Relationship of Date of Planting and Date of Harvest to Incidence of Disease, Stand Survival, Yield and Sugar Content of Sugarbeets at Yuma, Arizona[1]

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In the warm desert valleys of southern Arizona and California, sugarbeets are grown during the fall and winter for harvest in the spring. The campaign begins in late April and continues into July, but processors are seeking ways to extend factory operations over a longer period.

Since the normal harvest campaign in the Imperial Valley or the Salt River Valley is in the late spring when ambient temperatures are increasing daily, it is not feasible to store beet roots for later processing. Rates of catabolism within the root tissue are so high under these conditions that the root is rendered unfit for processing within less than 72 hours after it has been lifted from the soil. Processors manage the beet harvest so that each day growers deliver to a factory only that tonnage of roots which can be processed within 24 hours.

The possibility of leaving the beets in the soil for harvest during the summer has been considered. Price et al. (8)[3] reviewed the records of the Holly Sugar Corporation for the Imperial Valley and found that whenever the harvest period had extended beyond mid-July there was a decline in acre yields of sugar, due principally to reduced sugar percentage of the beets. However, from a date of planting study in the Imperial Valley, they concluded that the harvest period could be profitably prolonged by planting beets in July and August and harvesting them earlier than is the current practice.

The primary objective of this study was to determine the feasibility of planting beets at various times of the year at Yuma, Arizona in order to have them available for harvest over the longest period of time possible. If beets could be profitably harvested at Yuma during April or August they could be shipped to either Chandler, Arizona or Brawley, California, thereby extending the length of the processing campaign. Harvests often begin as early as April 20 in the Imperial Valley and May 1 in

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[3] Numbers in parentheses refer to literature cited.

the Salt River Valley, and are usually completed in both valleys by August 1.

Materials and Methods

The 1962-1965 Experiment

US H2 sugarbeets were planted on approximately the fifteenth of every month during the three-year period, June 1962 through June 1965. Each planting consisted of four standard 40-inch beds 300 feet long with two rows of beets per bed spaced 12 inches apart. The plants were thinned to an 8-inch within-row spacing as soon as possible after stand establishment. The soil was Glendale silty clay loam underlain with fine sand at depths varying from 24 to 48 inches.

All plantings received 100 pounds per acre of N as ammonium sulphate by sidedressing after the first cultivation. Residual phosphorus in the soil was considered to be adequate from applications on previous crops. Supplies of potassium and other nutrients are normally adequate in this alluvial soil. Plots reserved for later plantings were kept free of weeds by cultivation.

Stand percentages were determined periodically on the basis of 1.5 plants per foot of row as a 100% stand. Plants in the plots were rated for diseased condition during the season. Disease symptoms, as expressed on the leaves, were evaluated visually with no attempt to isolate the specific disease causing organisms. A scale of 0 to 10 was used to indicate the range from no apparent disease to dead plants.

Periodically from December to September, three 5-foot double row segments were harvested from inside beds of each planting for yield and sugar content. Sugar percentage estimates were made by multiplying refractometer readings by the factor 0.8 which was derived by comparing refractometer readings with laboratory analyses of the same beet samples.

The 1965-1966 Experiment

The presence of old beets in the field constituted a source of disease infection for each new planting and probably resulted in higher levels of disease than would have occurred if beets had been used in rotation with other crops. In order to determine the disease incidence, rate of growth, and summer decline for beets planted following a beet-free period, all plots were plowed and free of beets by September 1, 1965. On November 12, a new field previously planted to alfalfa was used for a sugarbeet date of harvest study. There were eight replications of six harvest dates. All other procedures were similar to those of the preceding experiment. One plot from each replication was harvested every 2 weeks from May 23 to August 9.

Results and Discussion

The 1962-1965 Experiment

Disease The average disease index readings for the three-year period are shown in Table 1. Disease symptoms were evident early in the investigation. Curly top was observed in October 1962, mosaic in November, and "yellows" in March 1963. Disease symptoms were slower to appear in the fall and early winter plantings, but appeared quickly in the late winter and early spring plantings and increased rapidly in all plantings during the spring. Observations made in May 1963 indicated that the effects of disease were especially severe in plantings made during the previous summer months, while plantings made during the fall and winter were not severely affected.

Since beets were grown continuously in the experiment, they undoubtedly served as a source of infection for each new planting. Duffus (7) showed that new plantings were infected with disease much earlier as the distance from older diseased plants was decreased. The summer plantings of 1963 and 1964 started to show symptoms of disease earlier in the fall than did the 1962 summer plantings, while the fall, winter, and spring plantings in 1963-1964 and 1964-1965 followed a pattern similar to that of 1962-1963. Apparently the earliness of infection is dependent upon both the proximity of the disease source and the presence and numbers of efficient insect vectors.

