Aphid Control and Planting Date for the Control of Yellows of Sugar Beet

F. J. Hills, W. H. Lange, J. L. Reed and R. S. Loomis[1]

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Approximately 45% of the sugar beet acreage in California occurs in the Sacramento Valley and in the northern portion of the San Joaquin Valley. The practice of overwintering spring and early summer planted beets for spring harvest has developed extensively in this area. As Table 1 indicates, average root yields for the counties of this region have declined in recent years. The increased prevalence of the beet yellows virus and other aphid-borne viruses may be partially responsible.

Table 1.—Sugar beet root yields by counties in the north central valley region of California. Weighted averages for successive 5-year periods (average tons per acre per county weighted by acres harvested).[1]

County	Tons per harvested acre	
	1953-1957	1958-1962
Glenn	16.2	15.7
Butte	18.9	18.0
Colusa	19.6	18.5
Sutter	20.4	19.6
Yolo	21.4	20.0
Solano	21.4	20.3
Sacramento	21.1	18.2
San Joaquin	20.7	20.7
Stanislaus	20.9	20.2

[1] Calculated from data of the Agricultural Stablization and Conservation Committee, 2020 Milvia Street, Berkeley, California.

The green peach aphid, *Myzus persicae* (Sulz.), is the principal vector of the aphid-borne viruses of sugar beet. Flight patterns of this aphid in the interior valleys of California are characterized by peaks in March and April (Figure 1). As temperatures rise, there is a rapid decline in numbers of alates to very low levels by the end of May. Populations then usually remain low until October or November, when a fall build-up and dispersal flight again occurs.

The three economically important viruses transmitted by the green peach aphid in California are the beet yellows virus, the beet western yellows virus, and the sugar beet mosaic virus. Several tests have shown that these viruses can produce percentage reductions in root yield in the following ranges: sugar

[1] Respectively, Extension Agronomist, Professor of Entomology, Assistant Entomologist, and Associate Agronomist, University of California, Davis.

beet mosaic virus—5-10%; beet western yellows virus—10-20%; and the beet yellows virus—20-40% (1) (3) (6). The effects of the viruses on the sugar beet plant are additive and all three exists as strains of varying virulence. The more virulent strains can be expected to increase with the continued practice of overwintering.

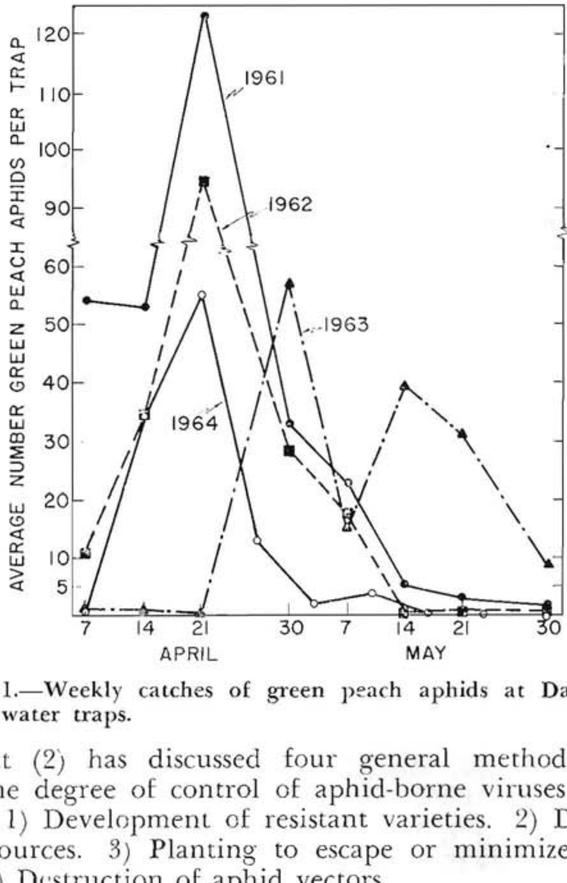

Figure 1.—Weekly catches of green peach aphids at Davis using 8 yellow pan water traps.

Bennett (2) has discussed four general methods through which some degree of control of aphid-borne viruses might be achieved. 1) Development of resistant varieties. 2) Destruction of virus sources. 3) Planting to escape or minimize virus infection. 4) Destruction of aphid vectors.

Control through the development of tolerant varieties is being vigorously pursued and some degree of success is to be expected soon (5).

