The Influence of Maleic Hydrazide on Bolting and Yield of Overwintered Sugar Beets in California

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Introduction

The increased tendency to overwinter sugar beets as practiced in recent years in California has resulted in more interest in the problem of bolting. Price, *et al.*, (5)[2] pointed out that reduction in root size, difficulty of processing at the factory, decreased sugar content, volunteer beets, and interference with mechanical harvest might all be objectionable results of bolting in fields planted for sugar production. Of the reasons mentioned above, decreased sugar content, harvest interference and processing difficulties were the most seriously considered as reasons for these studies.

Previously reported literature dealing with other plant species suggested that maleic hydrazide might prove to be a suitable growth regulator in delaying or preventing bolting. Jackson and Wittwer (2) reported a significant reduction of seed stalk formation of celery when maleic hydrazide sprays were applied to the maturing crop. Choudhri and Bhatnagar (1) referred to data showing reduction of bolting in onions as a result of the action of the same chemical.

Mikkelsen, *et al.*, (3) reported sugar content improvement in sugar beets as a result of foliar maleic hydrazide sprays. Peto, *et al* (4) reported results with maleic hydrazide which indicated a significant increase in sugar content and a yield reduction from applications at an early spray date related to the harvest period. Stout (6) reported no evidence in certain studies for sugar accumulation as a result of foliar application of maleic hydrazide.

A growth-regulating material such as maleic hydrazide could be of considerable value in overwintering beets, if bolting could be stopped or retarded and production increased by its use. The following series of experiments was, therefore, initiated to test the effect of maleic hydrazide on overwintered sugar beets with respect to sugar content, growth and bolting.

Methods

Four fields were selected in three sections of California in which beets overwinter. The sections were the Imperial Valley, Firebaugh, located in the San Joaquin Valley, the Dixon-Davis area of the Sacramento Valley. In each field foliar sprays of maleic hydrazide were superimposed on vigorously growing beets. In the Firebaugh and Imperial Valley tests maleic hydrazide 30 was used with wetting agents; in the other test maleic hydrazide 40, containing a wetting agent, was used.

The principal variations in treatment were time of application, time of harvest, and in the Imperial Valley, rate of material applied. The treatments in all experiments were applied by hand with a knapsack-type sprayer

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[2] Numbers in parentheses refer to literature cited.

at a rate of 50 gallons per acre. Observations and bolting counts were taken as conditions warranted and each plot was harvested on an area basis. From two to four sugar samples were taken from each plot in each replication at each harvest date. The following items of data were reported for each experiment: percent bolting, percent sucrose, tonnage of beets, and pounds of sugar per acre.

There were minor variations in procedure which will be discussed separately for each experiment.

In the Imperial Valley three concentrations of maleic hydrazide sprays were applied at three dates prior to harvest. The test included ten treatments replicated six times. The beets selected were from a commercial planting of variety U. S. 56, seeded in August, 1951. Between the date of the first spraying, March 19, and the harvest date, May 7, 1952, a considerable percentage of the beets bolted.

The next experiment was located near Dixon, California, and was established on beets of variety U. S. 56/2 planted August 1, 1952, and harvested the following spring. The field was in good condition at the start of the experiment, but the beets were small in size because of growing season limited by cold temperatures and short day length. The treatments included maleic hydrazide application on March 4, 14, and 25, and an undisturbed check arranged as a 4 x 4 Latin square. These main plots were split for dates of harvest in strips across the four applications. There was no indication of bolting at any of the spray dates.

The dates of harvest were: April 3, before bolting signs appeared; April 15, at the start of bolting; and May 22. when bolting in the untreated check reached 90 percent.

The remaining experiments were established on variety U. S. 22/3 planted May, 1952, near Davis, California, and on variety S-2[3] planted August, 1952, near Firebaugh, California. In each experiment a two-pound rate of maleic hydrazide was compared with an undisturbed check. Each treatment was replicated six times. In the Firebaugh test, maleic hydrazide was applied to the beets February 17, 1953, before bolting signs appeared, and the beets were harvested April 10, 1953. The sugar beets near Davis were sprayed March 14 shortly after bolting had started, and were harvested April 13, 1953.

Results

The yield and bolting data of the Imperial Valley experiment are reported in Table 1.

