Influence of Planting Date, Nitrogen Rate, and Harvest Date on Yield and Sucrose Concentration of Fall-Planted Sugarbeets in Central Arizona[1]

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In the desert valleys of central and southwest Arizona and southern California sugarbeets are planted primarily in September and October although some acreage, mostly where replanting is necessary, is planted as late as November. Stand establishment is usually more difficult in early September than in later plantings because of high temperatures and high soil salinities in these areas (2,4)[3]. August plantings, although advantageous for early harvest (6, 8), are limited because of the need for a 30-day beet-free period during the year to prevent carryover of virus yellows diseases (7).

Harvest of beets in these desert areas extends from late April through July. Root yields are generally low when harvest is earlier and root quality tends to decline when harvest is later than mid-July. Harvest is completed by the end of July to allow for the 30-day beet-free period before planting starts the following season. For efficient factory operation in these areas, it is desirable to harvest and deliver beets daily over as long a period as possible. Stockpiling of beets for extended periods as is done in cooler areas is not possible in the fall-planted areas of Arizona and California.

The proper management of nitrogen (N) fertilizer is a major factor in maximizing the production of sugar. Supplies of N must be readily available during early and mid-season to promote root and top growth. However, beets must become deficient in N prior to harvest to obtain maximum sucrose concentration. Hills and Ulrich (5) concluded that petiole NO_3-N concentration should be below 1000 ppm for 4 to 6 weeks before harvest.

For both successful stand establishment and efficient factory operation, it would be desirable to delay planting until late September or later and encourage rapid growth so that good yields

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[3]Numbers in parentheses refer to literature cited.

could still be obtained early in the season. The objective of this study was to determine the effect of delayed planting dates and 2 N rates on sugarbeet yield and quality on different harvest dates.

Materials and Methods

Sugarbeets were grown during 1973-74, 1974-75, and 1975-76 on Laveen loam at the University of Arizona Agricultural Experiment Station, Mesa, Arizona. The cultivar used, US H9B, produces excellent yields but generally lacks sufficient bolting resistance for September plantings in central Arizona. Four planting dates in September and October were compared each year. Sugarbeets were planted on 30-inch beds and seedlings were thinned to 8 to 12 inches apart. Soil moisture was supplied by furrow irrigations.

Nitrogen fertilizer was applied at rates of 20 and 100 lbs per acre. Each year, the plot area received a preplant application of 20 lbs of N and 38 lbs of P per acre as 11-48-0 fertilizer. An additional 80 lbs of N per acre (as ammonium nitrate) was sidedressed on one-half of each planting-date plot in January. Prior to planting, soil samples were collected in one foot increments to a depth of four feet and were analyzed for NO_3-N content as described by Bremner (3). There were approximately 170, 220, and 130 lbs of residual N per acre in 1973-74, 1974-75 and 1975-76, respectively. Petioles were collected at harvest and analyzed for NO_3-N concentrations with a nitrate-specific ion electrode using the procedure described by Baker and Smith (1).

Plots were sampled on three dates corresponding to early-, mid-, and late-season commercial harvest periods. On each date, beets from 28 feet of row per plot were harvested and root yield, sucrose concentration, and sugar yield were determined. One sample of 8 to 10 roots per plot was analyzed for sucrose concentration by Amstar Corporation, Spreckels Sugar Division. The experimental design was a split-split plot in randomized complete blocks replicated six times. Main plots were planting dates, sub plots were N rates, and sub-sub plots were harvest dates.

Results and Discussion

Root and sugar yields were high each year; however, yields were unusually high in the 1973-74 season (Tables 1, 2 and 3). The outstanding crop produced that year may have been due, in part, to the occurrence of above-normal temperatures during the winter and spring seasons, although favorable temperatures also occurred in the 1975-76 season without a similar effect on yield. This was probably due to a combination of factors including insufficient N and a light to moderate western yellows infection in the spring.

Table 1.—Effect of planting date, N rate, and harvest date on root yield, sucrose concentration, gross sugar yield, and petiole NO_3-N in 1973-74.