The beet yellows virus and the sugar beet mosaic virus are closely associated only with sugar beet and, though several common weeds are good reservoirs for the beet western yellows virus, its inoculum potential is greatly increased by a large acreage of overwintered sugar beets. Thus, if overwintered sugar

[2] Numbers in parentheses refer to literature cited.

beets could be eliminated, a considerable degree of control might be obtained. To terminate this practice, however, would mean a reduction of some 40% of the sugar beet acreage that is now processed by existing facilities. It is unlikely that companies or growers would be willing to make such a change.

A degree of control has been achieved by delaying spring plantings. In most years, sugar beets planted in May escape infection. In years of early, extensive aphid flights, this practice can result in improved production (4). However, any delay in planting after March or April means a considerable loss in growing season and therefore potential production. Since 1961, experiments have been conducted at Davis to evaluate the effects of date of planting and aphid control on beet production. The results of the 1961 experiment were reported earlier (4) and involved dates of planting and artificial inoculation with yellows viruses. In subsequent experiments, control practices involving planting date and aphid control have been evaluated under naturally occurring disease conditions. This paper will report the results of trials conducted in 1962, 1963 and 1964.

Methods

Each experiment involved a factorial set of combinations of planting dates, number of spray applications, and harvest dates. A split or split-split plot design was used for each experiment with from 4 to 5 replications of main plots in randomized complete blocks. The final split was for harvest date. Beets were grown on 40-inch beds, 2 rows per bed. Each harvest date plot was 4 rows wide by at least 60 feet long. Forty or 50 feet of the center 2 rows were harvested. Two samples of 10-15 roots each were taken from each plot for sucrose and tare analyses. In 1962 the Spreckels Sugar Company variety 202H was grown; in subsequent years a USDA multigerm hybrid (US H6), was utilized. In all experiments the sugar beets were grown at a high level of nitrogen fertilization to assure that differences in sucrose content would largely be due to the treatments applied and not to differing degrees of nitrogen deficiency at time of harvest. This objective was achieved except in 1963 when plants of the May planting date appeared to take up more NO_3-N than plants of the other planting dates. Leaf samples were periodically collected and analyzed to assay the nutritional status of the plants.

A single spray-material, Metasystox-R, oxydemetonmethyl, [S-2-(ethylsulfinyl) ethyl 0,0-dimethyl phosphorothioate] was used. This was applied with a backpack sprayer at a rate of 12 ounces in 50 gallons of water per acre. Differential spray treatments consisted of differing number of applications. Spray schedules for each year are given in Table 2.

Table 2.—Dates of aphicide application. All applications were Metasystox-R at 12 ounces per acre in 50 gallons of water.

Year	Date planted	Number of sprays	Application dates											
1962	April 10	8					4/28	5/5	5/11	5/19	5/25	6/1	6/15	6/28
	May 7	4									5/25	6/1	6/15	6/28
1963	March 2	10	4/2	4/9	4/16	4/23	4/30	5/7	5/13	5/21	5/28	6/4		
		3		4/9	4/19		4/29							
	April 2	7				4/23	4/30	5/7	5/13	5/21	5/28	6/4		
		3					4/29	5/9		5/19				
	May 2	3								5/19	5/29	6/8		
1964	March 1	8	4/3		4/17	4/24	5/1	5/8	5/15	5/22	5/29			
		3	4/3		4/17		5/1							
	April 1	7			4/17	4/24	5/1	5/8	5/15	5/22	5/29			
		3			4/17		5/1		5/15					
	May 1	3							5/15	5/22	5/29			
		1							5/15					

Table 3.—Effects of planting dates and sprays for aphid control on sugar beet production, Davis, California. 1962.

Date planted	No. of sprays	% yellows[2]	Roots, tons/acre				Roots, % sucrose				Gross sucrose, tons/acre				
			8/21	9/18	10/22	Average	8/21	9/18	10/22	Average	8/21	9/18	10/22	Average	% Change[3]
4/10	0	53	24.0	26.6	32.2	27.6	12.6	13.0	12.0	12.6	3.03	3.46	3.88	3.46	4
	8	10	27.7	33.1	40.8	33.8	12.7	13.2	12.5	12.8	3.51	4.36	5.10	4.32	29
5/7	0	1	19.2	25.3	32.5	25.7	12.4	13.2	13.2	12.9	2.38	3.34	4.28	3.34	---
	4	0	19.8	25.6	33.0	26.1	12.0	13.4	12.8	12.7	2.39	3.41	4.21	3.34	0
Harvest date means			22.6	27.7	34.6		12.4	13.2	12.6		2.83	3.64	4.37		
LSD, 5%[1]			2.7,	2.5,	1.2,	1.4	0.8,	0.8,	n.s.,	0.4	0.42,	0.42,	0.25,	0.21	

[1] In order given LSD's are for difference between: harvest dates for the same plant and spray treatment; plant and spray treatments for the same or different harvests; plant and spray treatment averages; harvest date means.

