213	32.4
Jerome	14	23,406	13,582	9,824	72.3	33,336	23,463	9,873	42.1
Kimberley	3	14,673	5,342	9,331	174.7	25,482	14,564	10,918	75.0
Twin Falls	2	28,396	14,223	14,173	99.6	42,849	20,389	13,460	45.8
Average	------	22,548	12,299	10,249	83.3	32,413	22,801	9,612	42.2

It will be noted that with the exception from the McCammon field, in which, irrespective of curly top, considerable stand variation occurred, the differences between the U. S. No. 1 variety and the

commercial brand used as check, determined by the two methods, are of approximately the same magnitude.

From the actual yield data in Table 9 the superiority of the U. S. No. 1 variety over the commercial brand used as a check appears even more striking than is shown in Table 8. This was partly due to the difference in the actual stands. In every case the resistant type showed a high percentage of gain over the commercial brand. This percentage of gain is higher than that found when the root weights of the average individual of each type growing under normal competition conditions were used as the basis of comparison. In yield of beets, however, the difference between the U. S. No. 1 variety and the commercial brand as determined by the two methods was approximately the same. Although theoretically it might be expected that stand differences would be reflected in the yields and that usually there is considerable compensating for missing beets in the row, it is not certain that these factors operate under curly-top conditions. It seems likely that basing judgment as to varietal performance on an adequate number of normally competitive beets was reliable and probably more conservative than judgment based on actual yields which may be biased by extraneous influences on stand. The conclusions warranted from the two methods of determining yield are (1) that the average root size of sugar beets from the U. S. No. 1 seed, under such conditions as existed in this test, was greater than the root size of the beets grown from commercial seed, and (2) that a given area planted with U. S. No. 1 seed was shown to outyield a similar area planted with commercial seed.

COMPARATIVE DEVELOPMENT STUDIES

A study of the rate of development of the beet plant was undertaken at Twin Falls on both the U. S. No. 1 variety and a commercial brand (Rabbethge & Giesecke Old Type). On April 17 the seed stocks were planted, 28 pounds to the acre, in rows 20 inches apart, in two adjoining 40-row blocks. The blocks were approximately 270 feet long, and were separated by 3-foot alleyways into three 90-foot sections. Every other row was used for sampling, thus insuring a 1-row buffer between each sampling area. The samplings were made at weekly intervals from June 17 to October 7. (Table 10.) The readings for percentage of obvious curly top paralleled those obtained in the grower-test plantings. (Table 7.) The U. S. No. 1 variety showed uniformly less obvious curly top than the commercial brand. In growth of foliage the U. S. No. 1 variety showed a uniformly greater development from late June until harvest, the difference being greater at time of harvest than during the earlier stages of growth. The root weight of the commercial brand, however, increased more rapidly during the early part of the growing season; but this advantage was lost about mid August, when the root weight of the U. S. No. 1 variety approximately equaled that of the commercial brand. During September there was a marked tendency on the part of the U. S. No. 1 variety to show a greater relative growth rate than the commercial brand, an advantage it maintained up to the time of harvest. As calculated from the data of October 7 (25 ounces for the U. S. No. 1 root weight and 18.86 ounces for the root weight of the commercial brand), the yields were 20.42 tons and

15.40 tons per acre, respectively, a difference of 5 tons in favor of the U. S. No. 1, which approximates closely the average difference (4.6 tons) as calculated for the grower-test plantings. In sucrose percentage there was a marked tendency for the commercial brand to show an advantage, although at harvest the differences became less pronounced. The quality of beets produced from the resistant variety (16.56 per cent sucrose as compared with 17.06 per cent from the commercial brand) was acceptable.

TABLE 10.—*Comparative development of the U. S. No. 1 variety and a commercial brand (Rabbethge & Giesecke Old Type) used at Twin Falls, Idaho, 1931*

Sampling date	Average weight of beets		Average weight of foliage		Average sucrose		Percentage of plants showing obvious curly top	
	U. S. No. 1	Commercial	U. S. No. 1	Commercial	U. S. No. 1	Commercial	U. S. No. 1	Commercial
	Ounces	*Ounces*	*Ounces*	*Ounces*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
June 17	0.50	1.35	2.40	2.85				
June 24	.85	1.95	5.30	4.80				
July 2	3.46	4.50	9.11	7.13			1.6	31.3
July 8	4.53	6.78	9.03	8.59			5.0	33.3
July 15	5.60	6.18	10.66	7.75			5.0	32.0
July 22	9.80	9.15	13.90	9.00			11.6	36.6
July 30	10.91	13.45	13.05	11.10	12.73	13.93	20.0	58.3
Aug. 6	13.10	13.16	14.55	9.43	13.33	14.73	18.0	70.0
Aug. 12	14.96	14.91	14.85	9.98	15.07	15.07	23.3	85.0
Aug. 19	19.38	19.51	15.68	13.38	13.53	14.60	30.5	86.5
Aug. 27	22.05	22.55	19.88	13.80	14.26	15.00	36.6	100.0
Sept. 2	25.50	21.41	23.03	14.28	13.86	15.26	21.7	95.0
Sept. 10	20.30	22.20	17.00	12.55	14.33	15.20	31.0	98.0
Sept. 18	25.30	18.20	20.30	10.51	15.13	15.20	36.6	98.0
Sept. 24	29.26	24.20	20.68	13.03	15.60	16.36	26.6	91.7
Sept. 30	26.41	19.88	22.86	11.35	16.03	17.10	15.0	95.0
Oct. 7	25.00	18.80	19.58	13.06	16.56	17.06	16.6	95.0

Although these results can not be assumed to have general applicability, since they involve only a single season and particular field conditions, the final readings are nevertheless consistent with the general trend of the results obtained in the other tests reported in this bulletin.

TESTS IN UTAH AND COLORADO [19]

INTENSIVE AGRONOMIC TESTS IN UTAH

In 1930 critical studies were begun in Utah on the U. S. No. 1 variety in order to test its resistance to curly top as compared with that of various commercial brands.

The first of these experiments were carried on in two ½-acre experimental plots on representative farms near Magna. This locality was chosen because curly-top epidemics had regularly occurred there for a number of years. The two experimental plots (Taylor field and Coon field) were about 4 miles apart. These fields were planted on April 8 and 9, respectively, somewhat later than the earliest commercial plantings in this district, in order that the plants might be comparatively small at the time of the early leaf-hopper invasion and therefore exposed to relatively severe injury from curly top.

[19] Contributed by F. V. Owen, F. A. Abegg, and Wesley Keller. The work in Utah was carried on with the cooperation of the Utah Agricultural Experiment Station. The writers acknowledge many helpful suggestions from Eubanks Carsner.

TESTS AT TAYLOR FIELD

At the Taylor field, the U. S. No. 1 variety was replicated seven times in single-row plots 50 feet long. There were also two rows 350 feet long used for an additional test. A commercial brand (Schreiber S. K. W.) [20] was used as a check.

The injury from curly top in this field was only moderate, although considerable numbers of beet leaf hoppers were observed. There was no artificial inoculation of any kind, so that the disease produced was entirely dependent upon the natural leaf-hopper infestation. Evidently the virus carried by these insects was attenuated or low in virulence, for until the first part of September no marked contrast was observed between the plots planted with the resistant variety and those planted with the commercial brand. At this time the U. S. No. 1 variety was darker green in color and appeared to be more vigorous. At harvest time (October 16) the commercial plots had changed to a very pale yellow, while the U. S. No. 1 plots still appeared green. The results from the harvest of the replicated plots are given in Table 11.

TABLE 11.—*Comparison of the U. S. No. 1 variety with a commercial brand, planted April 8, 1930, in Taylor field, near Magna, Utah*

[Data represent averages from seven single-row plots, each 50 feet long]

Variety	Yield per acre	Sucrose [1]	Gross sugar per acre [2]
	Tons	*Per cent*	*Pounds*
U. S. No. 1	19.5	17.7	6,903
Commercial (Schreiber S. K. W.)	14.6	18.3	5,344
Difference	4.9	−.6	1,559

[1] Determined on a 10-beet sample from each plot.
[2] Gross sugar per acre was computed by multiplying the average yield in pounds by the average sucrose percentage.

The difference in yield of practically 5 tons per acre in favor of the U. S. No. 1 variety (nearly four times as great as its standard deviation) was undoubtedly significant. There was a significant difference (0.6 per cent) in sucrose percentage in favor of the commercial brand. However, larger beets were used for analysis from the U. S. No. 1 variety than from the commercial brand, and there is a well-known tendency for small sugar beets to be slightly higher than large ones in sucrose percentage. In total yield of sugar per acre the U. S. No. 1 variety showed a very decided increase over the commercial brand.

The results from the additional test of two long rows were of the same order. The yield for the U. S. No. 1 variety was 23.7 tons per acre, as compared with 20.3 tons for the commercial brand, and the sucrose percentage for the U. S. No. 1 variety was 17.5 per cent, as compared with 18.2 per cent for the commercial brand.

[20] Produced by Schreiber & Son, Nordhausen, Germany.

TESTS AT COON FIELD

At the Coon field, the U. S. No. 1 variety was replicated four times. Each plot consisted of one row 50 feet long. Artificial measures were employed to induce a severe curly-top epidemic in this experimental field. A row of diseased mother beets infected with curly top the previous season was planted along one side of the field in order to supply a source of virulent virus for the beet leaf hoppers coming in from the desert breeding areas. The migrating insects in this area are usually nonviruliferous or else carry only an attenuated virus. If a source of virulent virus is in a field some of the incoming leaf hoppers will take up the virus by feeding on the diseased plants and transmit it to other plants, thus initiating an epidemic of the disease. The virulent virus was also introduced into this field by means of beet leaf hoppers that had been produced on diseased plants. These insects were obtained from the laboratory of the Bureau of Entomology at Twin Falls, Idaho. On June 3 the viruliferous leaf hoppers were caged two to a plant on one-half of each plot (25 feet) in order to give the plants in certain belts across the field a nearly uniform and very severe exposure to the disease.

Previous to this date a general migration of beet leaf hoppers into the Magna district had occurred, resulting in an infestation of both the Coon and the Taylor fields. Two counts in each field on June 3 indicated about 22 leaf hoppers per 100 feet of row in the Coon field and 32 per 100 feet in the Taylor field. More counts probably would have indicated about equal infestations in the two fields.

The success of the artificial inoculation measures used in the Coon field was noted by general observations and also by careful counts of the amount of curly top at intervals during the season. It was apparent that there was much more injury from the disease at the Coon field than at the Taylor field. The disease in the latter field was so mild that, as previously noted, no marked difference between the resistant variety and commercial brand appeared until the first part of September. In the Coon field the belts inoculated by caging were significantly more affected than the belts not so inoculated. This fact was better demonstrated by the extent of the yield reductions than by percentage of diseased plants on any particular date. That the rate of development of the epidemics differed in the two fields, doubtless because the virulent virus had been artificially introduced into the Coon field, is shown by comparing the amount of curly top in the commercial brand used as a check in the naturally infested portion of the Coon field with the amount in the commercial brand in the Taylor field during the same periods. On June 24, the Taylor field showed 3 per cent of the plants diseased, whereas the Coon field showed 63 per cent diseased. On July 17, the Taylor field showed 20 per cent diseased, whereas the Coon field showed 95 per cent diseased.

The harvest results at the Coon field are summarized in Table 12. The chemical analyses reported are based on a composite sample of five beets per plot.

TABLE 12.—*Comparison of the U. S. No. 1 variety with a commercial brand, planted April 9, 1930, in Coon field, near Magna, Utah*

[Data represent averages from four single-row plots, each 25 feet long]

PLANTS INOCULATED BY NATURAL INFESTATION

Variety	Number per 100 feet		Stand loss	Yield per acre	Sucrose	Gross sugar per acre [1]
	June 20	Oct. 25				
			Per cent	*Tons*	*Per cent*	*Pounds*
U. S. No. 1	104	98	5.8	17.1	16.20	5,540
Commercial (Schreiber S. K. W.)	81	69	14.8	7.1	10.34	2,320
Difference	23	29		10.0	—.14	3,220

PLANTS INOCULATED BY NATURAL INFESTATION AND BY CAGING LEAF HOPPERS

U. S. No. 1	91	86	5.5	7.6		
Commercial (Schreiber S. K. W.)	75	51	32	2.5		
Difference	16	35		5.1		

[1] Gross sugar per acre was determined by multiplying the average yield in pounds by the average sucrose percentage.

These results show that in the belts exposed only to natural infestation, the U. S. No. 1 variety exceeded the commercial brand in yield by 10 tons per acre. The percentage of sucrose was practically the same in the resistant variety as in the commercial brand. The calculated yield of sugar per acre was 139 per cent greater for the U. S. No. 1 variety than for the commercial brand. In the belts where, in addition to the natural infestation, viruliferous beet leaf hoppers were caged on the plants, the yield from the U. S. No. 1 variety, although it had been greatly reduced by the drastic exposure, was three times the yield from the commercial brand.

GROWER-TEST PLANTINGS

In 1931 an extensive program was outlined whereby U. S. No. 1 seed could be given actual field trials [21] in the beet-growing areas of Utah and on the western slope of Colorado. Generally districts were selected where there had previously been severe outbreaks of curly top. Some districts reporting little damage were included, however, because it was thought desirable to know the merits of U. S. No. 1 seed under conditions of relative freedom from curly top as well as under conditions of severe disease.

In order to evaluate the resistant variety under normal farm conditions, localities were chosen where the beets would have good cultural care in productive soil and where the grower would take a personal interest in the problem.

[21] Special acknowledgment should be made to the growers who made the tests possible and also to the sugar companies for their active and sympathetic cooperation. The Utah-Idaho Sugar Co., the Amalgamated Sugar Co., and the Gunnison Sugar Co. cooperated in securing the Utah plantings. The plantings in Colorado were made in cooperation with the Holly Sugar Co.

The plantings were made as early as the season permitted. In practically every case the seed was planted as soon as the farmer was ready.[22] Care was taken to plant sufficient seed to insure good stands, and in most of the plots the stands proved satisfactory.

In each field as many replications were made as seemed feasible. Generally blocks of 16 rows were planted alternately to commercial seed and to the U. S. No. 1 variety. The number of blocks of the resistant variety ranged from 2 to 4. Some plantings were larger than others, but an attempt was made to plant about 1 acre to U. S. No. 1 seed at each place.

Each planting was inspected about once a month throughout the season. During the early period of growth careful observations were made to detect the presence of beet leaf hoppers and the first signs of curly top. Numerous curly-top counts were made, especially while the plants were young, to determine the progress of the disease. As the plants advanced in age a simple count of those diseased seemed entirely inadequate. The only satisfactory method of comparing them was to classify each plant according to the degree of curly top. This method, however, was found to be very time-consuming and impracticable for large-scale operations. In order not to confuse the reader with a large amount of data of a more or less indefinite nature, a discussion of curly-top counts has been omitted from this report. Of the 12 tests reported, 5 showed damage by curly top to an intermediate extent, 2 showed very severe injury, and in the remaining 5 the plants were so slightly diseased as to be practically uninjured.

METHODS OF RECORDING DATA

As the most economical method of obtaining reliable results it was decided to limit the harvest records from the test fields chiefly to samples taken at random.[23] Each beet in the 20-beet samples was selected by counting a definite number, depending on the size of the field and the number of samples desired, and then taking the first normally competitive beet. The interval between beets chosen for a particular field was 25, 30, 50, or some other number that afforded a thorough sampling of the blocks. Normally competitive beets were selected in order to avoid beets that might have been favored by lack of competition. The normally competitive beet was only approximated, however, in some fields where there was not a good stand. If a consistent standard for competitive conditions had been maintained, many parts of some of the fields would have been skipped entirely. To avoid this difficulty, the standard held for competitive conditions came to depend entirely on the nature of the stand in each particular field.