Summer planted beets were always heavily diseased by the time growth was retarded by the cold weather of December and January. Therefore, they were in poor condition when growth resumed in February or March. Beets planted in October, or later, were not as severely infected with disease, withstood the cold weather better, and made better growth during the spring months. Apparently many of the common viruses which infect sugarbeets were present. In 1960, Bennett (1) reported that sugarbeet yellows disease was widespread in the Salt River Valley of Arizona and the Imperial Valley of California, and he named several weed hosts. Those common to the Yuma Valley include species of *Chenopodium, Amaranthus,* and *Atriplex.* Coudriet and Tuttle (4) reported on the movements of several efficient insect vectors of plant viruses in southern Arizona, the viruses transmitted, and the plants affected. According to them, curly top is spread in the cantaloupe fields of the Yuma Valley by the beet leafhopper, *Circulifer tenellus* (Baker), which migrates in large numbers from the desert to the cultivated areas throughout the year, with peaks of abundance in both spring and fall.

Table 1.—Three year average disease index readings on monthly plantings of sugarbeets at Yuma, Arizona, 1962-1965.

Month of reading	Month of planting											
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
July	.3[1]											
August	2	2										
September	2	2	1									
October	2.3	2.3	2.3	1								
November	3.3	3.3	3	2	0							
December	4	4.3	3.7	2.7	0	0						
January	5	5	4.7	3.3	.3	.7	0					
February	5.3	5.3	5.3	4	.3	.7	.3	.3				
March	6	6	5.7	4.7	1.3	1.7	1.3	1.3	2			
April	7	7	6.3	5	2	2.3	2	1.7	2.7	3.3		
May	7.3	8	7	6.3	2.3	3	3	3	3.7	5	3	
June	8	8.3	8	7.3	3.3	4	4	4.3	4.7	6.7	6.7	4.3
July		9	9	8.5	4	5	5	5	6	8.3	8.7	8
August					6	6	6.3	6.3	7.3	9.3	9.7	9.7
September								9	9	10	10	10

[1] Readings made on general diseased conditions using a scale of 0 to 10 to indicate the range from no disease symptoms to dead plants. The high readings of July, August and September include effects of high temperatures in combination with disease.

Beet yellows and beet western yellows both occur and are transmitted by the green peach aphid, *Myzus persicae* (Sulzer). Winged forms of this insect appear in September and gradually increase in population density during the winter. Maximum population density usually occurs between March 15 and April 15. Cucumber mosaic is common in cantaloupes at Yuma and readily transferred to sugarbeets by the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), which is prevalent in the Yuma area on johnsongrass, sorghum, and barley. This aphid has two distinct periods of winged form, September to December and February to May.

Reynolds et al. (9) reported that properly timed applications of insecticides during the normal growing season in the Imperial Valley (September - July) reduced the incidence of both curly top and yellows and increased both sugar percentage and tonnage of beets. However, he noted that in late spring tremendous numbers of alate aphids were flying and he doubted that any insecticide could protect the plants from infection with either beet yellows or beet western yellows under these conditions. Cook (3) reported that the beet leafhopper breeds continuously during the warmer months and that in California and Arizona nymphs are produced in every month except December and January. This fact and the migratory habits of the insect make control by ordinary methods very difficult.

Insects In addition to the vectors of virus diseases, there were other insects which damaged sugarbeets through the summer and fall. Flea beetles, principally *Systena blanda* Melsh., and the beet armyworm, *Spodoptera exigua* (Hübner), were active from June through September. Insecticides used were 5% Malathion dust, 2% Endrin dust, and Endrin spray. Applications made at intervals ranging from 14 to 30 days reduced populations but control was generally unsatisfactory.

From October 1963 to June 1965, all plantings were treated with Thimet. Twenty pounds per acre of ten-percent granules were applied in bands over the drill rows prior to each germination irrigation. No perceptable decline in either disease incidence or insect damage was noted as a result of these treatments.

In late October and early November, salt-marsh caterpillars, *Estigmene acrea* (Drury), moved into the beet plots from adjacent cotton fields and destroyed emerging seedlings by cutting them off at ground level. The most effective control was a 6-inch high aluminum-foil barrier placed around the field to keep the caterpillars out, a method commonly used to protect fields of emerging lettuce seedlings.