[2] July 30. Mosaic infection was less than 1%.

[3] Compared to May 7, spray 0.

Results

Treatments for each experiment and mean values for their effects on visible virus infection and on sugar beet production for several dates of harvest are given in Tables 3, 4, and 5. In all three experiments there was a highly significant interaction of plant date $\times$ spray treatment for root and gross sucrose production. These effects are presented for each experiment as averages of the plant and spray treatments over all harvest dates.

Statistically significant effects of spray treatments on sucrose concentration only occurred in the 1963 treatment. In general, however, where sprays achieved some degree of virus control, there was a tendency for higher sucrose concentrations in roots of sprayed compared to non-sprayed beets of a common planting date. This is what would be expected on the basis of the work of Bennett (1) and others (4). Increases in sucrose concentration associated with spray treatments within a planting date were not usually correlated with decreased uptake of nitrates (Table 6). An exception was the effect of the seven spray applications on April planted beets in 1964. In this case there was a consistently lower concentration of NO_3-N in petioles of plants of this treatment compared to other spray treatments of that planting date. No explanation other than chance location of these plots in areas of lower fertility can be given as this effect did not occur in the other experiments reported here nor in an earlier experiment (4).

At each harvest, tops from each plot were weighed. These data are not presented but in general there was little or no effect of the spray treatments on fresh weight of tops.

The principal effect of planting date and spray treatment was on root growth and consequently on sucrose production. Differences due to spray treatments were greater with late fall harvests compared to earlier harvests. This is shown in Tables 3 and 4 for the 1962 and 1963 experiments where harvests were from early to late fall.

In 1962, beets planted in April and sprayed 8 times for aphid control averaged 8.1 more tons of roots per acre for three fall harvests than beets planted in May. Judging from alate aphid catches (Figure 1), this same degree of control might have been obtained by 4 or 5 sprays. Non-sprayed April planted beets, 53% infected with yellows viruses, produced no better than May planted beets which were essentially virus free.

The 1963 experiment involved March as well as April and May plantings. Later than usual aphid flights (Figure 1) re-

Table 4.—Effects of planting dates and sprays for aphid control on sugar beet production, Davis. California. 1963.

Date planted	No. of sprays	% disease[2] yellows	% disease[2] mosaic	Roots, tons/acre 8/27	Roots, tons/acre 9/24	Roots, tons/acre 10/22	Roots, tons/acre Average	Roots, % sucrose 8/27	Roots, % sucrose 9/24	Roots, % sucrose 10/22	Roots, % sucrose Average	Gross sucrose, tons per acre 8/27	Gross sucrose, tons per acre 9/24	Gross sucrose, tons per acre 10/22	Gross sucrose, tons per acre Average	% Change[3]
3/2	0	93	100	24.2	29.1	31.2	28.2	12.0	12.2	12.3	12.2	2.91	3.54	3.81	3.42	20
	3	90	100	24.6	30.5	32.7	29.9	12.4	11.8	12.2	12.2	3.30	3.59	3.98	3.62	27
	10	86	100	30.4	36.0	43.2	36.6	12.7	12.6	12.8	12.7	3.86	4.54	5.52	4.64	63
4/2	0	67	99	26 2	32.0	33.0	30.4	12.3	12.1	12.4	12.2	3.24	3.87	4.06	3.72	31
	3	72	98	27.7	33.0	35.1	31.9	12.9	12.8	12.5	12.8	3.58	4.23	4.39	4.07	43
	7	51	99	32.3	34.0	40.6	35.6	12.2	12.4	12.7	12.4	3.96	4.22	5.16	4.44	56
5/2	0	44	79	22.4	25.2	27.0	24.9	11.3	11.4	11.6	11.4	2.52	2.88	3.12	2.84	...
	3	25	76	23.7	30.6	36.5	30.2	11.7	11.8	12.4	12.0	2.77	3.59	4.51	3.63	28
Harvest date means				26.3	31.2	35.1		12.2	12.1	12.4		3.21	3.78	4.34		
LSD, 5%[1]				3.1, 3.2, 4.0, 2.0, 5.1, 1.4				0.6, 0.7, 0.7, 0.4, 0.8, 0.3				0.43, 0.44, 0.56, 0.26, 0.77, 0.19				

[1] In order given the LSD's are for differences between: harvest dates for same plant and spray treatment; spray treatments for the same plant and harvest date; spray treatments for different plant dates and the same or different harvest dates; averages of spray treatments of the same plant date; averages of spray treatments for different plant dates; harvest date means.