As an example of the method of securing the harvest record, detailed data of the A. N. Wight planting, at Tremonton, Utah, are given in Table 13. Student's method (*10*) has been used in analyzing the results.

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[22] At the Frank Boyd farm, Fruita, Colo., where the first planting was lost from root rot, and at the Louis Spaulding farm, Hooper, Utah, where the first planting was blown out by a bad windstorm, second plantings were made at rather late dates.

[23] This method was recommended by A. W. Skuderna.

TABLE 13.—*Comparison of the U. S. No. 1 variety with a commercial brand (Frederiksen), planted in 1931 on the Wight farm at Tremonton, Utah*

Weight of 20-beet samples (pounds)			Difference between sucrose percentage of U. S. No. 1 and commercial [1]
U. S. No. 1	Commercial	Difference [1]	
35.0	15.5	19.5	−0.9
31.0	18.0	13.0	−1.6
23.0	13.0	10.0	−1.2
31.0	17.5	13.5	− .7
35.5	19.0	16.5	−2.2
25.5	18.5	7.0	− .9
31.0	16.5	14.5	.1
26.0	27.0	−1.0	− .4
[2] 29.750	[2] 18.125	[2] 11.625±1.516	[2] .975±.169

[1] When the commercial exceeds U. S. No. 1 a minus sign is used.
[2] Average.

Only eight samples were taken from each strain, but the data obtained were so consistent as to make possible certain general conclusions. With one exception there was a consistent difference in the weight of the 20-beet samples in favor of the U. S. No. 1 variety, the average difference being 11.625 ± 1.516 pounds. According to the odds given in Student's tables (*2*), this difference might occur by chance alone once in 832 times. The average sucrose percentage was 19.10 for the commercial brand and 18.13 for the U. S. No. 1 variety, a difference of 0.97 ± 0.17 per cent. With only one exception the difference in sucrose percentage was consistently in favor of the commercial brand.

By taking into consideration the stand counts and assuming the weight per beet obtained from the 20-beet samples to be truly representative, a theoretical yield per acre may be readily calculated. On the Wight farm this gives 16.1 tons per acre for the U. S. No. 1 variety and 9.2 tons per acre for the commercial brand.[24] The values actually obtained from the record of the total weight of beets harvested were 16.4 tons per acre for the U. S. No. 1 variety and 8.6 tons per acre for the commercial brand.[25]

The closeness of agreement in yield estimates is very remarkable and helps to establish confidence in the method of estimating yields from the 20-beet samples. Eight was considered a very small number of samples from which to draw conclusions. If time had permitted, at least twice as many samples would have been taken. Although the 20-beet samples were intended to give only the approximate yield, yet their accuracy was such that there can be little doubt about the results on the Wight farm. The yield per acre was nearly doubled by the use of the resistant seed. Although the difference in sucrose percentage was nearly 1 per cent, in favor of the commercial brand, the sucrose percentage of the U. S. No. 1 variety (18.13) was acceptable.

[24] Actual stand as determined by counts in the blocks was used as a factor in arriving at these values.
[25] This record was taken by A. N. Wight with the cooperation of the Utah-Idaho Sugar Co. The figures were obtained through the courtesy of J. P. Holmgreen, field superintendent, Utah-Idaho Sugar Co., Garland, Utah. The total yield for the U. S. No. 1 variety was 34,323 pounds and for the commercial brand 18,112 pounds, and according to measurements taken by the writers 1.05 acres were devoted to each.

COMPARATIVE DATA ON YIELDS

The final determinations of yields of beets and sugar are shown in Table 14. The actual data afford a measure of only the average weight per beet; but in order to compare the performance of the resistant variety and commercial brands, two columns of additional data have been calculated, namely, the yield in tons per acre and the yield of gross sugar in pounds per acre. As a basis for these calculations it seemed best to assume that a perfect stand (26,136 beets per acre) occurred in all cases. This basis is somewhat unfavorable to the resistant variety in most of the cases where curly top appreciably affected the yield, because the disease often reduces the stand and to a greater extent in the commercial brands than in the resistant variety. A striking example of this is shown in Table 12. A comparison of yields on the basis of actual stands is, however, apt to be confusing where differences in stands are due to factors other than the disease.

TABLE 14.—*Results from grower-test plantings of the U. S. No. 1 variety and commercial brands in Utah and Colorado in 1931*

[Data represent averages based upon 20-beet samples from replicated blocks of each variety]

(A) IRRIGATION WATER ADEQUATE; MEDIUM TO SEVERE CURLY TOP

Locality	Date of planting	Grower	Variety	Weight per beet [1]	Yield per acre [2]	Sucrose [3]	Gross sugar per acre [4]
				Pounds	*Tons*	*Per cent*	*Pounds*
Corinne, Utah	Apr. 2	A. M. Reeder	U. S. No. 1	1.89	24.7	17.5	8,644
			Dippe	1.41	18.4	18.3	6,744
			Difference	.48	6.3	[5] —.8	1,900
		O. Christensen	U. S. No. 1	1.47	19.2	17.8	6,839
			Dippe	1.12	14.6	18.4	5,387
			Difference	.35	4.6	[5] —.6	1,452
Tremonton, Utah	Apr. 7	A. N. Wight	U. S. No. 1	1.49	19.5	18.1	7,048
			Frederiksen	.91	11.9	19.1	4,543
			Difference	.58	7.6	[5] —1.0	2,505
		C. W. Summers	U. S. No. 1	1.08	14.1	17.6	4,968
			Frederiksen	.45	5.9	17.8	2,093
			Difference	.63	8.2	—.2	2,875
Lewiston, Utah	Apr. 25	D. Butters	U. S. No. 1	2.08	27.2	15.1	8,209
			R. & G. Pioneer	1.74	22.7	15.8	7,185
			Difference	.34	4.5	[5] —.7	1,024

[1] Determined from 20-beet samples harvested as explained in the text.
[2] Calculated on the basis of a 100 per cent stand (26,136 beets per acre) by multiplying average weight per beet in pounds by 26,136 and reducing to tons.
[3] The writers are indebted to the Utah-Idaho Sugar Co. and to the Gunnison Sugar Co. for analyses made in connection with this work.
[4] Determined by multiplying yield per acre in pounds by average sucrose percentage, hence it may differ slightly from a weighted average.
[5] Shows statistical odds of 30 to 1 by Student's method of analysis (*1, 10*) that a difference as great as this was not due to chance alone.

TABLE 14.—*Results from grower-test plantings of the U. S. No. 1 variety and commercial brands in Utah and Colorado in 1931*—Continued

B) IRRIGATION WATER EXTREMELY INADEQUATE; VERY LITTLE CURLY TOP AT ASARCO FARM AND S. TAYLOR'S; SEVERE CURLY TOP AT N. P. ANDERSON'S AND L. SPAULDING'S

Locality	Date of planting	Grower	Variety	Weight per beet	Yield per acre	Sucrose	Gross sugar per acre
				Pounds	*Tons*	*Per cent*	*Pounds*
Magna, Utah	Mar. 24	Asarco farm	U. S. No. 1	1.36	17.8	15.2	5,403
			Elite Braune	1.33	17.4	17.4	6,048
			Difference	.03	0.4	[1]—2.2	—645
	Mar. 23	S. Taylor	U. S. No. 1	1.61	21.0	16.4	6,901
			Elite Braune	1.48	19.3	17.6	6,808
			Difference	.13	1.7	[1]—1.2	93
Elsinore, Utah	Apr. 15	N. P. Anderson	U. S. No. 1	.67	8.8	15.5	2,714
			Strube	.53	6.9	16.6	2,299
			Difference	[1].14	1.8	[1]—1.1	415
Hooper, Utah	Apr. 27	L. Spaulding	U. S. No. 1	.83	10.8		
			R. & G. Old Type	.46	6.0		
			Difference	[1].37	4.8		

(C) IRRIGATION WATER ADEQUATE; VERY LITTLE CURLY TOP

Fruita, Colo.	Apr. 14	J. H. Talbert	U. S. No. 1	1.89	24.7	17.6	8,694
			Elite Braune	1.93	25.2	17.6	8,878
			Difference	—.04	—.5	0	—184
	May 26	F. Boyd	U. S. No. 1	1.47	19.2	18.1	6,954
			Elite Braune	1.32	17.3	18.0	6,210
			Difference	.15	1.9	.1	744
Salt Lake City, Utah.	Apr. 14	M. Park	U. S. No. 1	1.44	18.8	17.5	6,586
			Elite Braune	1.42	18.6	17.8	6,606
			Difference	.02	.2	—.3	—20

[1] Shows statistical odds of 30 to 1 by Student's method of analysis (*1*, *10*) that a difference as great as this was not due to chance alone.

Table 14, A, shows the results from 2 farms at Corinne, 2 at Tremonton, and 1 at Lewiston.[20] The districts at Corinne and Tremonton have come in recent years to have the reputation of being bad curly-top areas. Presumably the beet leaf hoppers reach these areas first in the course of the migration into the Bear River Valley. Lewiston, in Cache Valley, has not experienced heavy injury so often, but more or less damage has frequently been reported there. On all five farms the yield from the U. S. No. 1 variety was significantly greater than that from the commercial brands. Most of the yield comparisons are very clear cut. The 20-beet samples must have been very representative because of the remarkable uniformity.

Student's method (*10*) was used in analyzing the results. This was chiefly a matter of convenience, however, because the correlation between pairs was very small. The odds against the difference being

[20] The harvest at Butters' farm was completed by J. O. Culbertson, assistant agronomist, Division of Sugar Plant Investigations, and the analyses were made by the Amalgamated Sugar Co. The yield record secured on the Spaulding farm was likewise taken by J. O. Culbertson.

due to chance were very great at Reeder's, Christensen's, and Summers' (over 2,000 to 1); at Wight's, 832 to 1; and at Butters', 103 to 1. In estimating the odds, the difference is referred to as either plus or minus. Probably the most striking field demonstration was on the Wight farm, where the actual yield was nearly doubled by the use of the resistant seed.

The percentage of sucrose for the beets from the farms listed in Table 14, A, except the Summers' farm, was significantly lower in the U. S. No. 1 variety than in the commercial brand. Larger beets, however, were used in the samples taken for analyses of the U. S. No. 1 variety. In each case the gross sugar per acre was very materially increased by the use of the resistant seed.

Table 14, B, shows three cases where the sucrose percentage of the U. S. No. 1 variety was very much lower than that of the commercial brand. At Asarco farm there was a difference of 2.2 per cent in

FIGURE 8.—Grower-test planting on the Anderson farm at Elsinore, Utah, showing the U. S. No. 1 variety at the right and a commercial brand (Strube) at the left. Planted April 15, 1931; photographed August 14, 1931

favor of the commercial brand. This exceptionally low sugar content may be partly explained by the nature of environmental conditions during the summer. At Asarco farm there was an excellent stand of beets in most of the field. Conditions were optimum for a thrifty growth until the middle of July, and only a very small percentage of beets showed symptoms of curly top. Very suddenly the water supply for irrigation was shut off completely. The field became drier and drier until the leaves wilted down almost completely every day. At this time, a fairly marked contrast was apparent between the U. S. No. 1 variety and the commercial brand. Especially in the driest portions of the field, the U. S. No. 1 variety seemed more resistant to the drought. It maintained a darker green color and in general a somewhat better appearance. This difference in reaction to an inadequate supply of moisture presumably accounts in some way for the marked difference in the sucrose percentage.

The S. Taylor farm, at Magna, was within a short distance of Asarco farm and was affected by similar conditions as regards water. Here also the percentage of sucrose was exceptionally low in the U. S. No. 1 variety. At the N. P. Anderson farm, at Elsinore, the drought was very severe during most of the summer, but more especially during the first part of the growing season. Although the U. S. No. 1 variety was less injured by curly top than the commercial brand (Strube), as shown in the photograph taken August 14 (fig. 6), the yields obtained were so strongly influenced by the water shortage as to nullify largely the advantage arising from the resistance of the U. S. No. 1 variety. Table 14, B, shows very low yields at the Anderson farm, and again the sucrose percentage of the U. S. No. 1 variety was exceptionally low.

Through the courtesy of W. A. Shands, assistant entomologist, Bureau of Entomology, United States Department of Agriculture, at Grand Junction, Colo., two plantings were made possible in the Grand Valley of Colorado. Mr. Shands was well informed regarding invasions of the beet leaf hopper in the Grand Valley, and the plantings were located where considerable damage occurred in 1930. In 1931 migrations of leaf hoppers were known to have occurred, and the insects were observed in considerable numbers in both fields where the plantings were made. Nevertheless, the percentage of curly-top infection was light and seemed to be of a very mild type. At the end of the season, the observation of one of the writers (Owen) was that there was no appreciable damage from curly top in either the commercial brand or the U. S. No. 1 variety. Table 14, C, shows the results of both of the Colorado plantings. There was no significant difference in yield between the commercial brand and the U. S. No. 1 variety, and the percentage of sucrose was practically identical.

The grower-test plantings in Utah and Colorado have tended to confirm the results of the preliminary tests. Generally the sugar content was within close range of the commercial brands, but in three instances because of severe drought, the difference in sucrose percentage was 1.1 to 2.2 per cent, in favor of the commercial brands used as checks. It is believed, however, that this condition was exceptional. Furthermore, it would be entirely impracticable to attempt to grow sugar beets without a better supply of moisture than was available in the three instances referred to.

COMPARATIVE DATA ON QUALITY

A question of vital interest to the manufacturers of beet sugar is the purity of the juice. An effort was made, therefore, to secure extensive data on the apparent-purity coefficients of the U. S. No. 1 beets in the various plantings. Table 15 shows that in some cases the apparent purity for the U. S. No. 1 variety is somewhat higher than that for the commercial brand and that in other cases it is slightly lower. As none of these differences is statistically significant, it seems safe to conclude that the apparent purity for the U. S. No. 1 variety is fully equal to that of the commercial brands used for comparison.

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TABLE 15.—*Apparent purity of the U. S. No. 1 variety compared with that of commercial brands*

Locality	Grower	Apparent purity			Number of comparisons between commercial and U. S. No. 1
		U. S. No. 1	Commercial	Difference [1]	
Corinne, Utah	A. M. Reeder	90.2	90.0	0.2	8
	O. Christensen	90.1	90.2	—.1	12
Tremonton, Utah	A. N. Wight	89.7	89.9	—.2	4
	C. W. Summers	89.7	89.0	.7	4
Magna, Utah	Asarco farm	87.3	86.1	1.2	3
	S. Taylor	88.7	87.6	1.1	7
Elsinore, Utah	N. P. Anderson	87.6	87.4	.2	20
Fruita, Colo	J. H. Talbert	90.4	91.2	—.8	12
	F. Boyd	88.7	88.6	.1	6
Salt Lake City, Utah	M. Park	89.2	88.5	.7	9
Weighted average		89.12	88.94	.176±.14	

[1] When the commercial exceeds U. S. No. 1 a minus sign is used.

SPECIAL DATA ON U. S. NO. 1

BOLTERS

Wherever the plantings were made early and cold weather occurred during germination, a few plants of the U. S. No. 1 variety were observed to form seed stalks. Occasionally a bolter was observed also in commercial brands, but not nearly so frequently.