Stand persistence Early in the experiment it became apparent that high summer temperatures were a major factor in determining when sugarbeets could be planted and grown for economical production at Yuma. On the average, afternoon temperatures reach 100 F from June 8 to September 13 and 105 F from June 26 to August 16 (10). Although all plantings resulted in fair stands (Figure 1), plantings which were beyond the seedling stage by the time they were subjected to the summer heat were dead or dying by August. However, seedlings from June, July and August plantings survived the first summer but quickly declined when, as mature plants, they were subjected to the heat of the following summer. Death appeared to result from the interaction of disease, insects and high temperatures.

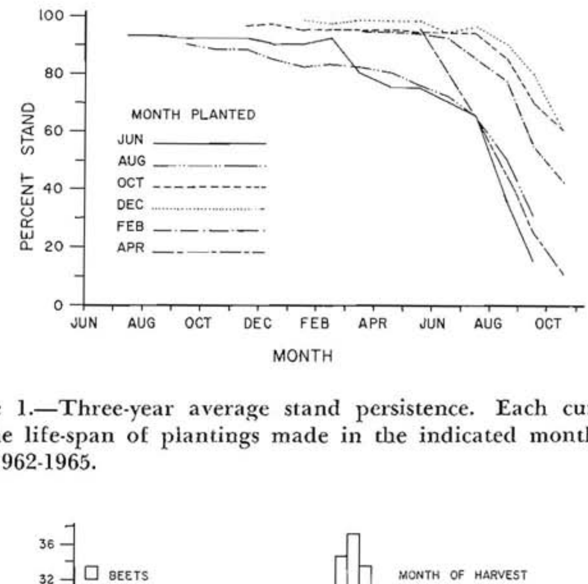

Figure 1.—Three-year average stand persistence. Each curve extends through the life-span of plantings made in the indicated month at Yuma, Arizona. 1962-1965.

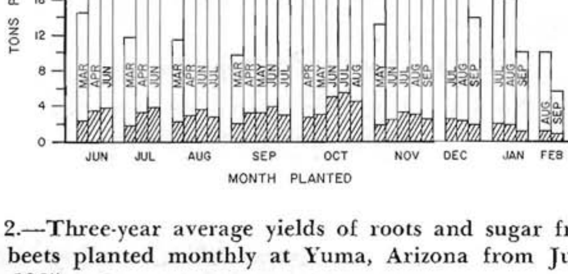

Figure 2.—Three-year average yields of roots and sugar from periodic harvests of beets planted monthly at Yuma, Arizona from June 15, 1962 to June 15, 1965.

Yield Highest average yields of both roots and sugar were obtained from beets planted in mid-October and harvested in late June or early July (Figure 2). Even with continuous beets, 41 tons of roots per acre were harvested on July 26, 1965 from the planting made October 15, 1964.

Examination of Figure 2 shows that the beets planted in October doubled in root size between mid-April and mid-July. The explanation of this occurrence is found in Table 1 which shows that beets planted in October were free of disease symptoms for at least 60 days after planting and then continued to show evidence of much less disease through the spring growing period than did the earlier plantings. Bennett et al. (2) reported that when infection by beet yellows was delayed 49 days, reduction in root weight was 22% less than when the beets were infected at the 12- to 16-leaf stage. Not only was the damage less as infection was delayed but the average daily reduction in root weight tended to decrease with the delay of infection.

If beets were to be harvested at Yuma as early as mid-March or early April, most of their development would have to be made during the previous summer and fall before growth was retarded by low temperatures in December and January. The highest average root yields obtained in March and April were from the June plantings which produced approximately 14 tons per acre by mid-March of the following year and 23 tons per acre in mid-April. The March and April yields from July, August and September plantings were progressively lower. When harvest of these summer plantings was delayed until June, their maximum yield potential was not realized because of the effects of disease (Table 1).

The possibility of extending the harvest campaign by planting beets in the winter or early spring for harvest in August does not seem promising. As shown in Figure 2, whenever the harvest was delayed until mid-August, regardless of the planting date, there was a decline in yield of sugar even though the tonnage of roots was slightly higher in some instances. In all cases the root sugar content decreased, plant growth rates were retarded and many plants died.

The 1965-1966 Experiment

Since production of maximum yields was not an objective of this experiment, planting was delayed until November 12 so that all beets and weeds could be completely removed from the plots of the 1962-1965 experiment. Apparently this precaution had little effect on the incidence of disease in this planting as is shown by comparison of the disease index readings in Tables 1 and 3. "Yellows" was observed early in March and was the most prevalent disease. This was probably beet western yellows. Duffus (5, 6) found that beet western yellows occurs extensively in California and is caused by a virus which is persistent in the aphid. Once the insect acquires the virus, it can transmit beet western yellows the rest of its life. On the other hand, Bennett (1) showed that the beet yellows virus is semipersistent. After acquiring the virus most of the aphids in his experiments lost the ability to transmit it in 24 hours. In a few aphids the virus was able to persist 72 hours but not for 96 hours.