The most effective treatment was the two-pound per acre rate applied seven weeks prior to harvest, which resulted in a significantly lower percent of bolters and an accompanying rise in sugar content. This effect diminished as the concentration of material applied at the first harvest date was decreased. The sugar content of beets sprayed three weeks and one week prior to harvest was not influenced significantly regardless of the rate ap-

[3] S-2 is a bolting resistant selection from U. S. 22/3.

plied. There was no significant effect on root yield. At the last two harvest dates there was no significant effect on sugar production, but, beets sprayed March 19, when compared at all three rates with the check, showed a significant increase in sugar yield. The sugar production of beets sprayed at the first date was significantly better than that of beets sprayed at the last two dates.

The results of the Dixon experiment appear in Table 2.

Table I.—The Effect of Maleic Hydrazidel Sprays on Yield, Percentage of Sucrose, and Bolting of Beets. **Imperial Valley Test, Planted August, 1951. Harvested May 7, 1952.**

MH treatment lbs./acre[1]	Date of Spray	Weeks prior to Harvest	% Sucrose	Yield Roots (tons/acre)	Yield Sugar[2] (lbs./acre)	% Bolters
2	Mar. 19	7	18.8	19.9	7,460	7
1	Mar. 19	7	18.2	19.8	7,200	25
1/2	Mar. 19	7	18.0	20.5	7,380	33
2	Apr. 16	3	17.8	19.5	6,940	34
1	Apr. 16	3	18.1	19.3	6,960	36
1/2	Apr. 16	3	17.9	19.6	7,040	40
2	Apr. 30	1	17.4	21.0	7,340	33
1	Apr. 30	1	17.6	19.1	6,720	37
1/2	Apr. 30	1	17.8	19.7	7,040	35
Check			17.6	19.4	6,820	40
L.S.D. Odds 19:1			0.4	N.S.	N.S.	7

[1] Pounds of active ingredient, formulation M.H. 30.
[2] A comparison of maleic hydrazide at the first spray date versus the latter spray dates or the check indicated a significant sugar yield improvement.

Table 2.—Effect on Yield and Sucose Percentage of Maleic Hydrazide Two Pounds Active Ingredient Per Acre Applied to Foliage of Sugar Beets o Beets Planted August 1, 1952, Near Dixon, California.

Harvest date	Dates of Application	Weeks prior to Harvest	% Sucrose	Yield Roots (tons/acre)	Yield Sugar (lbs./acre)	%[1] Bolters
Apr. 3	Check	..	14.9	11.8	3,520	....
	Mar. 4	5	15.6	13.2	4,120	....
	Mar. 14	3	15.5	12.4	3,840	....
	Mar. 25	1	15.0	12.6	3,780	...
Apr. 15	Check		16.3	12.6	4,100	....
	Mar. 4	7	17.1	12.5	4,280	....
	Mar. 14	5	16.8	12.7	4,270	...
	Mar. 25	5	16.7	11.7	3,910	.
May 22	Check		14.6	14.6	4,260	90
	Mar. 4	12	15.0	14.1	4,240	60
	Mar. 14	10	14.8	14.9	4,410	57
	Mar. 25	8	15.3	14.3	4,370	49
L.S.D. Odds 19:1			N.S.	N.S.	N.S.	11

[1] Bolting was negligible at the **April** 3 and 15 harvests.

Bolting was of no consequence in either treated or check plots for the April 3 and 15 harvests. It can be seen from the results of the April 3 harvest that sucrose percentages were apparently increased in the plots sprayed with maleic hydrazide March 4 and 14, but no increase resulted from beets sprayed March 25. The second harvest was completed April 15. An increase in sucrose percentage was found on beets sprayed at all three dates in comparison with untreated beets. The apparent increase in sucrose percentage at these harvest dates approached significance, but was not significant at the 5 percent level.

By the final harvest date, May 22, bolting had become a significant factor. **All** treatments were showing visible bolters with those in the check showing 12-18 inches higher than those in the treated plots. The untreated beets averaged 90 percent bolters May 21 as compared with 60, 57, and 49 percent respectively for the three dates of spraying. The differences between dates of spraying could be detected by the eye. As indicated by Figure 1, bolting was higher at the final harvest date than had been observed two weeks earlier.

Figure 1. Bolting was reduced by maleic hydrazide from the standpoint of time of appearance, total number of bolters, and size and condition of bolters at harvest time. The sucrose percentage, however, was not significantly increased by maleic hydrazide in the final harvest. Thus from the results of this test it would appear that maleic hydrazide benefits were derived from its ability to delay bolting by three to four weeks.