On the station plot at Salt Lake City, Utah, the first plantings were made on March 23 and 24, 1931. This was a very early planting for this locality, and the weather became very cold during germination and early growth. The result was a fairly high percentage of bolters among strains that had a tendency in that direction. The bolters were undoubtedly in higher proportion here than in any of the grower-test plantings in Utah or Colorado. Out of 1,857 plants in the Salt Lake City plot, where conditions favoring bolting were most pronounced, 24, or 1.3 per cent, of the U. S. No. 1 variety produced seed stalks in this abnormal manner. Under the same conditions, among approximately the same number of plants, there were only two bolters in a commercial brand (Pioneer). In later plantings there was a very decided decrease in the percentage of bolters. Even special strains, selected for genetic investigations, that bolted over 50 per cent in the March 23 planting, did not bolt at all when planted May 19. In plots on the same field at Salt Lake City planted April 20 there was only 1 bolter among 646 plants of the U. S. No. 1 variety. In a planting made May 19 there was no bolting whatever. From this experience it would seem that the small amount of bolting which occurs in the U. S. No. 1 variety, while noticeable, is of almost negligible economic importance and is not likely, under Utah conditions, to be a factor in any but extremely early plantings.

VARIABILITY

As previously stated, the U. S. No. 1 variety was produced by combining various strains selected on the basis of curly-top resistance and commercial quality. Under conditions of severe curly-top infection, some plants of the U. S. No. 1 variety are rather susceptible; the

majority, however, show a tolerance that is in decided contrast with that of commercial brands; and a few individuals seem to have a very high resistance.

The presence of these apparently extremely resistant individuals in the U. S. No. 1 variety was first observed in experimental plantings in 1930 near Castleford, Idaho.[27] Of these, the writers selected the most outstanding individuals, seed from which has now been produced and was subjected to critical tests during the summer of 1932.

Although the resistant plants selected at Castleford in 1930 appeared to be absolutely free from curly top while exposed to an extremely bad epidemic, yet soon after the roots were set out as mother beets the following spring severe cases of curly top developed. Some of these especially resistant individuals also showed conspicuous vascular discoloration in the root. It seems possible, therefore, that part of the apparent resistance may have been due to some environmental influence. A great many more selections were made in 1931, however, and the breeding work will soon indicate whether or not some of this apparently high resistance is truly heritable.

In these extremely resistant individuals there was a tendency for the root to be somewhat sprangled and for the crown to be large and of poor proportions. However, there were some very well-shaped roots among them, especially in the smaller individuals. Some individuals reached a large size, 8-pound to 10-pound beets being not at all uncommon.

The sugar content of these especially resistant large beets is also of considerable interest. Douglas Scalley, district manager of the Utah-Idaho Sugar Co., became interested in this point, and from the A. N. Wight farm at Tremonton, Utah, he secured three of the largest beets he could find. After removal of the crown, the average net weight per beet of these three beets was 4.5 pounds. The analyses as compared with analyses of 20-beet samples of the U. S. No. 1 variety and the commercial brand Frederiksen, made at the Garland factory, are shown in Table 16.[28]

During the harvest at the Wight farm, 30 of the especially resistant beets were taken by the writers for mother beets. The analyses of these beets in comparison with the agronomic samples are given in Table 17.[29]

TABLE 16.—*Comparison of three large, highly resistant sugar beets (U. S. No. 1 variety) with four random 20-beet samples of the U. S. No. 1 variety and a commercial brand (Frederiksen), taken from the Wight farm, Tremonton, Utah, in 1931*

[Analyses were made at the factory at Garland, Utah]

Data	Average weight per beet	Sucrose	Coefficient of apparent purity
	Pounds	*Per cent*	
Random 20-beet sample of commercial (Frederiksen)	1.01	18.6	89.3
Random 20-beet sample of U. S. No. 1	1.48	18.0	89.7
3 especially large beets of U. S. No. 1 [a]	4.50	16.5	88.5

[a] Selected by Douglas Scalley, district manager, Utah-Idaho Sugar Co.

[27] Experimental plantings made by C. E. Cormany.

[28] All figures were obtained through the courtesy of J. P. Holmgreen of the Utah-Idaho Sugar Co.

[29] These analyses were made at the Government laboratory at Salt Lake City. Comparisons can not be made directly with Table 14 because in that table analyses made by the Utah-Idaho Sugar Co. at Garland and those made at Salt Lake City are averaged together.

TABLE 17.—*Comparison of 30 highly resistant sugar beets (U. S. No. 1) with four random 20-beet samples of the U. S. No. 1 variety and a commercial brand (Frederiksen), taken from the Wight farm, Tremonton, Utah, in 1931*

Data	Average weight per beet	Sucrose
	Pounds	*Per cent*
Random 20-beet sample of commercial (Frederiksen)	0.8	19.4
Random 20-beet sample of U. S. No. 1	1.5	18.3
30 especially resistant beets of U. S. No. 1	[1] 3.9	15.5

[1] The average weight per beet of the 30 especially resistant beets, including the crown, was 4.69 pounds. Assuming that 20 per cent of the beet would be topped off in commercial practice, the approximate average weight per beet, comparable to the other weights given, would be 3.9 pounds.

It will be noted that the results secured from the 30 especially large beets are not so favorable as those from the 3 taken by Scalley. The former averaged only 15.5 per cent sucrose, whereas the latter averaged 16.5 per cent. Nevertheless, when one considers the large size of some of these outstanding individuals (average weight, 3.9 pounds per beet) 15.5 per cent sucrose seems acceptable. Mention might also be made of the variability of the sucrose percentage among the 30 large beets. The individual having the lowest sucrose percentage weighed (with crown) 6.2 pounds and contained 11.4 per cent sucrose. The individual showing the highest sucrose percentage weighed 4.1 pounds (with crown) and contained 18.4 per cent sucrose. One exceptionally fine beet weighed 5.2 pounds (with crown) and had 17 per cent sucrose. The largest beet in the group weighed 9.3 pounds (with crown) and had 14.4 per cent sucrose.

By selecting the most resistant individuals and those having the best shape and sugar content, it is hoped to develop a much better strain of beets than the present U. S. No. 1 variety.

COMPARISON OF FIRST AND SECOND GENERATIONS

Of considerable importance is the performance to be expected from successive increases of the U. S. No. 1 variety reproduced without continued selection. In the present study the investigators have utilized the overwintering-in-the-field method of seed growing in which the seed is planted in September, the plants overwintered in the field, and the seed crop obtained in the early summer of the following year. This appears to be a practical method for growing seed in those portions of the United States where the winter conditions are mild (*11*), but it does not permit of any selection of mother beets.

All investigators who have experimented with the U. S. No. 1 variety recognize the desirability of further selection and breeding work with this and with other promising selections. Continued effort is being made by Government workers and sugar companies in this direction. Nevertheless, a very vital question must be decided in connection with the immediate utilization of the new variety. Only a few hundred pounds of the first increase of the original U. S. No. 1 seed are available. Will the succeeding generations maintain the standard sufficiently to make it worth while to reproduce second, third, and even fourth direct multiplications?

From a theoretical standpoint, provided no unrecognized selections are taking place, it is difficult to see how a few generations of reproduction with full random mating could change the general constitution of the population of plants that make up a variety such as the U. S. No. 1. A careful observation of a field of sugar beets grown for seed, however, reveals the fact that full random mating may not be entirely possible. Even from transplanted mother beets there is a strong tendency for a certain percentage of the plants to flower earlier than the average and set seed in abundance; while other plants begin flowering later than the average, and many of these contribute very little or nothing to the following generation or "increase" of seed. With seed produced by overwintering plants in the field, this point is of particular interest because among closely spaced plants there is a very wide variation in time of flowering. What effect this uneven distribution in seed production has on the quality of the offspring can be determined only by experimental evidence. The greatest danger would appear to be in an increased percentage of plants that have a tendency to bolt, which is already an undesirable characteristic of the U. S. No. 1 variety. It is hoped, however, that undesirable tendencies will not be multiplied to an appreciable degree while the variety is being propagated to meet an emergency.

In 1931 an effort was made to secure preliminary data on the behavior of the first generation from the U. S. No. 1 seed as compared with a second generation (otherwise referred to in this paper as "first increase") reproduced at St. George, Utah, by the overwintering-in-the-field method. An effort was made to arrange plantings of the first and second generations of the U. S. No. 1 variety in such a way that a very critical comparison could be made. In order to have as many replications as possible, small plots were used. Each plot was made up of four rows 25 feet long and 20 inches apart. The plots were replicated up and down the field in a full random arrangement (*10*). A third strain, the commercial brand Pioneer, was used as a check. Only the two center rows were used for the harvest record. Ten replications were made at Salt Lake City, 10 at Granger, and 6 at Logan. At Granger a very severe epidemic of curly top was brought about by planting diseased mother beets in the vicinity of the experiment. At Salt Lake City curly top became severe during the latter part of the summer, but a very vigorous growth had already been made, so the disease did not have a marked effect upon the yield. The Logan planting was situated on the Greenville farm of the Utah Agricultural Experiment Station, where there was practically no damage from curly top. Table 18 gives a very brief summary of all the results.

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TABLE 18.—*Comparison of the first and second generations of the U. S. No. 1 variety with a commercial brand (Pioneer) in Utah in 1931*

[Results represent averages from the replicated plots]

Locality	Replications[1]	Yield per acre				Sucrose					
		U. S. No. 1		Commercial	Difference required for significance[2]	U. S. No. 1					Commercial
		First generation	Second generation			First generation	Second generation	Difference[3]	Variance of difference	Standard deviation of difference	
		Tons	*Tons*	*Tons*	*Tons*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Salt Lake City	10	25.5	25.1	19.6	3.4	13.31	13.92	−0.61±0.54	0.042	0.802	14.01
Logan	6	22.0	21.1	19.9	3.5	17.77	17.72	.05± .40	.353	.594	18.54
Granger	10	8.0	7.8	2.4	1.1	17.42	16.82	.60± .24	.124	.352	[4]16.15
Weighted average								−.13± .45	.438		

[1] A sample of 20 normally competitive beets was taken from the 2 center rows of each plot for analysis, with the exception of the Granger plots, where 2 plots were required for a 20-beet sample of normally competitive beets.

[2] The odds necessary for significance are considered to be approximately 30 to 1. In estimating these odds, average standard deviations were calculated according to the method outlined by Student (3) and Student's tables published in Metron (2) were used in deriving the odds.

[3] The probable errors were derived by considering the results in pairs, i. e., the third variable (the commercial variety) was not considered in this comparison. By working out an average variance including the third strain a slightly smaller probable error was secured for the Salt Lake City plot (0.423 instead of 0.540).

[4] Approximation derived from the sucrose in the juice. The commercial beets (Pioneer) on the Granger plot were too small to rasp and run with the cold-water-digestion method. For the other sucrose determinations the Sachs-Le Docte cold-water-digestion method was used.

Table 18 shows that the acre yields of the first and second generations of the U. S. No. 1 variety were almost identical. With the exception of the Logan results, there was, however, a very decided increase over the commercial brand Pioneer. At Salt Lake City the difference in sucrose percentage was 0.61,[30] in favor of the second generation; at Granger the difference was 0.60, in favor of the first generation. At Logan the sucrose percentages for the two different generations were practically equal.

No differences in bolting tendency were ascertained. In the entire test there were 8 bolters in the first generation of U. S. No. 1 variety, 7 bolters in the second generation, and 1 bolter in the commercial brand.

It is perhaps unfortunate that a still more extensive experiment was not carried out, but from the results available the second generation of the U. S. No. 1 variety does not appear to be significantly different from the first generation.

More experimental evidence is highly desirable, especially from the third, fourth, and fifth generations of this seed, reproduced in the same manner as the second generation, that is, by overwintering the plants in the field and without any selection. This method, moreover,

[30] On the plots at Salt Lake City a great deal of difficulty was experienced in securing irrigation water during the summer, as the supply of water was always exhausted before it reached the end of the rows. This irregular irrigation seemed to affect the percentage of sucrose even more than the yield. The sucrose percentages for the Salt Lake City plots were so extremely variable that the difference between the two generations of the U. S. No. 1 variety (0.61±0.54) was less than twice its probable error and was wholly insignificant. The difference in sucrose percentage at Granger (0.60±0.24), however, indicated much less variability.

if the results proved satisfactory, would be especially suitable to American conditions.

At various times the sugar-beet companies in this country have grown their own seed from commercial brands imported from Europe. Frequently these increases have been made without any effort at selection. Generally good results have been reported, but it is unfortunate that more experimental evidence is not available to show whether the seed of the second generation was genetically inferior or superior to the parental material.

Dean A. Pack became interested in this problem, and initiated two experiments. In 1929 commercial Braune seed was secured, and a random sample was taken for increasing at St. George, Utah, by planting in September and harvesting the next spring. The progenies from the St. George increase were compared with the parental seed on the experimental plots of the Gunnison Sugar Co. in 1930. Stands were not sufficiently comparable to enable one to judge yielding ability, but eight 5-beet samples from each failed to reveal any significant difference in percentage of sucrose. A sample from a lot of Pioneer was grown in a similar manner at St. George in 1930. This seed was compared with the parental Pioneer in 1931. The plan of the experiment was very similar to that described for the two generations of the U. S. No. 1 variety. There were 10 replications at Salt Lake City, 10 at Granger, and 6 at Logan. There were no significant differences in yield. At Salt Lake City there was a difference of 0.66 ± 0.20 in sucrose percentage, in favor of the original German seed, but a high probable error is associated with the difference for reasons given in footnote 30, page 38. At Logan there was a difference of 0.25 in sucrose percentage in favor of the parental seed. At Granger the two generations tested exactly the same in sucrose percentage.

The results of these tests indicate that, contrary to common belief, the second generation of sugar-beet seed from commercial brands does not immediately show great deterioration in the quality of the sugar beets produced. This conclusion seems justified also by the genetic considerations involved.

TESTS IN CALIFORNIA [31]

Agronomic-evaluation studies on the curly-top-resistant variety U. S. No. 1 have been conducted in California for two years. In 1930, the trial plantings were located at Shafter and Bakersfield, an area where the beet leaf hopper breeds abundantly and where any plantings of beets are almost invariably subject to heavy infestation. Beet culture was started a number of years ago on a large scale in this portion of the San Joaquin Valley, but after the disastrous outbreak of 1919 was abandoned.

The tests conducted in 1931 were on a more extensive scale. In conference with A. W. Skuderna, it was decided to distribute the agronomic tests and the grower-test plantings in such a manner that the U. S. No. 1 variety might be studied when exposed to different

[31] Contributed by Charles Price and Eubanks Carsner. The experimental work at Bakersfield, Buttonwillow, Chino, Dos Palos, Firebaugh, Oxnard, and Shafter was conducted by Price. The grower-test plantings in the central California area were handled by Carsner. Acknowledgment is due Glenn E. Gillespie, scientific aide, for assistance in the work conducted by Price.

degrees of curly top and when not exposed to the disease. The localities chosen and the curly-top hazard to be expected in each were as follows:

Oxnard.—In this locality losses from curly top are usually so slight as to be negligible.

Chino.—The curly-top disease in this area is more severe than at Oxnard; the most severe outbreaks have caused serious losses. The crop damage ordinarily caused by the disease may be classed as slight to moderate.

Shafter, Buttonwillow, Bakersfield, Firebaugh, and Dos Palos.—These places in the San Joaquin Valley were selected because of their location within the breeding area of the beet leaf hopper. Sugar-beet growing had been carried on from time to time, and factories had been established in the southern portion of the San Joaquin Valley. These had been abandoned for a number of causes, among which the curly-top disease was undoubtedly of major importance, and it was commonly conceded that sugar-beet growing in the entire southern area of the valley was extremely hazardous.

Manteca.—This district, at the northern end of the San Joaquin Valley, is practically on the edge of a vast leaf-hopper breeding area and has regularly suffered heavy losses from curly top.

Union Island, McDonald Island, and Clarksburg.—These districts are in the same general area. Clarksburg is in the lower Sacramento Valley; Union Island and McDonald Island are in the delta of the San Joaquin and Sacramento Rivers. These areas regularly experience some curly-top damage, and sometimes the damage is very great.

