

A Study of Sugar-Beet Growth—Years 1921 to 1928 and 1938 to 1941, Inclusive

A.W. SKUDERNA AND C.W. DOXTATOR

te of Development Studies 1921 to 1928

Weekly samplings of sugar beets have been in progress for many years, both in the United States and abroad. In general, the primary purpose of such studies has been to determine the rate of development of the crop, and the peak in sucrose percentage. In some of the areas where leafspot is a factor of major importance, the object of these sampling studies has also been to study the effects of leafspot upon the variety or varieties of sugar beets under test, and to determine the length of period required for the variety to outgrow the effects of leafspot attack. This probably was more important in previous years when leaf spot-resistant varieties were not generally available. However, even with present varieties, it is still important to know the rate of development so that judgment may be formed as to whether a field severely affected with leafspot should be among those early harvested, or whether harvest should be delayed until later in the season when partial or full recovery from leafspot attack has been made.

An 8-year study of this problem was made at Rocky Ford, Colorado, during the years 1921 to 1928, inclusive. In these studies, the development of the crop was observed by weekly periods from time of thinning until harvest. The plots were systematically replicated in 3 series, and 20 beet samples were taken consecutively in the row from the upper, middle, and lower sections of the field to obtain a fair sampling of the field. Allowance was made for skips in stand by not harvesting the beet immediately adjacent to the missing beet. The spacing interval used was 12 inches in the row between beets. A European brand of intermediate type was used for the first 3-year study; the Flat Foliage variety, a sugar type developed by the American Beet-Sugar Company, was used in the remaining 5 years of the sampling study. The percentage of sucrose in the beet was determined by the Sachs-Le Doete cold-water digestion method. The yearly results for the 8-year test are shown in table 1.

¹Skuderna, A. W. and Doxtator, C. W., Manager and Plant Breeder, respectively, Beet Seed Operations, American Crystal Sugar Company.

Table 1.—Tons beets, percentage sucrose, and sugar-per-acre yield resulting from weekly sampling studies—(Rocky Ford, Colo., 1921-1928, inclusive.)

Year	1921	1922	1923	1924	1925	1926	1927	1928	Average
Tons beets per acre	13.28	10.40	16.32	11.25	12.24	14.84	12.77	14.26	13.17
Percentage sucrose	14.81	14.92	14.05	17.99	14.56	16.77	16.09	16.20	15.67
Pounds sugar per acre	3934	3103	4586	4048	3504	4977	4102	4620	4127

Discussion

Tons Beets per Acre.—For the 8-year period, an average yield of 13.17 tons beets per acre was obtained. In the 3 years, 1921, 1922, and 1925, leafspot incidence was heavy and damage to the crop considerable. In 1923 the effects of leafspot were overcome by heavy rainfall which increased tonnage-beet yield to record heights. In 1924 there was a virtual absence of leafspot, but water shortage reduced tonnage yield to subnormal levels. In 1926, another year of slight damage from leafspot, the yield was better than average. In 1927 leafspot development was late, and to that extent appreciably reduced tonnage yield of beets. The season 1928 was the reverse of the preceding year. Leafspot developed early, but the hot dry weather in the fall months reduced materially injury to beet yield.

Percentage Sucrose.—The average value of 15.67 percent sucrose was undoubtedly increased by the use of the Flat Foliage sugar-type variety during the last 5 years of test. However, this variety was only slightly resistant to leafspot, since no critical attempt was made to increase its resistance other than through staking large numbers of less-susceptible beets and mass increasing the highest-testing population. It is worthy of note that the higher-sucrose values were obtained in years when leafspot was either absent or relatively light in incidence.

Pounds Sugar-per-Acre Yield.—The yields of sugar per acre generally followed the beet-tonnage yield. With exception of 1923, when the yield of sugar per acre was high because of the largest beet-tonnage yield during this period of test, and in 1925 where leafspot incidence was heavy, the larger sugar-per-acre yields were obtained from the use of the Flat Foliage variety.

Of interest is the average weekly development rate in tonnage yield, percentage sucrose, and pounds sugar per acre. The data as shown in table 2 are an average of 72 determinations or 1,480 beets for each reading.

Discussion

From the study of the 8-year average results over a 24-week period, it is evident that with minor exceptions, the tonnage develop-

Table 2.—Rate of development studies with sugar beets. (Increments in tons beets, percentage sucrose, and pounds sugar per acre, by weeks, years 1921-1928, inclusive).