[2] August 8.

[3] Compared to May 2, spray 0.

Table 5.—The effects of dates of planting and sprays for aphid control on sugar beet production at Davis, California, 1964-65.

Date planted	No. of sprays	% disease[2]		Roots, tons per acre						Roots, % sucrose					
		yellows	mosaic	9/22	10/26	12/2	3/3	3/31	4/28	9/22	10/26	12/2	3/3	3/31	4/28
3/1	0	93	24	32.3	38.6	38.0	40.1	38.6	36.4	13.8	13.7	12.7	11.8	12.1	11.2
	3	73	41	37.8	45.4	41.1	45.4	45.6	47.7	13.0	12.0	11.4	11.1	10.4	9.5
	8	58	9	40.8	46.4	48.6	51.2	45.4	52.4	14.4	13.5	12.0	11.6	12.2	11.0
4/1	0	91	30	31.1	37.4	36.7	38.3	39.1	40.6	13.6	12.9	12.2	11.2	11.1	11.0
	3	46	16	38.4	43.9	49.1	48.0	46.7	48.7	13.6	13.4	13.0	11.8	12.3	11.2
	7	32	19	40.7	48.7	43.1	49.5	50.9	48.9	14.4	14.4	14.0	13.1	13.6	12.4
5/1	0	16	12	32.3	37.2	37.1	40.7	39.8	43.6	13.5	12.7	12.5	12.1	12.0	11.4
	1	21	15	32.7	37.7	37.7	40.2	40.8	38.7	13.6	13.4	13.2	11.9	12.2	11.2
	3	5	9	32.1	42.3	41.8	43.4	43.4	44.8	13.6	12.6	12.3	12.1	11.4	10.2
Harvest date means				35.4	42.0	41.8	44.1	43.4	44.6	13.7	13.2	12.6	11.9	12.0	11.0
LSD, 5%[1]					4.7	5.2	1.6				0.8	1.6	0.3		

Date planted	No. of sprays	Gross sucrose, tons/acre						Average effect, all harvests			
								Roots		Gross sucrose	
		9/22	10/26	12/2	3/3	3/31	4/28	Tons/ac.	% sucrose	Tons/ac.	% Change[3]
3/1	0	4.47	5.28	4.84	4.73	4.68	4.06	37.4	12.6	4.68	1
	3	4.90	5.42	5.06	5.04	4.77	4.58	44.3	11.2	4.96	5
	8	5.85	6.24	5.85	5.93	5.54	5.79	47.5	12.5	5.87	24
4/1	0	4.20	4.81	4.50	4.27	4.37	4.45	37.2	12.0	4.43	6
	3	5.24	5.86	6.38	5.68	5.77	5.48	45.8	12.6	5.74	21
	7	5.87	7.03	6.06	6.48	6.91	6.06	47.0	13.6	6.40	35
5/1	0	4.35	4.74	4.66	4.95	4.76	4.99	38.5	12.4	4.74	.
	1	4.43	5.04	4.96	4.81	4.99	4.32	38.0	12.6	4.76	0
	3	4.36	5.33	5.17	5.24	5.09	4.57	41.3	12.1	4.96	5
Harvest date means		4.85	5.53	5.27	5.24	5.21	4.92				
LSD, 5%[1]			0.74	0.95	0.25			(2.9)	(1.4)	(0.67)	

[1] In the order given the LSD's are for differences between: harvest dates for the same plant and spray treatment; plant and spray treatments for the same or different harvests; harvest date means. LSD's in parentheses are for differences between means of the column in which they occur.

[2] Counts made 8 weeks after thinning.

[3] Compared to May 1, spray 0.