King City.—This area, in the southern Salinas Valley, has suffered severely and rather regularly for many years.

The tests undertaken have been of two sorts: (1) Intensive agronomic tests in which close evaluation was attempted by means of small plots frequently replicated, and (2) test plantings, usually in cooperation with a local grower, in which direct comparison of the U. S. No. 1 variety with a commercial brand was obtained by planting a series of alternating strips of the two sorts under consideration in fairly large field plantings. In two of these tests, several planting dates were used in order to provide various conditions of exposure.

INTENSIVE AGRONOMIC TESTS

TESTS AT SHAFTER

The tests at Shafter were conducted from February 6, 1930, to July 9, 1931, on land secured from the United States Cotton Field Station. In the first test the seed, which was planted Feburary 6, 1930, was of the following types: Seed of the U. S. No. 1 variety produced from the mother beets selected in 1929 at Twin Falls, Idaho, (p. 9); seed of a commercial brand (Old Type); and seed of another strain. Since only the comparison of the U. S. No. 1 variety with the commercial brand is of interest in this investigation, the data given herein refer only to these two lots.

In the 1930 test each plot consisted of four rows 60 feet long and 24 inches apart. The plots were arranged in four randomized blocks, thus furnishing four replications of the three seed lots. A stand of approximately 100 per cent was obtained in this planting. The yields were determined by weighing all the beets in a plot. Sucrose percentage and coefficient of apparent purity were determined on five 10-beet samples of normally competitive beets (p. 12) taken from the center two rows of each plot. The results as given are averages of the individual determinations. (Table 19, A.)

TABLE 19.—*Comparison of the U. S. No. 1 variety with a commercial brand (Old Type) at Shafter, Calif., in 1930 and 1931*

[Data represent averages from replicated plots each consisting of 4 rows 60 feet long and 24 inches apart]

Year and variety	Plots	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre	
					Gross	Indicated available
(A) 1930:	*Number*	*Tons*	*Per cent*		*Pounds*	*Pounds*
U. S. No. 1	4	23.073	16.77	86.25	7,739	6,675
Commercial (Old Type)	4	20.568	16.60	85.82	6,828	5,860
Difference		2.505	.17	.43	911	815
(B) 1931:						
U. S. No. 1	15	7.398	15.20	80.6	2,249	1,813
Commercial (Old Type)	5	4.029	14.50	80.8	1,168	944
Difference		3.369	.70	−.2	1,081	869

The yields obtained were high, doubtless because of the comparatively mild curly top of the 1930 growing season. On April 2, 3 per cent of the U. S. No. 1 variety and 27 per cent of the commercial brand showed mild curly top. On June 7, 5 per cent of the U. S. No. 1 variety and 40 per cent of the commercial brand showed mild curly top. It was noted at the close of the season that the U. S. No. 1 variety remained green, whereas the commercial brand was beginning to turn yellow.

The average yield of the U. S. No. 1 variety was greater than the yield of the commercial brand, the difference being 2.505 tons per acre. Because of the range of values obtained in the individual plots, it is doubtful whether this difference is significant. The sucrose percentages and the apparent-purity coefficients were not significantly different. The greater sugar-per-acre yield for the U. S. No. 1 variety was due to the higher tonnage for that variety.

In the test at Shafter in 1931, five seed lots were used, each of which was replicated five times. The plots were arranged in a Latin square. The planting was made from February 3 to 6.

The five seed lots consisted of the three increases of the original seed stock of the U. S. No. 1 variety, a commercial brand of seed (Old Type), and seed of another strain.

A heavy influx of beet leaf hoppers occurred just after thinning when the beets were in the 8-leaf stage. On April 4, counts of leaf hoppers showed about one leaf hopper per plant. At this time no disease was evident in any of the plots. Later examinations showed the following average percentages of infected plants: For the U. S. No. 1 variety, 1, 34, and 95 per cent; and for the commercial brand, 13, 88, and 100 per cent, on April 17, May 3, and June 8, respectively. After June 8 the curly-top percentages remained fairly constant. At this time distinct yellowing was shown by the commercial brand, in contrast to the green color of the U. S. No. 1 variety.

Unfortunately, the garden nematode was generally present throughout these plots and greatly affected the yields obtained. At the time of harvest an attempt was made to secure comparable samples for determining yield and sucrose percentages from the normally

competitive beets showing the least nematode injury in the various plots.

No significant differences were found among the three seed lots of the U. S. No. 1 variety produced in Utah, California, and New Mexico, respectively.[32] The data given represent averages of the 15 plots of the U. S. No. 1 variety as compared with the average of the commercial brand used as a check. (Table 19, B.)

Conclusions from this test are presented tentatively because of the nematode complication, which prevented accurate evaluation of the extent of curly-top injury. Assuming a fairly uniform effect of the nematodes, as seems justified from the field observations, and taking into consideration the attempt made to choose the plants least affected, the yields may be considered fairly indicative of the performance of the U. S. No. 1 variety as compared with that of the commercial brand. The yield of the resistant variety was significantly greater than the yield of the commercial brand. Only the three plots highest in yield of the commercial brand equaled or exceeded the plot lowest in yield of the U. S. No. 1 variety. The average sucrose percentages showed a difference of 0.7, in favor of the U. S. No. 1 variety, a difference found not to be significant. Similarly, the coefficients of apparent purity were practically equal. The yield of sugar per acre, in which weight, sucrose percentage, and the coefficient of apparent purity enter as factors, was almost twice as great for the U. S. No. 1 variety as for the commercial brand.

TESTS AT BAKERSFIELD

In order to compare the performance of the U. S. No. 1 variety with that of a commercial brand, plantings were made in 1930 and 1931 near Bakersfield, Calif.

The 1930 tests were made with seed from the original selection of the resistant variety. The commercial brand used as a check was Old Type. Because of the limited amount of land available, only one plot was planted to each variety. Each of these two adjacent plots consisted of eight rows 160 feet long and 24 inches apart. The experiment was conducted under optimum conditions of soil, moisture, and fertility. Because of the early date of planting (January 6) the plants did not suffer maximum damage from curly top. On June 4, when the plants were 5 months old, 27 per cent of the commercial brand and 5 per cent of the U. S. No. 1 variety showed curly top. The type of curly top was considered mild. The yield data were obtained by harvesting the entire plot. Determinations of sugar percentage and of coefficient of apparent purity were made on five 10-beet samples of normally competitive beets.

The results of this test are given in Table 20. It will be noted that under the conditions of this experiment the commercial brand exceeded the U. S. No. 1 variety by 1.9 tons per acre in yield and by 0.8 in sucrose percentage. The small number of plots did not permit determination of significance in this experiment.

[32] These data were computed by the analysis-of-variance method but are not reported in detail on account of the nematode complication.

TABLE 20.—*Comparison of the U. S. No. 1 variety with a commercial brand (Old Type), planted in January, 1930, at Bakersfield, Calif.*

[Data obtained from one plot for each variety, consisting of eight rows 160 feet long and 24 inches apart]

Variety	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre	
				Gross	Indicated available
	Tons	*Per cent*		*Pounds*	*Pounds*
U. S. No. 1	18.88	16.1	83.6	6,079	5,082
Commercial (Old Type)	20.80	16.9	83.5	7,030	5,870
Difference	−1.92	−.8	.1	−951	−788

The 1931 tests at Bakersfield were made with the first Beaumont multiplication of the original seed of the resistant variety. The same general planting arrangement was followed as in 1930, except that beets were planted on three dates (January 6, February 10, and March 3), two plots being put out for each type under test. Beet leaf hoppers were noticed on the plants as early as April 7. The first disease counts were made on April 17. The detailed readings of curly-top incidence in these plots are shown in Table 21. The January plantings showed very little curly top throughout the season in comparison with the later plantings. The February plantings were more severely diseased than the January plantings but did not show at the close of the season so high a percentage of curly top as the March plantings. In the March plantings the commercial brand used as a check was very severely affected, the disease incidence reaching 100 per cent on June 8. In the U. S. No. 1 variety 92 per cent curly top was found at the time of this count.

TABLE 21.—*Percentage of plants showing curly top in the U. S. No. 1 variety and in a commercial brand (Old Type), at Bakersfield, Calif., in 1931*

[Data represent averages from two plots, each consisting of eight rows 160 feet long and 24 inches apart]

Variety	Date of planting	Percentage of plants showing curly top on—		
		Apr. 17	May 3	June 3–8
U. S. No. 1 [1]	Jan. 6	1		4
Commercial (Old Type)	do	6		18
U. S. No. 1 [1]	Feb. 10	5		8
Commercial (Old Type)	do	15		30
U. S. No. 1 [1]	Mar. 3	8	8	[2] 29
Commercial (Old Type)	do	25	30	[2] 100

[1] First Beaumont multiplication of original seed.
[2] These counts were made June 8, 1931.

The yield data were based on normally competitive beets from the center four rows of each plot. The yields per acre were computed on the basis of a 100 per cent stand. Determinations of sucrose percentage and coefficient of apparent purity were made from three 20-beet samples from each plot.

Table 22 shows that the U. S. No. 1 variety outyielded the commercial brand, especially in the plantings of February 10 and March 3, where curly top was an important factor. In the March planting the commercial brand yielded only 3.92 tons per acre, a yield far below the cost of production, whereas the U. S. No. 1 variety yielded

11.87 tons per acre. In sucrose percentage and coefficient of apparent purity, the U. S. No. 1 variety, contrary to expectation, exceeded the commercial brand in the February and March plantings. These results seem to indicate that under the conditions of the test the resistant types did not definitely tend to be lower than the commercial brand in sucrose percentage or apparent purity. In yield of sugar per acre, the U. S. No. 1 variety exceeded the commercial brand, especially in the February and March plantings. In indicated-available sugar, the U. S. No. 1 variety greatly exceeded the commercial brand, except in the January planting.

TABLE 22.—*Comparison of the U. S. No. 1 variety with a commercial brand at Bakersfield, Calif., in 1931*

[Data represent averages from two plots, each consisting of eight rows 160 feet long and 24 inches apart]

Variety	Date of planting	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre [1]	
					Gross	Indicated available
		Tons	*Per cent*		*Pounds*	*Pounds*
U. S. No. 1	Jan. 6	27.87	13.4	71.63	7,471	5,366
Commercial (Old Type)	do	26.89	13.7	78.52	7,370	5,787
Difference		.98	−.3	−6.89	101	−421
U. S. No. 1	Feb. 10	24.61	15.20	76.30	7,481	5,708
Commercial (Old Type)	do	15.02	14.15	70.89	4,250	3,013
Difference		9.59	1.05	5.41	3,231	2,695
U. S. No. 1	Mar. 3	11.87	14.0	71.53	3,323	2,377
Commercial (Old Type)	do	3.92	13.3	69.92	1,042	729
Difference		7.95	.7	1.61	2,281	1,648

[1] Obtained by averaging computed sugar yields for the individual plots; hence differing slightly from the product of the means given in this table.

Because of the limited number of plots, it was not possible to estimate statistically the significance of the differences found in this test. It is very clear, however, that where curly top entered as an important factor the trend was strongly in favor of the U. S. No. 1 variety. As curly-top exposure in this experiment was much more severe than is usually encountered by early-planted beets in California, the performance of the U. S. No. 1 variety is noteworthy.

TESTS AT BUTTONWILLOW

Agronomic tests of the U. S. No. 1 variety in comparison with a commercial brand (Old Type) were carried out at Buttonwillow in 1931.

Seed was planted on January 13 and February 12. For the January planting the seed of the U. S. No. 1 variety consisted of three increases of the original seed stock produced at Las Cruces, N. Mex.; St. George, Utah; and Beaumont, Calif., respectively. In the test, these separate increases of the U. S. No. 1 variety were treated as individual varieties and data obtained from each. The plots, each consisting of 8 rows 174 feet long and 20 inches apart, were planted in 5 replications systematically arranged. Each replication consisted of a block of four plots planted to the three U. S. No. 1 increases and to the commercial brand, respectively.

A heavy infestation of beet leaf hoppers, which occurred early in April, resulted in very little injury to the January plants, because

of the preference of the leaf hoppers for the younger plants (February planting) and owing also to the large size of the January plants at the time of exposure and to the mild type of the disease. At harvest time (August 7) there was a definite color contrast between the resistant variety and the commercial brand, the latter being the yellower.

The results of the test are given in Table 23. The three increases of the U. S. No. 1 variety show no significant differences in average weight of individual beets, sucrose percentage, or coefficient of apparent purity. As compared with the commercial brand used as a check, two of the U. S. No. 1 lots were significantly [33] better in weight, and one was on the border line of being significantly better. No significant differences in sucrose percentage between the U. S. No. 1 lots and the commercial brand (Old Type) were found, one exceeding the commercial brand slightly, and two being slightly below it. The commercial brand had the higher coefficient of apparent purity, but the difference in only one case approached significance. It may be concluded that in weight of beets the trend is strongly in favor of the resistant U. S. No. 1 variety and that there are no positive indications of significant differences in quality.

TABLE 23.—*Comparison of three increases of the U. S. No. 1 variety with a commercial brand (Old Type), planted January 15, 1931, at Buttonwillow, Calif.*

[Data represent averages from five plots, each consisting of eight rows 174 feet long and 20 inches apart]

Variety	Weight of individual beets	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre [1]	
					Gross	Indicated available
U. S. No. 1 increase:	*Pounds*	*Tons*	*Per cent*		*Pounds*	*Pounds*
(A) Beaumont, Calif.	1.852±0.058	24.502±0.758	14.88±0.23	78.12±0.57	7,186±196	5,606±121
(B) St. George, Utah	1.690± .066	22.111± .862	15.22± .25	75.85±1.13	6,736±316	5,134±304
(C) Las Cruces, N. Mex.	1.574± .070	20.569± .993	14.74± .23	78.27±1.02	6,054±277	4,716±167
(D) Commercial (Old Type)	1.304± .015	18.217± .196	15.10± .33	81.00±1.36	5,497±208	4,440±154
Difference:						
A—D	[2] .458	[2] 5.985	−.22	−2.88	[2] 1,689	[2] 1,166
B—D	[2] .290	[2] 3.894	.12	−5.15	[2] 1,239	694
C—D	.180	2.352	−.36	−2.73	557	276

[1] Obtained by averaging individual plot values; hence it differs slightly from product of means given in this table.
[2] Significant.

On February 12, plots of each of the U. S. No. 1 seed increases were planted alternately with check plots of the commercial brand (Old Type). Each plot consisted of eight rows 174 feet long and 20 inches apart.

The harvest record was obtained by determining the net weight of all beets produced in one plot of each increase of the resistant variety and in two plots of the commercial brand. This procedure was necessary in order not to interfere with the harvesting operations of the cooperator. In view of the fact, however, that there was no significant difference among the three increases of the U. S. No. 1 variety, the three plots of the resistant variety harvested may be

[33] The probable error was computed by Bessel's formula:

$$P.E.=0.6745\sqrt{\frac{\Sigma d^2}{n(n-1)}}.$$

If the difference between two means was three times its probable error, it was regarded as significant.

considered as replications. Yield per acre was computed from the actual plot yield. The determinations of sucrose percentage and coefficient of apparent purity were based on three 20-beet samples. The results are given in Table 24.