Curly top was observed as localized infections during March and April, but increased rapidly in July. Mosaic, probably cucumber mosaic (4), developed rapidly during May, June, and July. This disease complex was widespread by early August (Table 2).

Disease symptoms appeared to be strongly influenced by temperature since they increased rapidly with the advent of warm weather in the spring. Conversely, plants weakened by disease were apparently unable to survive the high temperatures of July and August (Table 2). The stand was materially reduced by August 5. Beets left in the field through August were nearly all dead by September.

Table 2.—Stand survival as related to disease index readings and maximum daily temperatures for sugarbeets planted November 12, 1965 at Yuma, Arizona.

	Jan. 8	Feb. 5	Mar. 5	Apr. 9	May 8	June 4	July 4	Aug. 5
Disease index[1]	0	0	2.1	3.6	4.3	4.6	5.0	7.0
Maximum temperature[2]	66	68	69	93	99	98	106	104
Percent stand[1]	100	100	98.5	92.6	91.8	91.4	88.8	69.9

[1] Data are averages of 8 replications.

[2] Ten-day average maximum daily temperature ending on date indicated.

Table 3.—Relationship of date of harvest to disease index, stand survival and production of sugarbeets planted in November following a beet free period at Yuma, Arizona in 1965.[1]

Harvest date	Disease index	Percent stand	Percent sucrose	Yields in tons per acre[2]	
				Roots	Sugar
May 23	4.3	91.8	14.4	14.72 b	2.12 b
June 6	4.6	91.4	13.8	15.94 b	2.19 b
June 21	4.8	90.1	12.6	18.87 a	2.36 b
July 9	5.0	88.8	13.3	20.18 a	2.67 a
July 20	6.0	79.3	11.9	20.03 a	2.38 ab
August 9	7.0	69.9	10.6	15.94 b	1.69 c

[1] Data are means of 8 replications.

[2] Group means followed by the same letter do not differ significantly at the .05 level.

Table 3 shows yield and sugar content of beets, along with disease index and stand when harvested at two-week intervals between May 23 and August 9. Although disease symptoms increased and stands declined slightly, yields of roots and sugar tended to increase steadily until approximately mid-July. Apparently, this was the end of the productive growing season. The two remaining harvests showed a quickening decline in stand and sugar content with corresponding loss in yield of beets and of sugar.

The incidence of disease in sugarbeets had a direct relationship to the date of planting. Whenever beets were planted in the summer or allowed to go into the summer from earlier plantings they became highly infected with disease. Beets planted between June 1 and September 15 were highly diseased by midwinter, while beets planted after October 1 were relatively free of disease symptoms until March or April.

Beets planted in June, July, or August persisted through the summer as seedlings and made some growth in the fall, but not enough to be harvested before growth was retarded by the low temperatures of December and January. These beets were relatively susceptible to frost injury and recovered very slowly in early spring. This was probably due to the stage of plant growth, the effects of disease, or a combination of these factors. Beet seedlings from the October plantings were relatively free of disease during December and January. They withstood the low temperatures well and quickly resumed growth in early spring. By mid-May, they were equal in root size to beets planted in the summer months and, for a mid-June harvest, beets planted in October produced 8 tons of roots per acre more than the plants seeded earlier.

Conclusions

Summer plantings had three distinct disadvantages: 1) They occupied the land and required cultivation and irrigation for a full year. 2) They required an intensive insect control program. 3) They became highly infected with disease which limited their yield potential, regardless of the date of harvest. However, summer plantings could be advantageous if a premium was placed on an April harvest. Experimental results indicated that root yields of about 20 tons per acre could be harvested in mid-April from beets planted the previous June if insects were controlled.

There is little probability of extending the harvest season beyond July, regardless of planting date. Insects, disease, and high temperatures appeared to be the principal factors responsible for the decline and death of mature beets left in the soil during the summer months.

Summary

US H2 sugarbeets were planted on approximately the fifteenth of each month during a three-year period. Periodically, plants were rated for disease and stand percentage, and harvested for root yield and sugar content.

In general, summer plantings were subjected to insects and disease over a long period of time and produced low yields whenever they were harvested the following spring or summer. Beets planted in the fall, preferably in October, endured the low temperatures of December and January well and made most of their growth before the disease infection increased in late spring. These plants produced good yields when harvested in June or July. Nearly all plants beyond the seedling stage at the beginning of summer died from the effect of disease, insects, and high temperatures during July, August, and September.

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