Table 6.—Effect of planting date and spray treatment on the concentration of NO_3-N in petioles of recently matured leaves.[1]

Experiment	Date planted	No. of sprays	% yellows	ppm NO_3-N at different sampling dates					
				July 18	Aug 20	Sept 17	Oct 19		
1962	Apr 10	0	53	4880	2780	1100	1880		
		8	10	6700	2680	1110	2020		
	May 7	0	1	7370	2240	750	1770		
		4	0	10000	3520	800	2120		
				Aug 7	Aug 26	Sept 23	Oct 22		
1963	Mar 2	0	93	1020	280	580	740		
		3	90	920	360	910	780		
		10	86	700	570	880	630		
	Apr 2	0	67	2780	800	1320	730		
		3	72	1870	770	910	790		
		7	51	1900	1070	810	1300		
	May 2	0	44	5080	3580	1880	2300		
		3	25	4920	3460	2200	1930		
				Sept 18	Oct 23	Nov 30	Mar 2	Mar 30	Apr 27
1964	Mar 1	0	93	1320	1630	2180	3220	930	1120
		3	73	3340	3560	5540	4810	2260	3220
		8	58	1890	2030	2600	2640	980	1560
	Apr 1	0	91	2200	1530	3100	5430	2040	920
		3	46	2850	3960	2050	3090	1860	1560
		7	32	730	910	1460	1720	820	810
	May 1	0	16	2600	2580	4260	3870	2060	1010
		1	21	4030	1180	1920	3610	880	910
		3	5	1180	2050	5200	4710	2060	2220

[1] Each value is an average of samples collected from all the replications of the particular experiment.

sulted in 44% yellows infection in May planted beets. With this level of infection, non-sprayed May planted beets did not yield as well as non-sprayed March and April plantings. Beets of March, April and May plantings sprayed 10, 7 and 3 times respectively produced an average of 11.7, 10.7 and 5.3 more tons of roots per acre than non-sprayed beets of the May planting. Lower sucrose concentrations in roots of the May plantings were associated with higher levels of NO_3-N in petioles of plants of this planting date (Table 6). Within a planting date, sprays for virus control increased sucrose percent and had little or no effect on the uptake of NO_3-N.

The 1964 experiment (Table 5) was planned to provide three spring harvests to assay effects of overwintering. Spray treatments that were effective in the fall remained effective for spring harvests. The effects of planting date and spray treatments are best evaluated by comparisons among the averages for these treatments over all harvest dates. These data indicate that non-sprayed beets of all planting dates produced essentially the same root yield. Sprays had relatively little effect on root production for the May planting date but improved root production about 10 tons per acre for both March and April plantings.

It is interesting to note the effects of winter and spring months on root growth and sucrose concentration. As indicated by the harvest date means in Table 5, there was a significant increase in root production of 2.3 tons/acre over the 13-week winter period from December 2, 1964 to March 3, 1965—a growth rate of 0.18 tons of roots per acre per week. There was no increase in root growth during the subsequent 10-week spring period from March 3 to April 28. During the winter period there was a decline in the fresh weight of tops from an average of 25.6 tons/acre on December 2 to 15.5 tons/acre on March 3. Thereafter, top growth increased to 21.6 tons/acre on March 31 and 28.9 tons/acre on April 28. On March 3 there were no bolters, less than 1% bolters on March 31 but 25% of the plants were bolting on April 28. The average sucrose content of roots decreased 0.7 percentage point from December 2 to March 3 and subsequently 1.0 percentage point as bolting progressed. There was a gradual decline in gross sugar production from late fall through the spring harvest period.

Discussion

In our experiments, delaying planting to escape yellows infection markedly improved beet root and sucrose production in 1961 (4), had little or no effect in 1962 and 1964, and reduced production in 1963. Extensive sprays for aphid control on earlier plantings improved sucrose production as much as 60% over May planted beets.

A practical approach to virus suppression is to plant at a mid-spring date, about April 1, and to follow with 3 to 5 treatments for aphid control applied at regular intervals to protect plants from time of emergence until aphid activity decreases to low levels—usually about the third week in May. Yellow-pan water traps might be used to indicate when treatment for aphid control should terminate. Planting too early can result in prolonged exposure of small, slow-growing plants to aphid feeding and require the use of an excessive number of chemical treatments. Planting later fails to utilize valuable growing time.

Summary

Combinations of planting date and chemical control of aphids were evaluated over a three-year period for the control of natural infection by yellows viruses of sugar beet.

In an earlier experiment (4), a delay in planting time until early May resulted in an escape of virus infection and greatly improved beet root and sucrose production. In the experiments reported here, delayed planting did not improve production in 1962 and 1964. In 1963, due to late aphid flights resulting in 44% yellows infection in May planted beets, delayed planting reduced root yield compared to earlier planting dates.

The use of from three to five properly timed Metasystox sprays on April planted beets appears to have considerable promise for improving beet production in the Sacramento Valley and the north San Joaquin Valley areas.

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