Planting Date	N Rate	Root Yield Harvest Date			Sucrose Concentration Harvest Date			Gross Sugar Yield Harvest Date			Petiole NO_3-N Harvest Date		
		May	June	July	May	June	July	May	June	July	May	June	July
	Lbs N/A		*Tons/Acre*			*%*			*Tons/Acre*			*ppm*	
Sept. 7	20	33.6	40.7	50.8	15.95	17.17	17.03	5.36	6.99	8.65	310	350	820
	100	35.2	43.6	50.3	14.82	17.02	16.77	5.22	7.42	8.44	440	520	910
	Ave.	34.4a[1]	42.2a	50.6a	15.39a	17.10a	16.90a	5.29a	7.21a	8.55a	380	440	870
Sept. 21	20	30.5	38.6	50.2	15.50	17.15	16.68	4.73	6.62	8.37	350	360	730
	100	32.5	43.0	48.8	14.52	16.43	16.77	4.72	7.06	8.18	800	610	940
	Ave.	31.5ab	40.8a	49.5a	15.01a	16.79a	16.73a	4.73ab	6.84a	8.28a	580	490	840
Oct. 5	20	29.7	38.2	49.3	14.40	16.75	16.68	4.28	6.40	8.22	670	410	870
	100	29.6	39.6	48.5	13.68	15.02	15.97	4.05	5.95	7.75	1670	720	990
	Ave.	29.7b	38.9ab	48.9a	14.04b	15.89b	16.33ab	4.17b	6.18b	7.99a	1170	570	930
Oct. 20	20	25.2	38.1	44.3	13.27	15.33	16.12	3.34	5.84	7.14	1810	1230	1030
	100	26.1	36.3	44.1	12.62	14.92	15.13	3.29	5.42	6.67	1420	1670	1280
	Ave.	25.7c	37.2b	44.2b	12.95c	15.13b	15.63b	3.32c	5.63b	6.91b	1620	1450	1160
Statistically significant effects[2]			PD** N x HD* HD**			PD** HD** N** PD x HD**			PD** HD**				

[1]Planting date means within a harvest date column followed by the same letters are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

[2]*, ** = F ratio exceeds the .05 and .01 probability levels, respectively.

Table 2.—Effect of planting date, N rate, and harvest date on root yield, sucrose concentration, gross sugar yield, and petiole NO_3-N in 1974-75.

Planting Date	N Rate	Root Yield Harvest Date			Sucrose Concentration Harvest Date			Gross Sugar Yield Harvest Date			Petiole NO_3-N Harvest Date		
		May	June	July	May	June	July	May	June	July	May	June	July
	Lbs N/A		*Tons/Acre*			%			*Tons/Acre*			*ppm*	
Sept. 10	20	27.5	36.4	38.4	14.65	14.55	14.97	4.02	5.29	5.76	640	510	430
	100	28.7	40.9	38.7	14.20	14.22	14.35	4.08	5.78	5.55	890	800	470
	Ave.	28.1a[1]	38.7a	38.6a	14.43a	14.39a	14.66a	4.05a	5.54a	5.66a	770	660	450
Sept. 23	20	24.7	39.1	37.1	14.48	14.32	14.68	3.57	5.62	5.46	710	680	410
	100	27.5	37.3	39.8	13.48	13.85	14.38	3.69	5.16	5.72	1190	790	360
	Ave.	26.1a	38.2a	38.5a	13.98a	14.09a	14.53a	3.65a	5.39a	5.59a	950	740	390
Oct. 7	20	23.0	36.8	41.6	12.60	12.78	14.20	2.89	4.69	5.90	1640	880	440
	100	23.2	37.0	40.3	12.12	12.65	13.52	2.81	4.68	5.43	2260	1420	440
	Ave.	23.1b	36.9ab	41.0a	12.36b	12.72b	13.86a	2.85b	4.69b	5.67a	1950	1150	440
Oct. 21	20	16.8	32.3	36.9	12.33	11.72	13.15	2.06	3.80	4.87	2210	1920	560
	100	18.6	36.1	40.4	12.32	11.92	12.68	2.29	4.29	5.12	2550	2300	1350
	Ave.	17.7c	34.2b	38.7a	12.33b	11.82b	12.92b	2.18c	4.05c	5.00b	2380	2110	960
Statistically significant effects[2]		PD** HD** N** PD x HD**			PD** HD** N** PD x HD**			PD** HD** N x PD*					

[1]Planting date means within a harvest date column followed by the same letters are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

[2]*, ** = F ratio exceeds the .05 and .01 probability levels, respectively.