TABLE 24.—*Comparison of three increases of the U. S. No. 1 variety with a commercial brand (Old Type), planted February 12, 1931, at Buttonwillow, Calif.*

Variety	Plots	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre	
					Gross	Indicated available
	Number	*Tons*	*Per cent*		*Pounds*	*Pounds*
U. S. No. 1 increase from—						
Beaumont, Calif.	1	25.262	15.4	78.12	7,781	6,079
St. George, Utah	1	21.426	15.8	75.85	6,771	5,136
Las Cruces, N. Mex.	1	17.272	15.8	77.59	5,458	4,235
Average	1	21.320	15.7	77.19	6,670	5,150
Commercial (Old Type)	2	13.026	15.5	80.99	4,038	3,270
Difference	------	8.294	.2	−3.80	2,632	1,880

Curly top injured this planting considerably, especially the commercial brand. An invasion of beet leaf hoppers occurred early in April; on April 7 it was estimated that the population was about one insect per plant. There was marked color contrast between the resistant variety and the commercial brand as early as April 20; the commercial plants at that time were beginning to show a yellow color. On May 3, 17 per cent of the commercial brand and 2 per cent of the U. S. No. 1 variety were diseased with curly top. The disease increased sharply, and on June 8 both the commercial brand and the U. S. No. 1 variety showed 100 per cent curly top.

The yields of the resistant variety in the January tests were very closely duplicated in the February planting. The yield of the commercial brand in the latter planting was, however, sharply depressed because of the more severe curly-top involvement. The quality of the sugar beets was practically the same. The average sucrose percentage of the U. S. No. 1 variety slightly exceeded that of the commercial brand, and the difference between the coefficients of apparent purity was slightly in favor of the commercial brand. The computed values for sugar per acre, both gross and indicated available, show the marked differences between the resistant and nonresistant sugar beets under curly-top conditions.

TESTS AT OXNARD AND CHINO

In an intensive agronomic test at Oxnard in 1931 comparison was made of the results from the three increases of U. S. No. 1 seed, a commercial brand of seed, and another strain.

The plots in this experiment were arranged in a Latin square. Each plot consisted of four rows 73 feet long and 20 inches apart. The planting was made on April 8, 1931.

The yield data were obtained from normally competitive beets. Yield per acre was computed on the basis of a 100 per cent stand. Sucrose percentage and apparent purity were determined on three 20-beet samples of normally competitive beets from each plot. The results given in Table 25 were computed from the data by Fisher's analysis-of-variance method (*9*). The significance of the differences found has also been determined for certain data.

TABLE 25.—*Comparison of three U. S. No. 1 increases with a commercial brand (Old Type) at Oxnard and Chino, Calif., in 1931*

Variety	Oxnard test [1]					Chino test [2]					Average of Oxnard and Chino test				
	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre [3]		Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre [3]		Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre [3]	
				Gross	Indicated available				Gross	Indicated available				Gross	Indicated available
U. S. No. 1 increase from—	*Tons*	*Per cent*		*Pounds*	*Pounds*	*Tons*	*Per cent*		*Pounds*	*Pounds*	*Tons*	*Per cent*		*Pounds*	*Pounds*
Las Cruces, N. Mex.	26.502	13.48	83.48	7,135	5,954	24.568	14.08	86.30	6,894	5,944	25.535	13.78	84.89	7,014	5,949
Beaumont, Calif.	28.854	13.02	82.49	7,485	6,173	24.672	14.48	87.00	7,145	6,208	26.763	13.75	84.74	7,315	6,190
St. George, Utah	26.842	12.84	80.26	6,874	5,509	25.875	14.38	85.72	7,420	6,360	26.358	13.61	82.99	7,147	5,934
Average	27.399	13.11	82.08	7,164	5,878	25.038	14.31	86.34	7,153	6,171	26.219	13.71	84.21	7,159	6,024
Commercial (Old Type)	26.633	12.61	78.16	6,717	5,253	25.169	13.34	85.72	6,667	5,704	25.901	12.97	81.94	6,692	5,478
Difference	.766	.50	3.92	447	625	−.131	.97	.62	486	467	.318	.74	2.27	467	546
z [4]	.1889	.4057	.4260	.2925	.5508	.0409	.3994		.6190	.6129					
Standard error									559	522					
Standard error of mean									250	234					161
Standard error of difference									354	330					228
Difference required for significance									708	661					456

[1] Data represent averages from 5 plots, each consisting of 4 rows 73 feet long and 20 inches apart, planted Apr. 8.
[2] Data represent averages from 5 plots, each consisting of 4 rows 65 feet long and 20 inches apart, planted Mar. 10.
[3] Obtained by averaging individual plot values; hence it differs slightly from products obtained from the means given in this table.
[4] z=one-half the difference between the natural logarithms of the variances for variety and error. The 5 per cent point for z=0.5907; 1 per cent point=0.8443.

Curly top did not enter as a factor into the Oxnard tests, being present in less than 1 per cent of the plants. The plots were severely injured by a general attack of the leaf-spot disease, and to this the low sucrose percentage obtained throughout the test can safely be assigned.

The arrangement of the plots and the statistical analysis employed have permitted the determination of the standard error of the experiment. This analysis reveals no significant differences among the varieties under these conditions, where curly top was not a factor. In sucrose percentage and in coefficient of apparent purity the data tend to corroborate the results reported from other California localities.

An intensive agronomic test, duplicating the Oxnard test, was conducted at Chino in 1931, planting being made on March 10. In this test comparisons were made of the three increases (made at Beaumont, Calif.; St. George, Utah; and Las Cruces, N. Mex.) of the original U. S. No. 1 seed with one another and with a commercial brand (Old Type) commonly used in this area. The plots, each of which consisted of four rows 65 feet long and 20 inches apart, were arranged in a Latin square.

Curly top was but a slight factor in the experiment. At harvest time the percentage of disease was small, and all cases were of the mild type. There was considerable injury from the leaf-spot disease, but this damage is represented by a reduction in sucrose percentage rather than by a reduction in weight.

Data from the plots were obtained from the center two rows, and only normally competitive beets were taken. Acre yields were computed on the basis of a 100 per cent stand. The determinations of sucrose percentage and coefficient of apparent purity were obtained from three 20-beet samples of normally competitive beets from each plot. Results are given as averages of individual readings.

From the data of the individual plots it has been possible (by Fisher's analysis-of-variance method) to determine the significance of the differences.

In agreement with the results of the test at Oxnard, the test at Chino demonstrated no significant differences in yield per acre, sucrose percentage, or coefficient of apparent purity. The values for sugar per acre, both gross and indicated available, show a certain degree of significance, corresponding to odds of approximately 20 to 1 that the differences obtained were not due to chance. This degree of significance indicates that a fair degree of reliance may be placed on the test and suggests a cumulative effect of the factors previously listed as not significantly different. In this test one of the U. S. No. 1 increases was significantly better than the commercial brand in sugar per acre, but the two other increases were not shown by the test to be better than the commercial brand. Under the conditions at Chino, however, where curly top was not a factor, it could not be shown that the commercial brand had an advantage over the U. S. No. 1 variety in any attribute measured, and it is fairly reasonable to assume a slight superiority of the U. S. No. 1 variety.

The differences among the three increases of the U. S. No. 1 variety were not significant in any attribute measured.

Since the Oxnard and Chino tests so nearly duplicate each other, it is possible to use the two experiments as the basis for an estimate

of the behavior of the U. S. No. 1 variety as compared with that of the commercial brand. (Table 25.) It seems fair to take the average of the three increases of the U. S. No. 1 variety for this comparison, attributing to each mean the standard deviation of the mean found for the experiment.

The standard error of the mean for the two tests was calculated from $\frac{1}{2}\sqrt{V \text{ Chino} + V \text{ Oxnard}}$, which equals 161 pounds. Multiplying by $\sqrt{2}$, 228 was obtained as the standard error of the difference between the mean yields at the two places. The difference in indicated-available sugar, 546, is therefore significantly in favor of the U. S. No. 1 variety, the odds being approximately 72 to 1 that the difference between the U. S. No. 1 variety and the commercial brand would again be in favor of the U. S. No. 1 variety if the two kinds were grown again under similar conditions.

In these experiments the curly-top injury was negligible. It is noteworthy that the U. S. No. 1 variety was apparently the equal of the commercial brand of sugar beets in all important attributes, and that in every case it exceeded the commercial brand in sucrose percentage and in coefficient of apparent purity, though not by significant amounts.

GROWER-TEST PLANTINGS

PLANTING AT FIREBAUGH

A grower-test planting was made at Firebaugh, January 15, 1931, to compare the U. S. No. 1 variety of sugar beets with a commercial brand (Old Type). The seed of the U. S. No. 1 variety used was the first multiplication of the original selection and had been increased at Beaumont, Calif., in 1930. Plots consisting of 12 rows 171 feet long and 20 inches apart were used. Two plots were planted with each type of seed, resistant and nonresistant (commercial). The soil contained a large amount of organic matter and required irrigation only four times during the growing season. The beets in all the plots made a luxuriant top growth. A heavy infestation of the plants by the beet leaf hopper occurred early in April, but because of the comparatively mild type of disease that developed and also because of the size of the plants when first exposed, the injury was not very great. At the time of harvest (July 27) there was a marked contrast in color between the resistant variety and the commercial brand. The commercial-brand plots showed strikingly more yellow color. On June 8, 39 per cent of the U. S. No. 1 variety and 91 per cent of the commercial brand showed curly top. All the normally competitive beets in the four center rows of each plot were taken for the weight determinations. For determinations of sucrose percentage and coefficient of apparent purity, three 20-beet samples were taken from the normally competitive beets of the four center rows of each plot.

The results of this experiment are given in Table 26. The yield from the U. S. No. 1 variety exceeded that from the commercial brand by 5.4 tons per acre. No marked difference in sucrose percentage or in coefficient of apparent purity was found. The indicated-available sugar of the U. S. No. 1 variety exceeded that of the commercial brand by 1,440 pounds per acre. Although this experiment did not permit the determination of the statistical significance of these figures, the results seem to indicate a strong trend in favor of the U. S. No. 1 variety.

TABLE 26.—*Comparison of the U. S. No. 1 variety with a commercial brand (Old Type), planted January 15, 1931, at Firebaugh, Calif.*

[Data represent averages from 2 plots, each consisting of 12 rows 171 feet long and 20 inches apart]

Variety	Percentage of plants showing curly top [1]	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre	
					Gross	Indicated available
		Tons	*Per cent*		*Pounds*	*Pounds*
U. S. No. 1	5	20.255	17.75	81.06	7,191	5,829
Commercial (Old Type)	27	14.831	17.77	83.26	5,271	4,389
Difference		5.424	−.02	−2.20	1,920	1,440

[1] Based on counts made May 3, 1931.

PLANTING AT DOS PALOS

A grower-test planting was made at Dos Palos, on January 15, 1931. Because of unfavorable soil conditions and difficulties in regard to supervision resulting in poor cultural care, no attempt was made to secure yield records. Certain observations made during the course of the season are, nevertheless, of interest. The exact date of the principal influx of beet leaf hoppers is not known, but the plots were found to be heavily infested on May 4. On June 9, it was possible to distinguish the resistant from the check plots (Old Type) but the differences in color and size were not pronounced. On that date 85 per cent of the Old Type plants and 42 per cent of the U. S. No. 1 plants were diseased. The type of disease was very mild in the resistant plots. On July 4, both the resistant variety and the commercial brand showed 100 per cent curly top. There was then a very definite color contrast, the Old Type plots being much more yellow than the U. S. No. 1 plots.

PLANTINGS IN CENTRAL SUGAR-BEET AREA [34]

Additional grower-test plantings were made in the following localities: One near Clarksburg, in the southern end of the Sacramento Valley; 1 on McDonald Island and 1 on Union Island, in the peat-land delta of the San Joaquin and Sacramento Rivers; 1 near Manteca, at the northern end of the San Joaquin Valley; and 1 near King City, in the southern part of the Salinas Valley.[35] In previous seasons sugar beets in the King City and Manteca areas had been regularly affected more or less severely by curly top. Clarksburg, McDonald Island, and Union Island, while regularly suffering some damage, had in general been less severely exposed.

Because of circumstances beyond the control of the investigators, the only data obtained from the Clarksburg planting were those on the comparative rate of development of infection in the resistant variety and the commercial brand. For the same reason, records secured at King City were likewise inadequate. When examined shortly before harvest in midseason, the plots in both localities showed striking differences in favor of the U. S. No. 1 variety both in foliage resistance to curly top and in size of root produced.

[34] N. J. Giddings, senior pathologist, assisted in these tests.

[35] Acknowledgment for helpful cooperation in the location of the plots and in the analyses of samples is due the Holly Sugar Corp. and the Spreckels Sugar Co. The cooperation of the California Packing Corp. and Arthur Shauer, as growers, was also of value in carrying out the tests.

The results from the other grower-test plantings are given in Table 27. The stand in the Manteca plot was so severely damaged by wireworms that yield records were not attempted, but the average weights per beet of the samples taken for the purpose of comparative sugar analyses afford some basis of comparison. As a means of discounting the wireworm complication the calculated yield per acre on the basis of a 100 per cent stand is likewise given. The data were obtained from 5 samples, comprising 53 roots, of the U. S. No. 1 variety, and 5 samples, comprising 57 roots, of the commercial brand. At Union Island and McDonald Island [36] the data were secured from ten 20-beet samples taken at random from each plot. The fact that the plants were selected at random rather than as normally competitive beets is disregarded in the theoretical yields calculated on the basis of a 100 per cent stand.

TABLE 27.—*Results from grower-test plantings at Manteca, Union Island, and McDonald Island, Calif., in 1931*

[Data represent averages from samples]

Locality	Date of planting	Variety	Average weight per beet	Yield per acre [1]	Sucrose	Coefficient of apparent purity	Sugar per acre	
							Gross	Indicated available
			Pounds	*Tons*	*Per cent*		*Pounds*	*Pounds*
Manteca	Jan. 15	U. S. No. 1	1.43	18.687	16.36	90.8	6,114	5,552
		Commercial [2]	1.05	13.721	17.40	92.2	4,775	4,403
		Difference	.38	4.966	−1.04	−1.4	1,339	1,149
Union Island [3]	Feb. 15	U. S. No. 1	2.13	27.834	17.00	78.9	9,464	7,467
		Commercial [4]	1.68	21.954	16.25	78.1	7,135	5,572
		Difference	.45	5.880	.75	.8	2,329	1,895
		U. S. No. 1	2.72	35.544	16.45	78.7	11,694	9,203
		Commercial [4]	2.025	26.462	16.75	79.6	8,865	7,057
		Difference	.695	9.082	−.30	−.9	2,829	2,146
McDonald Island	Mar. 12	U. S. No. 1	2.32	30.317	17.89	88.2	10,847	9,567
		Commercial [5]	1.97	25.743	18.23	88.3	9,386	8,288
		Difference	.35	4.574	−.34	−.1	1,461	1,279

[1] The acre yields were computed on a 100-per-cent-stand basis for sugar beets of the average weight as shown by the samples. Actual yields obtained from the McDonald Island plot were: U. S. No. 1, 19.4 tons per acre; commercial, 16 tons per acre.
[2] Dieckmann brand.
[3] The records from each of the plots on Union Island are shown separately because of wide differences in soil conditions between the 2 sets of plots. The effects of this variability are largely avoided by the comparisons as given.
[4] Schreiber & Son brand.
[5] Brand not recorded.

These tests show that in every case the U. S. No. 1 variety outyielded the commercial brand with which it was compared. In three cases the difference in the sucrose percentage was in favor of the commercial brand and in one case in favor of the U. S. No. 1 variety. Because of the limited number of samples the significance of these differences in sucrose percentage was not determined, but it should be noted that the small range is well within the sampling error. Similarly, the coefficients of apparent purity are not widely different. The

[36] It is interesting to note in the case of the McDonald Island test that for the increase in yield from the resistant plot, the grower, A. Shauer, reported receiving $36.04 more return than from the average of the 2 adjacent commercial brand plots, or an increase of $25 per acre.

indicated-available sugar of each of the U. S. No. 1 lots was substantially larger than that of the commercial brand with which it was compared.