Month	Weeks after planting	Tons beets accumulated		Percentage sucrose accumulated		Pounds sugar per acre accumulated	
		Total	Rate	Total	Rate	Total	Rate
June	8	.10	.10	5.90	5.90	11.80	11.80
	9	.16	.06	6.02	.12	19.26	7.46
	10	.26	.10	6.24	.22	32.45	13.19
July	11	.44	.18	6.73	.49	59.22	20.77
	12	.67	.23	7.70	1.06	104.39	45.17
	13	.96	.29	8.88	1.09	170.50	66.11
August	14	1.33	.37	10.02	1.14	296.53	96.03
	15	1.74	.41	10.90	.94	381.41	114.88
	16	2.27	.53	11.03	.67	528.00	140.59
	17	2.97	.70	11.41	.22	677.75	149.75
	18	3.58	.61	12.14	.73	899.22	191.47
September	19	4.19	.61	12.48	.34	1045.82	176.60
	20	4.77	.58	12.21	-.27	1164.53	170.01
	21	5.50	.73	12.81	.60	1409.10	244.27
	22	6.34	.84	13.37	.56	1695.32	289.22
October	23	7.24	.90	13.83	.46	2002.58	307.26
	24	8.11	.87	13.94	.11	2261.07	338.40
	25	9.04	.93	13.99	.05	2526.39	268.32
	26	9.89	.85	13.91	-.08	2751.40	222.01
	27	10.75	.86	14.09	.18	3029.33	277.95
November	28	11.70	.95	14.50	.47	3407.04	377.09
	29	12.29	.59	15.16	.69	3723.33	310.20
	30	12.84	.55	15.44	.28	3974.99	238.66
	31	13.17	.33	15.67	.23	4127.48	162.49
Totals			13.17		15.67		4127.48

ment of the sugar-beet crop in the Arkansas Valley area for the varieties under test was most pronounced from the second week of September until completion of the beet harvest in mid-November. For maximum yields, this "laying on" period of tonnage should commence at least 1 month earlier. This implies the development of adapted varieties, having leafspot resistance, high-sugar, and good-tonnage yield. Leafspot resistance is especially important, since the rate of tonnage increase is noticeably slowed up by leafspot incidence in mid-to-late July and by another recurrence of this disease in late August. The general slowing down in rate of increase during early November is due to cool temperatures.

The most rapid increase in percentage sucrose was in the pre-leafspot period, and extending up to about the last week in July. A sharp depression is generally experienced about 2 weeks after the beet foliage has been affected. In years of severe leafspot attack, from 4 to 6 weeks may elapse before sucrose values recover sufficiently to reach levels recorded before onset of the disease. In the results shown in table 2, there were actually 3 cycles of sucrose depression, all of which affected the quality and manufacturing worth of the crop.

The accumulation of pounds sugar-per-acre yield shows a steady development until early in August, when, because of the slowing down effects of the leafspot disease, retardation set in. This continued until a recovery in foliage growth was made early in September. Following this, rapid progress was again made until mid-October when effects of leafspot were felt once more. From then on, until mid-October, the rate of sugar storage was greatly accelerated.

Conclusions

From this study, 3 definite trends were established.

1. Primary infection of leafspot influences sucrose values as early as the last week in July.
2. In early light attacks of leafspot, the recovery is quite rapid. This is especially true in the case of infections occurring in early July when recovery is effected in 2 to 3 weeks.
3. In the case of late development of leafspot, or a second attack coming in late August or early September, the recovery of the sucrose in the plant is very slow, ranging from 4 to 6 weeks. From standpoint of both processor and grower, the harvesting of these late-affected fields first seems indicated, and is a practice that has generally been followed in this area.

Rate of Development Studies—1938 to 1941

With the development of leaf spot-tolerant varieties, more or less resistant to the *Cercospora heticola* fungus, rate of development studies were resumed in 1938. Two varieties, one domestic and the other foreign, were used. The domestic variety was of intermediate type. While the sucrose percentage was satisfactory, it was not equal to the Flat Foliage variety used in the 1925 to 1928 work. In resistance to leafspot, the reading was about 3 on a scale reading 1 to 5, in which 1 was resistant and 5, highly susceptible. The susceptible foreign variety was intermediate in yield and under leafspot exposure had a reading of 5. It had, however, the remarkable ability of a quick comeback in growing out new leaves and producing under favorable conditions of late harvest a beet of acceptable quality.

During the present 4-year period of test, the plot arrangement was fully randomized in 7 replicates, width of plots 4 rows wide, 100 feet in length. The rows were 20 inches apart, and the beets were spaced 12 inches between plants in the row. Two 20-competitive-beet samples were taken for weight and sucrose determination for each sampling date. At harvest, yields were made on an actual yield basis. The data are shown in table 3.