Table 3.—Effect of planting date, N rate, and harvest date on root yield, sucrose concentration, gross sugar yield, and petiole NO_3-N in 1975-76.

Planting Date	N Rate	Root Yield Harvest Date			Sucrose Concentration Harvest Date			Gross Sugar Yield Harvest Date			Petiole NO_3-N Harvest Date		
		May	June	July	May	June	July	May	June	July	May	June	July
	Lbs N/A	*Tons/Acre*			%			*Tons/Acre*			*ppm*		
Sept. 11	20	24.0	29.4	32.6	15.47	17.05	16.78	3.71	5.01	5.46	380	730	520
	100	27.2	35.8	39.5	14.38	16.25	16.33	3.92	5.81	6.45	510	650	540
	Ave.	25.6a[1]	32.6a	36.1a	14.93a	16.65ab	16.56a	3.82a	5.41a	5.96a	450	690	530
Sept. 23	20	23.1	30.4	31.8	15.07	17.25	16.12	3.48	5.24	5.12	380	700	590
	100	28.2	34.6	42.2	13.70	17.00	16.33	3.88	5.87	6.89	460	540	640
	Ave.	25.7a	32.5a	37.0a	14.39a	17.13a	16.23a	3.68ab	5.56a	6.01a	420	620	620
Oct. 7	20	23.6	30.4	32.8	13.30	15.47	15.98	3.12	4.69	5.24	630	520	640
	100	24.9	32.6	35.6	13.07	16.57	16.07	3.26	5.40	5.73	560	560	500
	Ave.	24.3a	31.5a	34.2a	13.19b	16.02b	16.03a	3.19b	5.05a	5.49a	600	540	570
Oct. 22	20	17.6	24.1	26.8	12.27	15.38	15.27	2.17	3.67	4.10	790	510	470
	100	20.6	27.0	33.6	12.73	15.03	14.53	2.60	4.06	4.88	1100	810	500
	Ave.	19.1b	25.6b	30.2b	12.50b	15.21c	14.90b	2.39c	3.87b	4.49b	950	660	490
Statistically significant effects[2]		PD** HD** N** N x HD**			PD** PD x HD* HD**			PD** HD** N** N x HD**					

[1]Planting date means within a harvest date column followed by the same letters are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

[2]*, ** = F ratio exceeds the .05 and .01 probability levels, respectively.

There were no significant differences between early and late September plantings in root yield in any of the years. Beets planted in early October generally produced yields comparable to those planted in September when harvest was in June or July. Late October plantings did not yield as much as earlier plantings in two of three years.

Root growth rates during the harvest season were similar for the various planting dates except in 1974-75. In that year, growth rates for October plantings were markedly greater than those for September plantings. For example, root yield for the late October planting increased 21 tons per acre during the harvest season compared to 10.5 tons per acre for the early September planting. Possibly, the lower root growth rates of September plantings in 1974-75 were due to the high incidence of bolting (Table 4).

Table 4.—Effect of planting date and N rate on the production of bolters.

Planting Date[2]	N Rate	Bolting Percentage[1]		
		1973-74	1974-75	1975-76
	Lbs N/A			
Sept. 9	20	17	48	5
	100	25	44	7
	Ave.	21	46	6
Sept. 22	20	10	40	1
	100	14	36	1
	Ave.	12	38	1
Oct. 6	20	2	29	0
	100	2	9	0
	Ave.	2	19	0
Oct. 21	20	0	0	0
	100	0	0	0
	Ave.	0	0	0

[1]Counts were made each year in mid-May.
[2]Average planting dates for 3 years.

Sucrose concentrations for the September plantings did not differ significantly between different harvest dates. Beets planted in early October generally were lower in sucrose concentration than those planted in September when harvest was in May and June, but not in July. Sucrose concentration of beets planted in late October did not approach that of beets planted in early or late September on any of the harvest dates.

The lower sucrose concentrations in late October plantings were probably related to high N levels at harvest. In 2 of 3 years,

late October plantings were not deficient in N on any harvest date. In contrast, September plantings were generally N deficient by May.