The results of the grower-test plantings in the central California area indicate that the U. S. No. 1 variety is distinctly superior in curly-top resistance to the commercial brands now being used and approximately equal to them in quality. Its apparently satisfactory performance under various conditions indicates that the U. S. No. 1 variety has a wide adaptability.

TESTS IN NEW MEXICO [37]

A series of tests was undertaken in 1930 and 1931 at State College and in 1931 at Las Vegas, in order to observe the performance of the U. S. No. 1 variety in comparison with commercial brands of sugar beets.

Observations from 1923 to the present time have shown that the curly-top disease occurs as practically a 100 per cent infestation in the sugar beets grown in the area near Las Cruces. It has always been so severe as to make the yield from commercial sugar beets entirely unprofitable. At Las Vegas, which is in a commercial sugar-beet-growing area, the outbreaks of the disease have been of a sporadic nature. Very little damage has been noticed in some years, whereas in other years, for example, in 1930 and 1931, the disease has been prevalent and has reduced yields sharply.

TESTS AT STATE COLLEGE

For the 1930 tests at State College, the seed used was from (1) the original U. S. No. 1 seed produced in 1929 at Twin Falls, Idaho; (2) an inbred line (90116–0) produced at Rocky Ford, Colo.; and (3) a commercial brand (Pioneer). In order to have at least one planting in the young-seedling stage at the period of the greatest influx of beet leaf hoppers, thus affording maximum exposure, plantings were made on three dates, namely, March 20, April 15, and May 15.

Each of the three kinds of seed was planted in systematically arranged plots replicated five times. Each plot was a single row 195 feet long and 22 inches from the adjacent plot. Table 28 shows the results for the three plantings of the U. S. No. 1 variety and the commercial brand used as a check.

The test demonstrated very clearly that in curly-top resistance the U. S. No. 1 variety is decidedly superior to the commercial brand used as a check. (Fig. 7.) Shortly before harvest each plant in this test was graded (0 to 6) according to the degree of curly-top injury it showed. The average of these grades represents the mean curly-top injury to the sugar-beet strain under consideration. A comparison of the averages shows decisively that in every case the commercial brand was more seriously diseased with curly top than was the U. S. No. 1 variety.

A comparison of the final stand with the original stand shows that there was a higher mortality in the commercial brand than in the U. S. No. 1 variety. For the plantings of March 20, April 15, and May 15, the resistant beet showed a mortality [38] of 20, 28, and 29.5

[37] Contributed by Harry A. Elcock. Acknowledgment is made to the New Mexico Agricultural Experiment Station for cooperation in these tests.

[38] Observation throughout the season indicated that the curly-top disease was the chief factor decimating the stand.

per cent, respectively; whereas the corresponding plantings of the commercial brand showed a mortality of 42.7, 67, and 44.6 per cent, respectively.

FIGURE 7.—Sugar-beet tests under curly-top epidemic conditions at State College, N. Mex. Rows 19a and 22a, U. S. No. 1 variety; rows 20a and 23a, commercial (Pioneer) brand; rows 18a, 21a, and 24a, inbred line. Planted March 20, 1930; photographed September 12, 1930

TABLE 28.—*Comparison of the U. S. No. 1 variety with a commercial brand (Pioneer) of sugar beets in tests at State College, N. Mex., in 1930*

(Data represent averages from five single-row plots, each 105 feet long [1])

Date of planting and variety	Curly-top grade [2]	Stand count of beets per plot		Original stand remaining at harvest	Yield per acre	Sucrose [3]	Coefficient of apparent purity [4]	Sugar per acre	
		June 17	Sept. 2 (harvest)					Gross	Indicated available
		Number	*Number*	*Per cent*	*Tons*	*Per cent*		*Pounds*	*Pounds*
Mar. 20:									
U. S. No. 1	3.4±0.10	95	76	80.0	6.695±0.289	13.5±0.21	84.6	2,348	1,986
Commercial (Pioneer)	4.0± .07	129	74	57.3	2.993± .246	13.5± .20	86.0	808	695
Difference	−1.2± .12	−34	2	22.7	5.702± .379	0	−1.4	1,540	1,291
Apr. 15:									
U. S. No. 1	4.0± .07	125	90	72.0	0.499± .417	13.4± .20	80.6	1,742	1,404
Commercial (Pioneer)	5.5± .03	121	40	33.0	1.119± .147	14.8± .20	85.8	331	284
Difference	−1.5± .08	4	50	39.0	5.380± .442	−1.4± .35	−5.2	1,411	1,120
May 15:									
U. S. No. 1	3.8± .11	88	62	70.5	2.728± .231	13.4± .25	80.1	731	586
Commercial (Pioneer)	4.8± .09	74	41	55.4	.946± .073	13.9± .20	83.0	263	218
Difference	−1.0± .14	14	21	15.1	1.782± .242	−.5± .38	−2.9	468	368

[1] Probable error was computed by Bessel's formula:

$$PE = 0.6745\sqrt{\frac{\Sigma d^2}{n(n-1)}}$$

[2] Based on a scale graded from 0 to 6, in which 0 indicates no curly top, and 6 death of plant from curly top. The intervening grades indicate, progressively, slight, moderate, severe, and very severe effects.

[3] Determined on 3 samples from each plot.

[4] Determined by use of the refractometer, mare assumed to be 5 per cent.

Increased resistance was shown by the U. S. No. 1 variety also in the yield of beets. In every case the yield from the resistant variety was greater than that from the commercial brand used as a check, though none was commercially profitable. These yields were based upon harvest records from measured areas, computed to an acre basis. The planting of May 15, however, produced a poor initial stand of beets, and, because of the extremely hot weather, the young seedlings were very slow in growth; the low yield of beets from this planting, therefore, was not wholly due to curly-top injury. The conditions of this test probably represent an extreme degree of curly-top exposure; under less severe conditions the yield from the U. S. No. 1 variety doubtless would be much greater.

The sucrose percentages for the 1930 experiments were determined, by the Sachs-Le Docte cold-water-digestion method, on three 5-beet samples per plot, taken at random. The average sucrose percentages for the commercial (Pioneer) brand and the U. S. No. 1 variety were the same for the March 20 planting, but for the April 15 planting the sucrose percentage was significantly in favor of the commercial brand. In the third planting (May 15), the commercial brand again showed the higher sucrose percentage, but the difference was not significant. It should be remembered that the size of beets in the two sets of samples differed markedly, since the sugar beets from the commercial brand were in nearly all cases smaller than those from the U. S. No. 1 plots.

The indicated-available sugar, determined from the three factors actual yield per acre, sucrose percentage, and coefficient of apparent purity, was in every case significantly greater in the U. S. No. 1 variety than in the commercial brand.

Two experimental tests were conducted at State College in 1931. The plots were arranged as randomized blocks. In each experiment three seed increases of the original stock of seed of the U. S. No. 1 variety, which had been tested in 1930, were used for comparison with two commercial brands. The seed of the U. S. No. 1 variety was produced in three different localities, namely, at Beaumont, Calif. (A), St. George, Utah (B), and Las Cruces, N. Mex. (C); the seed of the commercial brands used, namely, Old Type (D) and Pioneer (E), was ordinary commercial seed from Germany.

The plantings at State College were made on two different dates, namely, March 16 and April 1, in an attempt to secure high exposure to curly top by having the plants in a susceptible stage at the time of the greatest influx of the beet leaf hoppers. Because of conditions in the breeding grounds, the leaf-hopper influx was later than normal, and the curly-top infection was less severe than that of the preceding season.

Each plot consisted of four rows 185 feet long and 22 inches apart. The randomized-block arrangement for the five seed lots provided five replications of each. The plots were arranged as 4-row strips across the field in the following order (each letter representing one plot): D E C B A, C A E D B, C A B D E, D C A B E, A C D E B. The two center rows of each plot were harvested and the yield determined from the weights of all the beets in the plot. These plot yields were computed to a ton per acre basis. Determinations of sucrose percentage and the coefficient of apparent purity were made from three 20-beet samples taken at random from the center rows.

Sucrose was determined by the Sachs-Le Docte cold-water-digestion method. The coefficient of apparent purity was determined by the refractometer, a 5 per cent marc being assumed in calculating sucrose in the juice from sucrose in the pulp.

The data from the individual plots of the 1931 test have been analyzed according to accepted statistical methods (*9*) and the results are given in Table 29. In this presentation of the data, computations have been made to determine the statistic z as a convenient measure of the significance of the test for the attribute considered. Standard errors of the means were computed [39] in all cases where the value of z as found equaled or exceeded the value of z at the 5 per cent or the 1 per cent point as given in Fisher's tables (*9*), corresponding approximately to odds of 20 to 1 or 100 to 1, respectively. From this computation a value has been found for the difference between two means necessary for significance.

TABLE 29.—*Comparison of three increases of the U. S. No. 1 variety with two commercial brands, planted March 16 and April 1, 1931, at State College, N. Mex.*

[Data represent averages from 5 plots, each consisting of 4 rows 185 feet long and 22 inches apart]

PLANTING OF MARCH 16

Variety	Curly-top grade	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre [a]	
					Gross	Indicated available
		Tons	*Per cent*		*Pounds*	*Pounds*
U. S. No. 1 increase from—						
(A) Beaumont, Calif.	2.00	13.354	14.2	75.96	3,788	2,881
(B) St. George, Utah	2.10	13.238	14.6	76.30	3,986	2,953
(C) Las Cruces, N. Mex.	2.10	13.632	14.8	78.26	4,040	3,149
Average	2.07	13.408	14.5	76.84	3,938	2,994
Commercial:						
(D) Old Type	3.29	9.275	14.9	79.28	2,759	2,186
(E) Pioneer	3.49	8.574	15.4	77.58	2,626	2,034
Difference:						
Av. U. S. No. 1—D	−1.22	4.133	−.4	−2.42	1,179	808
Av. U. S. No. 1—E	−1.42	4.834	−.0	−.74	1,312	960
z [b]	2.9995	.6367	.7379	.5271	.5958	.5552
Standard error	.0813	2.925	.4505		823	638
Standard error of mean	.0364	1.308	.2015		368	285
Standard error of difference	.0515	1.849	.2849		520	403
Difference required for significance	.1030	3.699	.5698		1,040	806

PLANTING OF APRIL 1

U. S. No. 1 increase from—						
(A) Beaumont, Calif.	2.80	12.845	14.4	73.02	3,709	2,699
(B) St. George, Utah	2.79	13.780	14.5	75.02	4,022	3,034
(C) Las Cruces, N. Mex.	2.70	13.064	15.0	75.78	3,930	2,979
Average	2.76	13.230	14.6	74.61	3,887	2,904

[a] Obtained by averaging individual plot values; hence differing slightly from the product of means given in this table.

[b] z=one-half the difference between the natural logarithms of the variances for variety and error. The 5 per cent point for z=0.6505; 1 per cent point=0.7814.

[39] Standard error of a single determination was found by extracting the square root of the variance due to error (mean square). The standard error of a mean was found by dividing this standard error by $\sqrt{n}$; in this case, the number of replications was 5. The standard error of the difference was found by multiplying the standard error of the mean by $\sqrt{2}$. The last-named number multiplied by 2 was taken as the difference required for significance between two means.

TABLE 29.—*Comparison of three increases of the U. S. No. 1 variety with two commercial brands, planted March 16 and April 1, 1931, at State College, N. Mex.*—Continued.

PLANTING OF APRIL 1—Continued

Variety	Curly-top grade	Yield per acre	Sucrose	Coefficient of apparent purity	Sugar per acre	
					Gross	Indicated available
Commercial:		*Tons*	*Per cent*		*Pounds*	*Pounds*
(D) Old Type	3.60	8.839	14.2	73.59	2,498	1,837
(E) Pioneer	3.80	7.245	14.8	73.60	2,136	1,572
Difference:						
Average U. S. No. 1—D	−.84	4.391	.4	1.02	1,389	1,067
Average U. S. No. 1—E	−1.04	5.985	−.2	1.01	1,751	1,332
z[1]	2.8088	1.2725	.1957	.3995	1.3092	1.2981
Standard error	.0700	1.827			529	413
Standard error of mean	.0313	.817			237	185
Standard error of difference	.0443	1.156			335	262
Difference required for significance	.0886	2.312			670	524

[1] z=one half of the difference between the natural logarithms of the variances for variety and error. The 5 per cent point for z+0.5505; 1 per cent point=0.2814.

The injury from curly top in 1931, though very marked, was somewhat less than in 1930 because the invasion of the beet leaf hoppers occurred much later in the season. Nevertheless, a 100 per cent infection was present by August 15. As compared with the severity of curly top in later experimental plantings in the same field, however, neither the 1930 nor the 1931 test showed maximum injury from the disease. No significant differences in susceptibility to curly top were found among the three seed lots of the U. S. No. 1 variety. There was, however, a significant difference between the average grade of the U. S. No. 1 variety and that of each of the commercial checks in both the March 16 and the April 1 planting. (Table 29.) Of the three types, the U. S. No. 1 variety showed the least injury from curly top, and the commercial brand Pioneer showed the most injury.

In yield per acre the average of the three seed lots of the U. S. No. 1 variety was decidedly greater than that of either of the two commercial checks. (Table 29.) The superiority of the resistant variety was especially marked in the planting of April 1, where the injury from curly top was the greater. In both tests, however, the difference in favor of the U. S. No. 1 variety was significant.

In sucrose percentage the statistical analysis of the results for the planting of March 16 showed that the value of z exceeded the 5 per cent point.[40] The commercial brand Pioneer showed a sucrose percentage significantly higher than the average for the three U. S. No. 1 lots. (Table 29.) The differences between the sucrose percentages of Old Type and Pioneer and between those of the two U. S. No. 1 increases (B and C) were not significant. There was, however, a slight significant difference between increases A and C of the U. S. No. 1 variety. These results indicate a slight superiority of the commercial brand Pioneer in sucrose percentage. When analyzed statistically, the average sucrose percentages in the April 1 planting showed no significant differences among the five seed lots; the value of z was found not to exceed the 5 per cent point.

[40] The fact that the value of z exceeds the 5 per cent point indicates odds of approximately 20 to 1 that the differences shown are not due to chance alone.

For indicated-available sugar, calculated from the three factors yield per acre, sucrose percentage, and coefficient of apparent purity, the average of the three seed lots of the U. S. No. 1 variety in the planting of March 16 exceeded by a significant amount that of each of the commercial brands. (Table 29.) In the planting of April 1 the average for indicated-available sugar of the three seed lots of the U. S. No. 1 variety was also significantly greater than that for each of the two commercial brands. In neither planting were the differences among the three seed lots of the U. S. No. 1 variety or between the two commercial brands significant. The difference in indicated-available sugar per acre in favor of the U. S. No. 1 variety over the commercial brands was greater for the April 1 planting than for the March 16 planting, doubtless because of the severity of the disease in the April planting and the marked resistance of the U. S. No. 1 variety.

The 1931 test at State College showed that under conditions of fairly severe curly top the U. S. No. 1 variety produced a crop greatly superior to commercial brands in yield and equaling or closely approaching them in quality. The results do not indicate, however, that the U. S. No. 1 variety would be commercially satisfactory in this area.