It is apparent from Table 2, however, that date of harvest did have an influence on yield of untreated beets. The data for the three harvests of this treatment are summarized in Table 3 for easier comparison.

Table 3.—The Effect of Time of Harvest on Overwintered Beets. Planted August 1, 1952, Near Dixon, California.

		Yield		
Date of harvest	**Percent sugar**	**Roots (tons/acre)**	**Sugar (lbs./acre)**	**% Bolters**
Apr. 13	**14~9**	**118**	**3,520**	**None**
Apr. 15	**16.3**	**12.5**	**4,010**	**Starting**
May 22	**14.6**	**14.6**	**4,260**	**92%**
L.S.D. Odds 19:1	0.3	1.1	N.S.	

It is evident from table 3 that tonnage of beets increased consistently between April 3 and May 22. The percent sucrose also increased significantly between April 3 and 15, but decreased between April 15 and May 22. This decrease in sucrose percentage is probably the result of seed stalk formation and/or increased beet growth. Yields of sugar, however, did not increase significantly between April 3 and May 22. From the standpoint of most efficient harvest, April 15 seemed to be the most effective harvest date.

Similar results were obtained from the Davis and Firebaugh tests. Bolting was significantly reduced by the maleic hydrazide in both of these tests; sucrose percentage was increased but yields in tons of beets and sugar per acre were not significantly affected.

The results from the Firebaugh test appear in Table 4.

Table 4.—The Effects of a Two-Pound Per Acre Application of Maleic Hydrazide Applied as a Foliage Spray to Sugar Beets Planted August 10, 1952, Near Firebaugh, California. (Sprayed February 17, 1953. Harvested April 10, 1953.)

		Yield	
	Sucrose Percentage	Roots (tons/acre)	Sugar (lbs./acre)
Check	14.1	16.4	4,630
Treated	16.2	17.4	5 610
L.S.D. Odds 19:1	08	N.S	N.S

In this test it can be seen that the results considerably favor the treated plots. In addition to the sucrose percentage increase, bolting was stopped almost completely in the treated plots until the time of harvest: on April 10 there were no bolters showing above the foliage in the treated plots as compared to approximately 50 percent visible bolters in the untreated plots. The yield differences were not statistically significant, however.

The results from the Davis test appear in Table 5.

Table 5.—The Effect of a Two-Pound Per Acre Application of Maleic Hydrazide Applied as a Foliage Spray to Sugar Beets- Planted May, 1952, near Davis, California. (Sprayed Mach 14, 1953. Harvested April 13, 1953).

		Yield		Ave. No. bolters per 100' of row
	Sucrose Percentage	Roots (tons/acre)	Sugar (lbs./acre)	
Check	16.0	15.5	4,970	93
Treated	17.0	14.8	5,020	44
L.S.D. Odds 19:1	0.7	N.S.	N.S.	

It was observed in this test that spraying maleic hydrazide after bolting had started was effective in reducing the total number, size, and appearance of seed stalks in overwintered beets. Bolting was reduced by more than half in the sprayed beets in this test. The sucrose percentage was increased significantly by maleic hydrazide, but no significant increase in beet tonnage or sugar yield resulted from the treatment.

Discussion

In all tests, and with several varieties, maleic hydrazide exhibited a marked tendency to reduce and delay bolting. Bolting differences were not observed, however, unless maleic hydrazide was applied before or shortly after the appearance of seed stalks. After a period of 3 to 5 weeks from initiation of bolting secondary seed stalk formation seemed to occur and small spindly seed stalks developed.

Although it was possible to demonstrate significant increases in sucrose percentages, differences in sugar yield were not generally large enough to measure significant increases. Root yields were not consistently influenced by any treatment. As indicated in Table 3, considerable delay in harvest after bolting was initiated, tending to reduce sucrose percentages, offsetting any observed tonnage gains.

From the results of this series of experiments *it* would appear that any benefits from maleic hydrazide would be derived from its ability to delay bolting.

Summary

Four experiments were conducted in the Sacramento (San Joaquin, and Imperial Valleys of California on sugar beets planted in May or August for harvest the following spring. In the tests, foliar sprays of maleic hydrazide were applied by varying concentrations and at different dates with respect to time of harvest.

Maleic hydrazide delayed and reduced bolting and increased sucrose percentages in every case in which the material was applied before there was any visible evidence of bolting. In no case was root yield of beets significantly increased by any treatment. Generally speaking, yields of sugar per acre were not significantly affected by maleic hydrazide sprays.

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