Table 3.—Rate of development studies with sugar beets. Increases in tons beets, percentage sucrose, and pounds sugar per acre by 2 weekly periods (1888 to 1941, inclusive, Rocky Ford, Colorado).

Month	Leafspot reaction	Weeks after planting	Tons beets accumulated		Percentage sucrose accumulated		Pounds sugar per acre accumulated	
			Total	Rate	Total	Rate	Total	Rate
August	Resistant	18	8.40	8.40	12.01	12.01	2020	2020
	Susceptible		8.30	8.30	11.55	11.55	1920	1920
September	Resistant	20	10.40	2.00	21.99	-.02	2500	480
	Susceptible		9.80	1.50	11.45	-.10	2240	320
October	Resistant	22	11.70	1.30	12.10	.11	2840	340
	Susceptible		11.20	1.40	11.46	.01	2500	260
	Resistant	24	12.80	1.10	12.75	.65	3200	420
	Susceptible		11.30	.10	12.70	1.30	2580	320
November	Resistant	26	13.10	.30	13.85	1.10	3820	260
	Susceptible		12.50	1.2	12.75	-.01	3180	300
	Resistant	28	13.40	.30	14.80	.95	3060	340
	Susceptible		12.00	.40	14.51	1.76	3740	500
Totals	Resistant	30	13.40	0	17.00	2.20	4500	000
	Susceptible		13.50	.60	16.38	1.87	4420	680

Discussion

Tons Beets Per Acre.—In the 4-year test, leafspot was moderately severe in 1 year, comparatively light in 2 years, and almost negligible the fourth year. The rate of tonnage development was rapid for both varieties during the early part of the growing season. The susceptible variety utilized the growing season to better advantage, showing a consistent increase as the season progressed. On the other hand, the resistant variety proved to be earlier maturing, and to that extent it did not take full advantage of the relatively long-growing season.

Percentage Sucrose.—The effect of leafspot upon percentage sucrose in the beet is shown in its depressing effect upon sucrose values during the latter part of August and September. Along with need of greater tonnage, the improvement in resistance to leafspot and maintenance of sucrose values at a higher level is indicated by these studies. There was, however, material improvement in the performance of the domestic variety when comparison is made with the susceptible variety, and in which sucrose values remained depressed until late in October.

Pounds Sugar-per-Acre Yield.—It is gratifying to note the rapid early increase in sugar-per-acre yield in favor of the resistant variety. From the standpoint of early harvest, to reduce the tons beets into storage, and the attendant shrinkage therefrom, improved varieties which make quick earlier growth are an essential consideration to

efficient and economical production of sugar. It is evident, that in the present varieties, earlier development in rate of sugar-per-aere production has been realized to a certain degree.

Comparison of Results: 1921 to 1928 and 1938 to 1941 Inclusive

Three graphs have been prepared to show the rate of development of present varieties compared to those of a decade ago. The tonnage yield of beets for these periods is shown in figure 1.

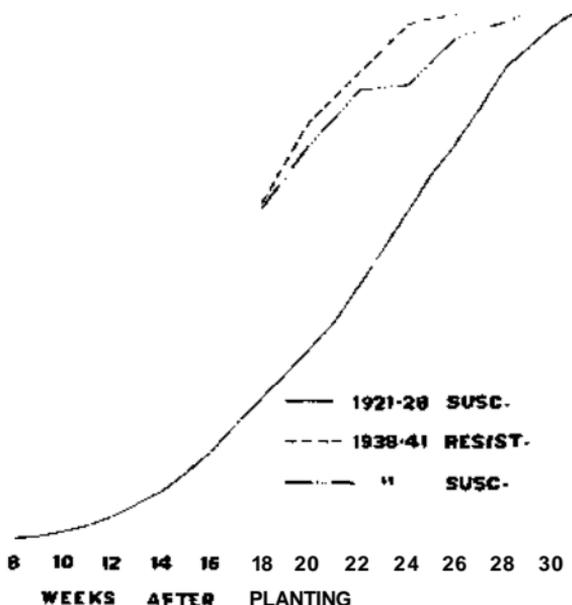


Figure 1.—Tonnage beets per acre. Years 1921 to 1928 and 1938 to 1941, Inclusive.

It is obvious that in earlier rate of development, both the resistant and susceptible varieties used in the 1938 to 1941 studies were greatly superior to the varieties used during the 1921 to 1928 period. The resistant variety showed less fluctuation, but proved to be entirely too early maturing for best utilization of a relatively long-growing season. However, the improvement made in earlier maturity is of decided advantage to the industry in advancing the date of harvest.