TEST AT LAS VEGAS

A test was conducted at Las Vegas, in 1931, on the farm of the New Mexico Agricultural Experiment Station,[41] which is located in the sugar-beet-growing area of that locality. In this experiment the three seed lots (A, B, and C) of the U. S. No. 1 variety used in the State College tests, an inbred line 90116–0 (D), and the commercial brand Pioneer (E) were planted in the following randomized-block arrangement: D E C B A, B D E A C, C A B D E, E B A C D. Each plot consisted of four rows 80 feet long and 22 inches apart. The yield was determined by harvesting all the beets in the two center rows. The sugar and purity determinations were made from one 10-beet sample taken at random from each plot. These samples were sent to the United States Sugar Plant Field Laboratory at Rocky Ford, Colo., for analysis.[42]

For nearly all attributes measured (Table 30), the results of this test were in close conformity with those obtained in the State College tests. The U. S. No. 1 variety was superior in curly-top resistance, as shown by comparing its average curly-top grade (2.36) with that of the inbred line 90116–0 (3.59) and that of the Pioneer commercial brand (4.00). Statistical analysis shows that the value of z for this portion of the experiment exceeded the 1 per cent point.[43] The three U. S. No. 1 seed lots were significantly more resistant to curly top than either the commercial brand or the inbred line, but showed no significant differences among themselves. If the Pioneer commercial brand be regarded as the criterion, the curly-top injury at Las Vegas was apparently slightly greater than that at State College.

[41] Acknowledgment is made to Shelby Utz, manager of the experimental farm at Las Vegas, for planting and caring for the beets during the course of the experiment.

[42] The sucrose percentage was determined by the cold-water-digestion method, and the coefficient of apparent purity was determined from the Brix reading as compared with the sucrose reading of the expressed juice.

[43] Corresponding approximately to odds of 100 to 1 that the differences shown were not due to chance.

Each of the three seed lots of the U. S. No. 1 variety gave significantly better tonnage than either the commercial brand or the inbred seed. The differences between the three seed lots of the U. S. No. 1 variety do not indicate significant differences in yield among themselves. In percentage of sucrose no significant differences were found.

TABLE 30.—*Comparison of the U. S. No. 1 variety (three increases) with an inbred line and a commercial brand at Las Vegas, N. Mex., in 1931*

[Data represent averages from four plots, each consisting of four rows 80 feet long and 22 inches apart]

Variety	Curly-top grade	Yield per acre	Sucrose [1]	Coefficient of apparent purity	Sugar per acre [2]	
					Gross	Indicated available
U. S. No. 1 increase from—		*Tons*	*Per cent*		*Pounds*	*Pounds*
(A) Beaumont, Calif.	2.40	13.250	14.6	82.35	3,857	3,176
(B) St. George, Utah	2.29	14.328	13.7	83.85	3,937	3,211
(C) Las Cruces, N. Mex.	2.39	12.593	14.5	85.07	3,660	3,117
Average	2.36	13.390	14.3	83.76	3,818	3,201
(D) 90116-0 (inbred)	3.59	8.003	14.3	85.50	2,291	1,953
(E) Commercial (Pioneer)	4.00	6.706	15.0	85.16	1,966	1,712
Difference:						
Average U. S. No. 1—D	−1.23	5.387	0	−1.74	1,527	1,248
Average U. S. No. 1—E	−1.64	6.684	−.7	−1.40	1,852	1,489
z [3]	1.2240	.8921	.1577	.7093	.8555	.7890
Standard error	.4213	2.488		1.2785	713	616
Standard error of mean	.1884	1.112		.5717	319	275
Standard error of difference	.2664	1.572		.8084	451	389
Difference required for significance	.5328	3.144		1.6168	902	778

[1] Determined on one 10-beet sample per plot.
[2] Obtained by averaging individual plot values; hence it differs slightly from product of means given in this table.
[3] z=one-half the difference between the natural logarithms of the variances for variety and error. The 5 per cent point for z=0.5907; 1 per cent point=0.8443.

The sugar-per-acre values (gross and indicated available) were uniformly in favor of the various U. S. No. 1 seed lots. (Table 30.) The value of z was found to exceed the 5 per cent point. No significant differences were found among the three seed lots of the U. S. No. 1 variety, but each was significantly better than the commercial brand in the yield of sugar per acre.

Close watch was kept in 1931 for any tendency of the plants to bolt. Of approximately 32,000 individual beets subjected to close observation only three beets were found that produced seed stalks in the first year of growth. This number is so insignificant as to be entirely negligible.

In the U. S. No. 1 variety, produced originally by mass selection of resistant plants, the resistant individuals appear to be in the majority. Because of the superior performance of these resistant individuals the U. S. No. 1 variety shows better results under curly-top conditions than do standard commercial brands. Readings of the degree of curly top present in hundreds of individual plants were made at State College in 1930 and 1931 and at Las Vegas in 1931. Evidence of curly top was found in every plant examined. The results obtained, therefore, are not due to immunity of certain individuals or to escape of infection. The effect of curly top in the majority of the individual plants seemed less severe than in the

ordinary commercial beet, and this general resistance, together with the striking performance of many individuals that were outstanding in resistance, is responsible for the very encouraging results obtained. It was clear from the examination of the plots that, although a considerable portion of the beets had been killed by curly top and some that were attacked early did not reach commercial size, the majority grew well in spite of curly top.

The results seem to indicate that under New Mexico conditions there is no large or consistent difference in quality between the U. S. No. 1 variety and commercial brands.

The U. S. No. 1 variety, as judged by the 1931 tests and the general course of curly top in that area, seems to be especially well adapted to the Las Vegas district, where in some years sugar beets are produced at a profit, whereas in other years the crop, under a moderate curly-top outbreak, drops to 7 or 8 tons per acre, a yield that is probably below the cost of production. The performance of the U. S. No. 1 variety clearly indicates that under a curly-top outbreak of this type such gains in yield and sugar per acre would result from the use of this variety as to make the crop profitable instead of unprofitable.

DISCUSSION AND CONCLUSIONS [44]

The degree of curly-top resistance in the variety U. S. No. 1 and hence the measure of curly-top control, which use of this variety will assure, are clearly indicated by the studies reported in this bulletin. The results presented also afford some evidence as to the performance of this variety under conditions where curly top is absent or only a minor factor.

YIELD

TESTS IN 1930

Intensive agronomic tests on a limited scale were conducted with the U. S. No. 1 variety in 1930 in Idaho, Utah, California, and New Mexico.

In the Idaho tests, because of adverse soil conditions as well as severe curly-top injury, the U. S. No. 1 variety gave an average yield of only 5.5 tons per acre; but the commercial brand (Pioneer) used as a check averaged slightly less than 1 ton per acre.

In the Utah tests, three degrees of curly-top exposure were secured. In one field, where the exposure was due solely to the natural leafhopper infestation and where only a mild type of the disease resulted, the average yield from the U. S. No. 1 variety was 19.5 tons per acre and from the commercial brand (Schreiber S. K. W.) 14.6 tons per acre. In another field, where the plants were artificially inoculated by caging viruliferous leaf hoppers on each plant and severe curly-top injury resulted, the U. S. No. 1 variety yielded 7.6 tons per acre as compared with a yield of 2.5 tons per acre from the commercial brand (Schreiber S. K. W.). Chiefly because of the disease, a noteworthy reduction in stand took place between the time of thinning and harvest; 5.5 per cent of the original stand was lost in the U. S. No. 1 variety and 32 per cent in the commercial brand. Such drastic injury as

[44] Contributed by Eubanks Carsner and A. W. Skuderna.

resulted in this case is rarely if ever encountered naturally under good soil and cultural conditions when the planting is made as early as advisable. A third test was made in the field where the foregoing one was conducted. In this case the plants were exposed only to the natural infestation of leaf hoppers, but distinctly more curly-top injury resulted than in the first test because of the fact that the virulent virus was introduced into this field both through the plants artificially inoculated and by the planting of a few severely diseased mother beets from the year before. From the severely diseased plants the leaf hoppers in moving about could acquire the virulent virus and carry it throughout the field. The U. S. No. 1 variety in this third test yielded 17.1 tons per acre, whereas the commercial brand (Schreiber S. K. W.) yielded 7.1 tons per acre.

The tests in California in 1930 were conducted under conditions of very light curly-top exposure. In one case the U. S. No. 1 variety gave an average yield of 23 tons per acre and the commercial brand (Old Type) yielded 20.5 tons per acre. There were only four replications in this test, and in view of the range in plot yields it is uncertain how much of the difference between the commercial brand and the resistant variety should be attributed to curly-top injury. In the other test there was only one plot of each variety and, although the commercial brand (Old Type) showed a greater percentage of cases of curly top, there was obviously no significant disease injury. The U. S. No. 1 variety yielded 18.8 tons per acre and the commercial brand yielded 20.8 tons per acre.

In New Mexico three degrees of curly-top injury were obtained by planting on three dates. A planting on March 20 gave for the U. S. No. 1 variety an average yield of 8.7 tons per acre and for the commercial brand (Pioneer) approximately 3 tons per acre. The second planting, April 15, gave a yield for the U. S. No. 1 variety of 6.5 tons per acre and for the commercial brand (Pioneer) 1.1 tons per acre. In the last planting, May 15, the U. S. No. 1 variety yielded 2.7 tons per acre, and the commercial brand (Pioneer) averaged 0.9 ton per acre.

These tests in 1930 indicate that the U. S. No. 1 variety will outyield susceptible commercial brands under all conditions when curly top is a controlling factor. This advantage of the resistant variety is often increased as the disease exposure becomes greater, but it should be noted that the U. S. No. 1 variety is strongly injured by severe exposure. The results also suggest that where curly top is not an important factor the yield of commercial brands may equal or exceed that of the U. S. No. 1 variety.

TESTS IN 1931

Further comparisons between the U. S. No. 1 variety and various commercial brands were made in 1931. Fourteen intensive agronomic tests were conducted in the four States previously mentioned. In addition to these there were 33 large-scale tests in commercial fields from which data were obtained. In each of the latter tests, known as grower-test plantings, a total of approximately 1 acre of the U. S. No. 1 variety was compared with a similar area of a commercial brand, and in most instances the planting arrangement was such as to give two or more replications.

The harvest records were secured from the grower-test plantings in essentially the same manner that the records of the more intensive

tests were taken. For this reason and in view of the similarity in trend of the results, it will be advantageous in this discussion to consider the results of the two series of experiments together.

Most of the tests were carried out under conditions where curly top was an important factor, and those which may be so grouped will be considered first. Forty-one of the tests fall in this category, and these included a wide range in degrees of curly-top exposure. This fact is brought out by the yield records. The yield-per-acre values were calculated in all but a few instances by multiplying the average weight of the individual normally competitive beets by the appropriate factor for a 100 per cent stand for the conditions of the planting.

The comparative records for 19 tests (2 intensive agronomic and 17 grower-test plantings) conducted in Idaho show yields ranging from 8.1 to 24.4 tons per acre for the U. S. No. 1 variety and from 4.3 to 19.5 tons per acre for the commercial brands. These Idaho tests as a whole showed average yields of 14.8 tons per acre for the U. S. No. 1 variety and 10.1 tons per acre for the commercial brands.

The evaluation studies carried on in Utah included four cases in which the results were vitiated by failure of the irrigation-water supply. The results of these four tests are not included in the present discussion, but it is of interest to note that the trend of yield results is in the same direction as in all the other tests. The U. S. No. 1 variety exceeded the commercial brand in yield in each case, but in one instance the difference was probably not significant. In five other Utah tests where curly top was an important factor, the yield of the U. S. No. 1 variety ranged from 14.1 to 27.2 tons per acre with an average of 20.9 tons. The commercial brands in the same tests yielded 5.9 to 22.7 tons per acre, an average of 13.2 tons.

The California experiments in 1931 included nine tests in which curly top was an important factor influencing yields. The results at Shafter are omitted because of the fact that the yields obtained were influenced by the garden-nematode infestation of the field. Only one experiment from Bakersfield (February 10) is included, since so far as possible the results used in this general summary have been confined to those from plantings made on dates conforming to what would be a normal planting date for the locality. Repeated experience at Bakersfield has shown that March 3 is too late for commercial plantings there; hence, the results from the planting of that date are omitted. It may be noted that the March 3 planting showed an average yield of 11.9 tons per acre for the U. S. No. 1 variety and 3.9 tons per acre for the commercial brand (Old Type) used as a check. At Buttonwillow, similarly, only the results from one of the two trials have been used, since it is believed that the results from the February 12 planting are the more representative for the purposes of this discussion. It should be noted that the January 13 planting at Buttonwillow, which is omitted, gave an average yield of 22.2 tons per acre for the U. S. No. 1 variety and an average of 18.2 tons per acre for the commercial brand.

Six tests in California (three intensive agronomic and three grower-test plantings)[45] are considered as representative of the U. S. No. 1 variety growing under conditions where curly top is a factor. The yields of the resistant variety ranged from 18.7 to 30.3 tons per acre,

[45] The results from only the first set of plots from the grower-test planting on Union Island were used in this summary.

with an average of 23.8 tons, in contrast with the commercial brands, which ranged in yield from 13 to 25.7 tons per acre, with an average of 17.3 tons.

The New Mexico plantings in 1931 included two at State College and one at Las Vegas. The planting of March 16 at State College yielded an average of 13.4 tons per acre for the U. S. No. 1 variety and 8.9 tons per acre for the commercial brands (Old Type and Pioneer). In the April 1 planting the average yield of the U. S. No. 1 variety was 13.2 tons per acre, and that of the commercial brands was 8 tons per acre. Only the results of the March 16 planting are included in the averages shown in Table 31. The Las Vegas test showed an average yield of 13.4 tons per acre for the U. S. No. 1 variety and 6.7 tons per acre for the commercial brand (Pioneer).

Six of the 1931 tests were conducted under conditions where curly-top injury was absent or else an unimportant factor. These tests were: One near Salt Lake City, Utah; 2 near Fruita, Colo.; and 1 each at Bakersfield (the January planting), Chino, and Oxnard, in California. The results of these comparisons with commercial brands afford some indication of the performance to be expected of the U. S. No. 1 variety if it should be planted in seasons when curly top does not cause serious damage. The same may be said for areas only slightly affected. The range in yields for the U. S. No. 1 variety in these tests was from 18.8 to 27.9 tons per acre and for the commercial brands from 17.3 to 26.9 tons per acre. The difference between the averages (0.5 ton per acre), as shown in Table 31, if significant at all, is probably to be attributed to the curly-top factor.

QUALITY

Because of the large number of determinations of sucrose percentage and purity made in connection with the many field tests, it has been possible to compare the quality of the U. S. No. 1 variety with that of the commonly used commercial brands.

The test in Idaho in 1930, as mentioned earlier in this discussion, was made under unfavorable soil conditions. This fact probably explains the exceptionally low sucrose percentages found. Tests of the U. S. No. 1 variety showed a higher sucrose percentage than tests of the commercial brand (Pioneer) used as a check. In 1931, sucrose percentages were determined in connection with each of the 19 field tests carried on in Idaho. In 5 cases the average sucrose percentage of the U. S. No. 1 variety was numerically lower by between 0.2 and 0.9 per cent than that of the commercial brand compared with it, and in 5 other cases it was higher by the same amounts. The general average of the 19 tests shows a sucrose percentage of 18.09 for the U. S. No. 1 variety and 18.01 for the commercial brands. The U. S. No. 1 variety showed a slightly higher coefficient of apparent purity in most cases, but the average difference was too small to be significant.

Sucrose determinations were made in connection with two of the field tests in Utah in 1930. They showed numerical differences of 0.14 and 0.6 per cent sucrose in favor of the commercial brand (Schreiber) used for comparison.

The six Utah field tests, in 1931, where irrigation water was adequate, showed in every case a higher sucrose percentage for the commercial brands used. The numerical differences ranged from 0.2 to 1 per cent, with an average of 0.6 per cent. The coefficients of

apparent purity were not significantly different. The two tests in Colorado showed practically the same sucrose-percentage readings for the U. S. No. 1 variety as for the commercial brand (Braune Elite).