There was no consistent pattern of sucrose accumulation during the three seasons. In 1973-74 and 1975-76, sucrose concentration of September plantings increased between May and June but remained constant or decreased by July. October plantings showed similar patterns except that there was a tendency for sucrose concentration to increase late in the season. In 1974-75, a year characterized by a high level of residual N, overall increases in sucrose concentration between May and July harvests were small. The leveling off or decline in sucrose concentration between June and July in early plantings was associated with such factors as high air temperatures, N deficiency, and reduced leaf areas.

In this study, high sucrose concentration was not dependent on a cessation of storage root growth. Substantial increases in sucrose concentration occurred concurrently with rapid root growth in the first half of the 1973-74 and 1975-76 harvest seasons. The increase in sucrose concentration in these years appeared to be associated with a period of restricted top growth prior to harvest. Apparently, the N supply in the soil during these harvest seasons supported only limited top growth, but was adequate for moderate root growth. In 1974-75, excessive N was available throughout the spring, resulting in high rates of both root and top growth; hence sucrose concentration was low.

Sugar yields were unaffected by delaying the planting until late September. Early October plantings generally resulted in the same sugar yields as September plantings when harvest was in June or July. Sugar yields of late October plantings were lower than those of September plantings on all harvest dates.

Nitrogen rate had a significant influence each year on sucrose concentration, root yield, or both. However, only in 1975-76, when residual N was low, did the N rate significantly affect the production of sugar. In that year, the addition of 80 lbs of N per acre in January increased yields.

The date of planting had a marked effect on the production of bolters (Table 4). In 1973-74 and 1974-75, when bolting was excessive, early plantings had a higher incidence than late plantings. Late October plantings did not produce bolters in any year. The low percentage of bolting in 1975-76 was partly attributed to mild winter temperatures.

Summary

The influence of planting date, nitrogen rate, and harvest date on root yield, sucrose concentration, and sugar yield of sugarbeets was studied for three consecutive seasons in central Arizona.

Delaying planting from early September to late September did not significantly affect yield or sucrose concentration, regardless of the harvest date. Early October plantings generally produced yields and sucrose percentages similar to September plantings when harvest was in June or July, but not in May. Sucrose concentration and sugar yields of late October plantings did not approach those of September plantings on any of the harvest dates.

Nitrogen rate had a significant effect on sugar yield in only one season. Delaying the planting date from early September to late September or October resulted in reduced bolting.

Literature Cited

(1) BAKER, A. S. AND R. SMITH. 1969. Extracting solution for potentiometric determination of nitrate in plant tissue. Agr. and Food Chem. 17(6):1284-1287.

(2) BEMIS, W. P. 1962. Temperature tables and their uses in crop production for 10 stations in southern Arizona. Ariz. Agr. Expt. Sta. Tech. Bull. No. 151.

(3) BREMNER, J. M. 1965. Inorganic forms of nitrogen. *In* C. A. Black (ed.) *Methods of Soil Analysis.* Part 2. Agronomy 9:1179-1237. Amer. Soc. of Agron., Madison, Wis.

(4) FRANCOIS, L. E. AND J. R. GOODWIN. 1972. Interaction of temperature and salinity on sugar beet germination. Agron. J. 64:272-273.

(5) HILLS, F. J. AND A. ULRICH. 1971. Nitrogen Nutrition, p. 112-135. *In* R. T. Johnson *et al.* (ed.) *Advances in Sugarbeet Production: Principles and Practices.* The Iowa State University Press, Ames, Iowa.

(6) JACKSON, E. B. AND F. M. CARASSO. 1969. Relationship of date of planting and date of harvest to incidence of disease, stand survival, yield and sugar content of sugarbeets at Yuma, Arizona. J. Am. Soc. Sugar Beet Technol. 15(6):528-537.

(7) NELSON, J. M. AND M. E. STANGHELLINI. 1972. Virus yellows control in sugarbeets — sanitation and resistant varieties. Progressive Agriculture in Arizona Vol. XXIV(2):10-11.

(8) PRICE, CHARLES, DON FIFE, AND B. A. KRANTZ. 1954. Sugar beet planting date studies in Imperial Valley, Calif. Proc. Am. Soc. Sugar Beet Technol. 8:164-167.