As indicated previously, the resistant variety did not have the early high-sucrose values as shown by the Flat Foliage variety. De-

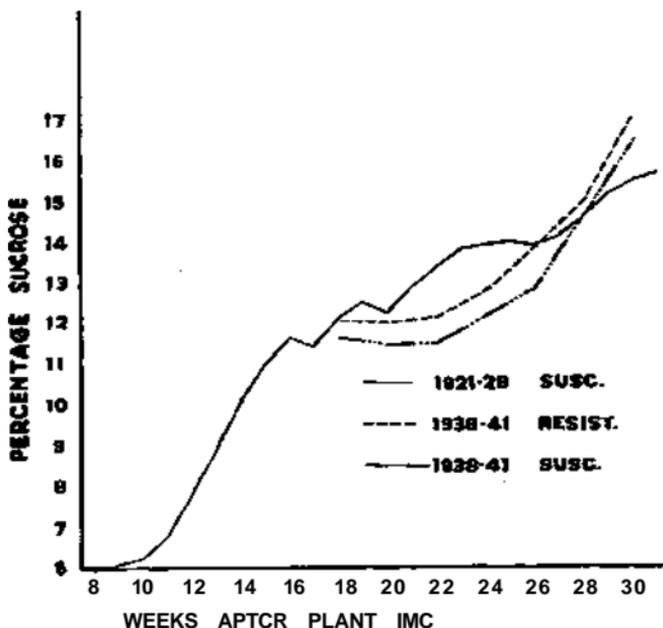


Figure 2.—Percentage sucrose in the beet. Years 1921 to 1928 and 1938 to 1941, inclusive.

spite a lag in sucrose accumulation in late August and September, the final percentage sucrose from the resistant variety at time of harvest, from mid-October to mid-November, was higher than that experienced in the 1921 to 1928 -work. Additional work in increasing the resistance so as to improve sucrose values earlier in the season is indicated by these results.

As in the case of the graph on tonnage yield of beets, the sugar-per-acre trend follows a similar pattern. With the resistant variety as used in these tests, it is economically feasible to start harvesting operations in mid-September. To overcome the lag in rate of sugar increase from mid-October until conclusion of harvest, greater tonnage-yielding ability is required. This apparently is the objective in the development of newer varieties, which have the ability to make better use of the fall season for the manufacture of sugar.

Summary

1. Studies conducted over an 8-year period (years 1921 to 1928 inclusive) indicate that the rate of percentage sucrose accumulation in the beet is most pronounced during the early life of the plant.

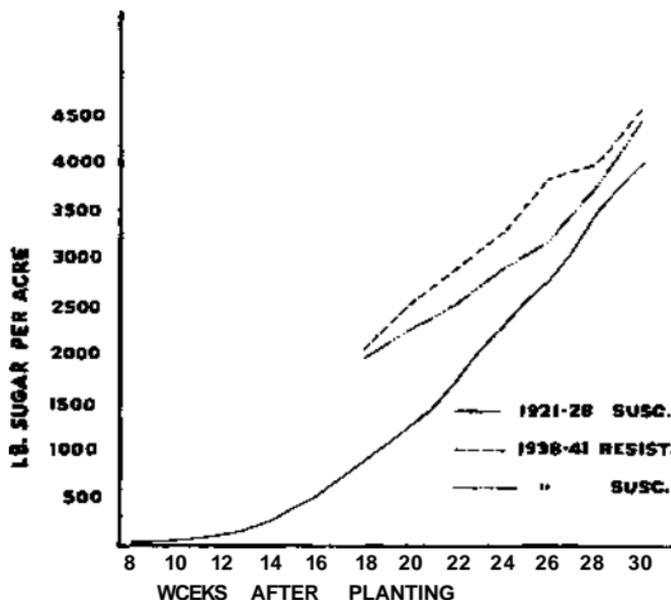


Figure 3.—Pounds sugar per acre. Years 1921 to 1928 and 1938 to 1941, inclusive,

2. Leafspot attacks of light incidence, occurring during the latter part of July, are generally overcome by the natural recovery of the plant within a period of 2 weeks, with relatively small sugar-per-acre loss. Those occurring later inflict much heavier sugar-per-acre losses and may require 4 to 6 weeks for return to the preinfection period of sucrose levels.

3. The most rapid rate of beet-tonnage increase is in the late summer and early fall months.

4. Development of more resistant varieties to leafspot has reduced the lag in development appreciably, increasing the sugar-per-acre accumulation to a point where earlier harvesting operations are feasible.

5. The need of higher-yielding tonnage types of sugar beets for maximum production of sugar per acre is indicated.