In the two California field tests in 1930, the sucrose percentage of the U. S. No. 1 variety was higher by 0.14 than that of the commercial brand (Old Type) in one case and lower by 0.8 in the other. Twelve sets of comparative determinations in 1931 showed the U. S. No. 1 variety higher in sucrose percentage in six cases and lower in six cases. The average of the differences was too small to be significant. There was no significant difference in purity.

The New Mexico tests in 1930 showed the U. S. No. 1 variety equal in sucrose percentage to the commercial brand (Pioneer) in one case and lower by 1.4 and 0.5 in the other two cases, respectively. The three tests in 1931 showed a slight but significant superiority for the commercial brand Pioneer over the U. S. No. 1 variety.

The results of the investigation seem to justify the conclusion that the average sucrose percentage of the U. S. No. 1 variety was lower by a fraction of a per cent than that of the commercial brands with which it was compared. The evidence indicates no significant difference in purity.

Since the U. S. No. 1 variety closely approaches the commercial brands in quality, it will probably show under curly-top conditions a superiority in yield of sugar per acre almost directly proportional to its superiority in yield of beets.

Table 31 summarizes the results of 6 tests under conditions where curly-top injury was not an important factor and of 32 tests where the disease was a factor of varying degrees of importance. The results under nearly normal conditions are too few to be conclusive, but they suggest that when curly top is not a factor little difference is probably to be expected between the U. S. No. 1 variety and the commercial brands used. The tabulated results also show clearly that under curly-top conditions the U. S. No. 1 variety is markedly superior to the commercial brands.

TABLE 31.—*Summary of comparisons of the U. S. No. 1 variety with commercial brands, based on tests made in Idaho, Utah, Colorado, California, and New Mexico in 1931*

Conditions	Tests	Yield per acre [1]			Average sucrose			Gross sugar per acre [1]		
		U. S. No. 1	Commercial	Difference	U. S. No. 1	Commercial	Difference	U. S. No. 1	Commercial	Difference
	Number	*Tons*	*Tons*	*Tons*	*Per cent*	*Per cent*	*Per cent*	*Pounds*	*Pounds*	*Pounds*
Curly top a minor factor or absent	6	23.8	23.3	+0.5	15.7	15.5	+0.2	7,473	7,223	+250
Curly-top injury ranging from moderate to severe	32	17.3	11.8	+5.5	17.45	17.53	−.08	6,038	4,137	+1,901

[1] Yields were computed to the ton-per-acre basis for easy comparison. In nearly all cases, the yields were computed from the average weight of beet by multiplying by a factor suitable for the row width employed in the test. They are expressed in terms of 100 per cent stands. Actual stand would need to be taken into consideration to make the yield data strictly applicable to actual yields. For curly-top conditions, it seems probable that the actual yields would be closely approached by direct application of the actual-stand factor. (See p. 22 and 29.)

[2] Obtained from general averages for yield and sugar given in this table.

The tests reported in this bulletin have demonstrated that through disease resistance curly top as it affects sugar beets can be fairly well controlled. This fact is of more importance than is the development of a particular variety such as the curly-top-resistant variety U. S. No. 1. The utilization of this variety to secure curly-top control by disease resistance indicates the possibility of an entirely satisfactory solution of this problem.

IMPERFECTIONS IN U. S. NO. 1

The U. S. No. 1 variety is not immune to curly top. The extent to which it is injured by the disease depends on the severity of the exposure. Data have been presented which indicate this fact. Under curly-top exposure, many individual plants in the variety show conspicuous symptoms of the disease. The variety as a whole shows a degree of resistance intermediate between the susceptibility of the commercial brands and the very high resistance of certain low-sugar strains.

A more serious imperfection in the U. S. No. 1 variety is a tendency to bolt.[46] There is evidence that this characteristic is attributable to the inclusion in the U. S. No. 1 variety of the strain 905a2, which has this tendency, and possibly because of the inclusion of other strains that show the bolting tendency to a lesser degree. This tendency in the U. S. No. 1 variety will probably continue to manifest itself in practically the same degree provided full random mating occurs in subsequent generations. It seems probable, however, that through additional selection the U. S. No. 1 variety may be greatly improved with respect to bolting.

It is recognized that the resistant variety U. S. No. 1, as now constituted, is not a finished product and that it offers considerable opportunity for improvement. Under many conditions, however, its shortcomings do not preclude its use. The general consensus of opinion of all who have closely followed the tests is that utilization of this resistant variety will constitute a distinct step in curly-top control, since under all conditions but that of extreme exposure to the disease the variety gives promise of satisfactory results. On the basis of the experience reported in this bulletin, the use of this variety is recommended until a better variety can be developed from the resistant strains now in process of selection and improvement.

PLAN FOR MAKING U. S. NO. 1 COMMERCIALLY AVAILABLE

The Bureau of Plant Industry is planning to release, under proper restrictions, the U. S. No. 1 variety for use by growers in the area affected by curly top. It is estimated that there are at least 50,000 to 75,000 acres which have been used within the past few years for sugar-beet culture and which have been made marginal for sugar-beet

[46] In 1932, because of a seasonal difference, bolting in the U. S. No. 1 variety was generally more evident in the area west of the Rocky Mountains. The U. S. No. 1 variety showed 1 to 6.7 per cent bolters in locations in Idaho where in 1931 it had had less than 1 per cent bolters. A planting at King City, Calif., on Jan. 16, 1932, developed 52 per cent bolters in contrast to 5 per cent bolters in the check (Old Type). The 1931 plantings of the U. S. No. 1 variety made at four places in California from Jan. 13 to 16 developed so small a number of bolters as not to attract special notice. Replicated tests of the original selection and the first and second generation multiplications were conducted at Castleford, Idaho, in 1932. The percentage of bolters was small, ranging from 1 to 3.14.

production by the frequent outbreaks of curly top. There is in addition the large acreage of good land under irrigation from which the sugar-beet industry has withdrawn and to which, by use of the curly-top-resistant variety, the industry may, as economic conditions justify, return. To supply the present active area of 50,000 to 75,000 acres in the affected districts where beets are now being grown requires, at the customary rate of planting, approximately 1,000,000 to 1,500,000 pounds of seed annually. To produce such a quantity of seed, at the conservative estimate of 1,000 pounds of seed per acre, would require about 1,000 to 1,500 acres.

The first difficulty to be overcome is that of securing an adequate supply of seed to plant the 1,500 or more acres for seed production, because the original quantity of seed of the selected variety was small and to make the needed increase under conditions where selection for curly-top resistance could be continued would require too much time and expense.

Under these circumstances, in order to secure a massive increase of the seed supply, it is proposed to continue the multiplication of the present seed stock without further selection. Special care will be taken, however, that full random matings shall occur within the plantings, in order to maintain the variety at its present level, if possible, without serious retrogression.

As has been stated, theoretically this seems a safe procedure and has proved practicable with other crops. The tests in 1930 were conducted with the original seed stock of the U. S. No. 1 variety and for the tests in 1931 the first multiplication of the original seed was used. The detailed data presented herein indicate that no drop in curly-top resistance, in quality, or in yield capacity occurred in the first multiplication of the original seed. There is some evidence that the second increase is essentially like the original seed and like the first multiplication of the original seed. At the Rocky Ford field station [47] an intensive field study was made of the behavior of successive increases of the U. S. No. 1 variety that had been produced without selection. A quantity of the first multiplication of U. S. No. 1 seed produced at Las Cruces, N. Mex., in 1930, was planted in the greenhouse in early October in 1930, and a crop of beet seed was produced from several hundred unthinned plants late in the winter and early in the spring. This second multiplication of the U. S. No. 1 variety, produced without selection, was compared in a replicated field test with the original seed, the first multiplication, and a commercial brand. Unfortunately, the plots suffered from a nematode attack, so that reliable yield data were not obtainable, but inspection of the plots indicated no retrogression in yields in the areas unaffected by nematodes. Comparable samples taken for sucrose analysis gave closely comparable values for the beets grown from these three seed lots (15.5, 15.6, and 15.8 per cent sucrose, respectively). No data in regard to curly-top resistance were obtainable, because of the absence of the disease at Rocky Ford, Colo. No indication of bolting was seen.

[47] These tests were conducted by G. W. Deming, assistant agronomist.

In order to meet the present need for rapid increase of seed, on the basis of the plant-breeding experience and the preliminary tests reported, the immediately available seed stock of the U. S. No. 1 variety (about 300 pounds), which is the first multiplication of the original seed, has been devoted to increasing the seed supply by growing, without selection, a second increase. By extensive plantings this in turn is to be directly increased to many thousand pounds in the third multiplication. Thus the first seed to be used for sugar-beet production will be two generations removed from the seed stock which has now been extensively tested, and reliance for its behavior will have to be placed on the present rather limited information in regard to the results of such direct multiplications without selection.

The experimental work of the Division of Sugar Plant Investigations with this variety, however, is carried on each season with a stock of seed of the variety one year in advance of the commercial production of such seed, so that opportunity will be afforded to determine definitely the performance of the sugar beets from such seed before it is utilized on any comprehensive scale by growers.

Investigational work already reported (*11*) and in progress has shown that sugar-beet seed can be produced economically by the overwintering-in-the-field method in at least three southwestern areas in the United States, namely, Mesilla Valley in New Mexico, the "Dixie" section of Washington County and the Virgin River Valley in Utah, and the Hemet Valley and the Beaumont sections of California. The possibilities of beet-seed production by the overwintering-in-the-field method have not been investigated in other sections where the climate is adapted to it, and it is probable that other areas will be found suitable for the growing of the crop. The growing of beet seed requires some special knowledge of crop handling, fertilization, fitting of land, and care of the crop. Moreover, the market for sugar-beet seed is restricted to the sugar-beet factories concerned, which are the sole purchasers of the seed to be allotted to the growers in their respective districts.

In order to maintain and safeguard the resistant qualities from deterioration by accidental hybridization with nonresistant beets, to prevent mislabeling, and to coordinate the seed supply with a continuing breeding program, the Bureau of Plant Industry has supplied an association of interested sugar-beet companies with seed, for multiplication purposes only, of the first increase of the U. S. No. 1 variety. This provisional arrangement has been made subject to the requirement that the seed resulting be multiplied in the United States and that the designation "U. S. No. 1 variety" be restricted to lots of seed conforming to such standards and requirements as the bureau may need to impose in order to safeguard the public interest. During the introductory period the multiplications of the seed are being made under the direct supervision of the bureau. The performance of the variety under field conditions will be closely followed.

Because of (1) the limited available supply of seed of the U. S. No. 1 variety, (2) the obvious absence of a market for sugar-beet seed not produced by previous definite arrangement with the sugar companies, who constitute the sole market for it, and (3) the obligation enforced

by all companies that beets must be grown from the seed furnished by the contracting companies, no seed of this variety is being made available for general distribution.

Under the plan of operation outlined the second multiplication of the original stock of seed of the U. S. No. 1 variety was produced in the summer of 1932. This amounted to several thousand pounds; enough of this was planted in the fall of 1932 to produce a large amount of seed in 1933 for general use in the curly-top areas for the planting season in 1934. As has been stated, the Federal experimental work in 1933 will be carried on with the type of material available for general use in 1934. If the resistant qualities and other attributes maintain themselves as expected, the U. S. No. 1 variety, when substituted for the present susceptible brands in the most severely affected beet-growing areas, should be very beneficial in relieving curly-top damage, and in those areas continually menaced and sometimes seriously damaged it should give a highly desirable assurance against excessive losses to the beet crop. Utilization of the variety in its present form is recommended with full recognition of the fact that it is far from a finished product and is being released in order to meet an emergency.

SUMMARY

The curly-top disease of sugar beets has been a limiting factor in many of the areas west of the Rocky Mountains from the time the beet-sugar industry was started in those areas. The beet leaf hopper is the only known transmitting agent of the curly-top virus, but the efforts to combat this insect have not yet resulted in adequate measures for its control.

Progress in the study of disease resistance in sugar beets as a control measure for curly top has previously been reported by several workers. This bulletin reports an important advance in the production of a resistant variety. By the combination of a number of strains selected for resistance, a variety has been produced which has a fair degree of resistance to curly top and is reasonably satisfactory in other respects. This variety has been designated U. S. No. 1.

The curly-top-resistant variety U. S. No. 1 was tested in agronomic trials, in 1930, in Idaho, Utah, California, and New Mexico and much more extensively, in 1931, in these States and in Colorado. These extensive tests demonstrated that it is markedly superior in resistance to any of the standard commercial brands with which it was compared. In sucrose and in purity it compares satisfactorily with standard commercial brands of sugar beets now in general use.

The resistant variety U. S. No. 1 has some imperfections which make further improvement desirable, but until a better variety is produced from the strains now being worked upon, it seems advisable that widespread use be made of this variety. Its use should afford a commendable degree of curly-top control.

LITERATURE CITED

(1) ANONYMOUS
1908. THE PROBABLE ERROR OF A MEAN. By Student. Biometrika 6: 1–25, illus.

(2) ———
1925. NEW TABLES FOR TESTING THE SIGNIFICANCE OF OBSERVATIONS. By Student. Metron 5: 105–108.

(3) ———
1926. MATHEMATICS AND AGRONOMY. By Student. Jour. Amer. Soc. Agron. 18: 703–718.

(4) BROWNE, C. A.
1912. A HANDBOOK OF SUGAR ANALYSIS: A PRACTICAL AND DESCRIPTIVE TREATISE FOR USE IN RESEARCH, TECHNICAL AND CONTROL LABORATORIES. 787 p., illus. New York.

(5) CARSNER, E.
1926. RESISTANCE IN SUGAR BEETS TO CURLY-TOP. U. S. Dept. Agr. Circ. 388, 8 p., illus.

(6) CARTER, W.
1930. ECOLOGICAL STUDIES OF THE BEET LEAF HOPPER. U. S. Dept. Agr. Tech. Bul. 206, 115 p., illus.

(7) COONS, G. H., STEWART, D., and ELCOCK, H. A.
1931. SUGAR-BEET STRAINS RESISTANT TO LEAF SPOT AND CURLY TOP. U. S. Dept. Agr. Yearbook 1931: 493–496, illus.

(8) ESAU, K.
1930. STUDIES OF THE BREEDING OF SUGAR BEETS FOR RESISTANCE TO CURLY TOP. Hilgardia 4: 415–440, illus.

(9) FISHER, R. A.
1928. STATISTICAL METHODS FOR RESEARCH WORKERS. Ed. 2, rev. and enl., 269 p., illus. Edinburgh and London.

(10) LOVE, H. H., and BRUNSON, A. M.
1924. STUDENT'S METHOD FOR INTERPRETING PAIRED EXPERIMENTS. Jour. Amer. Soc. Agron. 16: 60–68.

(11) OVERPECK, J. C., and ELCOCK, H. A.
1931. METHODS OF SEED PRODUCTION FROM SUGAR BEETS OVERWINTERED IN THE FIELD. U. S. Dept. Agr. Circ. 153, 22 p., illus.

(12) PIEMEISEL, R. L.
1932. WEEDY ABANDONED LANDS AND THE WEED HOSTS OF THE BEET LEAF HOPPER. U. S. Dept. Agr. Circ. 229, 24 p., illus.

(13) TAYLOR, W. A.
1929. REPORT OF CHIEF OF BUREAU OF PLANT INDUSTRY. U. S. Dept. Agr. Ann. Rpt. 1929, 39 p. [Separately paged.]

(14) TOWNSEND, C. O.
1908. CURLY-TOP, A DISEASE OF THE SUGAR BEET. U. S. Dept. Agr., Bur. Plant Indus. Bul. 122, 34 p., illus.

U. S. GOVERNMENT PRINTING OFFICE: 1933

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