Two Years' Results Evaluating Effect of Preharvest Sprays of Maleic Hydrazide on Respiration and Spoilage of Sugar Beets

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Introduction

Maleic hydrazide has recently received considerable attention as a plant growth regulator and herbicide (2, 3, 4)[2]. It has also been used as a preharvest spray for improving the storage of carrots and onions (6). Other reports have indicated it to be effective in reducing sugar losses in stored sugar beets (7, 8).

Sodium azide inhibits the action of several of the enzymes involved in plant respiration (1). Since maleic hydrazide is readily translocated within the plant (3, 4, 5) and is somewhat similar in chemical constitution to sodium azide, it might be expected to affect respiration by affecting some of the enzymes involved. Wittwer and Hansen (6, 7) observed that beets previously treated with maleic hydrazide and stored in a large bin were cooler than untreated beets stored in a similar bin, and suggested that the chemical may have inhibited respiration and thereby reduced the heat output of the treated beets.

Several sugar factories in the intermountain and northwestern part of the United States operate for periods of from five to six months. This long operating period requires that they start processing sugar beets before sugar percentage and purity values have attained a desirable level. Since maleic hydrazide has been reported to affect sugar metabolism in other plants (3, 4), it might be expected to affect sugar accumulation in sugar beets.

The studies here reported were designed to give some information on the possible effect of preharvest sprays of maleic hydrazide on sugar accumulation in the beet as well as its effects on reducing storage losses.

Experimental Results

The maleic hydrazide used in the following tests was applied as the diethanolamine salt formulation containing the equivalent of 30 percent maleic hydrazide. All spray concentrations reported are calculated to the equivalent concentration of maleic hydrazide. Maleic hydrazide was applied to sugar beets at two concentrations and at three dates before harvest in 1950. Each plot consisted of eight rows of beets 40 feet long. The spray was applied at the rate of about 82 gallons per acre (one gallon per plot) by means of a hand-operated tank sprayer. Twelve and six-tenths grams of Dreft per gallon of spray were added as a wetting agent. No rain fell for 48 hours after the first beets were sprayed September 1. A "trace" of rain fell 24 hours after the beets were sprayed September 12. Three one-hundredths inches of rain fell about 48 hours after the beets were sprayed September 15.

Six analytical samples of beets were harvested before the beets were sprayed September 1, 1950.

The beets were harvested, washed and samples selected for immediate analysis or respiration study September 18-19, 1950. Each sample consisted

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[2] Numbers in parentheses refer to literature cited.

Table I.—Effect of Maleic Haydrazide on the Respiration Rate and Spoilage of Sugar Beets. Beets Grown in 1950 at Hill Brothers Farm.

Sprayed Date	Sprayed Conc.	Beets per acre	Dry substance	Sugar	Purity	Invert	Respiration rate (at 72° F.) O_2 per Kg. per Hr.—Period: 1[1]	2[2]	3[2]	4[2]	Calculated losses during 27-day period at 72° F. Wt.	Sugar	Purity	Invert	Sugar by resp.
	P.P.M.	tons	%	%	%	%	mg	mg	mg	mg	%	%	%	%	%
			September 1, 1951												
Top check		25.1	14.61	12.45	85.24										
Bottom check		24.4	13.81	11.13	80.63										
			September 18, 1951												
Top check		27.0	14.95	12.78	85.48	.06									
Bottom check		26.6	13.73	11.14	81.14	.08									
Average		26.8	14.34	11.96	83.31	.07	15.61	14.14	16.12	20.49	1.95	1.65	10.50	.71	.82
9/1	1,000	27.9	15.00	12.72	84.80	.08	15.82	12.02	10.17	10.17	1.18	0.62	6.15	0.32	.69
9/1	2,500	27.5	15.11	12.63	83.59	.08	15.73	13.30	13.24	15.36	0.95	1.26	8.29	0.51	.77
9/12	1,000	26.0	13.44	11.21	83.41	.07	16.25	14.13	13.16	15.00	1.62	1.10	9.03	0.50	.82
9/12	2,500	29.9	13.07	10.51	80.41	.08	16.04	12.76	11.24	12.38	0.68	0.79	7.04	0.38	.74
9/15	2,500	29.2	13.82	11.24	81.33	.06	15.52	12.14	10.41	11.10	0.70	1.21	8.76	0.64	.70
9/15	5,000	28.4	13.47	10.92	81.07	.08	16.36	12.59	10.60	11.24	0.18	1.28	9.42	0.43	.73
Dipped															
9/18	2,500	26.8	13.34	11.96	83.31	.07	16.62	13.10	12.19	14.84	0.58	1.79	10.26	0.53	.76
Diff. for Sig. 5% point								2.94				1.00	5.00	0.44	.17

[1] = 5-day period.
[2] = 7-day periods.

of 13 beets weighing a total of 20 kg. or 44.1 pounds. Four samples per plot were analyzed and four samples were used in the respiration studies (2 samples per respiration chamber). The data in Table 1 show a gradient in sugar and purity from the top to the bottom of the field. This gradient is also shown in the check samples harvested September 1. The spray treatments in Table 1 are listed in consecutive order from the top to the bottom of the field. The gradients in sugar and purity values of the various spray treatments are well within the limits of error expected and indicate no real differences due to the application of the sprays. The respiration data in the central part of Table 1 show no significant differences between treatments during the second period of the test.

During the latter part of the test fungi developed in some of the respiration chambers, causing an appreciable increase in the measured respiration values. Fungi developed on three beets in one chamber of the "check" beets, causing a very high "respiration rate" toward the end of the test. The other chamber containing "check" beets was free of fungi and among the lowest in respiration rate. True respiration values can be expected only comparatively early in the test. Later values serve to indicate relative growth of fungi.

The loss in sugar of the beets sprayed September 1 at a concentration of 1,000 ppm. appears to be significantly lower than the check or those dipped in the maleic hydrazide solution before storage. The calculated F value, however, was 1.33 while that required for significance at the 5 percent level was 2.49. It is believed that the analytical loss of sugar is probably the least reliable measurement in determining total losses during storage. If the total of the calculated losses of sugar due to respiration and spoilage (inversion) are determined, they should be approximately equal to the losses of sugar as shown by analysis. The average losses of all treatments, when calculated by respiration and inversion, were 1.26 percent sugar. The average analytical losses were 1.21 percent sugar. The losses of sugar due to non-spoilage respiration required only 0.17 percent for significance, and that due to spoilage required a difference of 0.44 percent, while the analytical loss of sugar required 1.00 percent for significance. The respiration losses are probably the most reliable values in such a test because of greater freedom from analytical sampling errors.

A more highly replicated test was conducted in 1951. The plan, suggested by Dr. D. D. Mason, head of Biometric Services of this Bureau, consisted of two adjacent Latin squares (eight replications of four treatments). The plots were laid out in a selected commercial field of beets. Each plot consisted of two rows of beets 30 feet long. One buffer row was left between adjacent plots. A fresh lot of maleic hydrazide was secured and Triton B-1956 was used as the wetting agent. The spray was applied at the rate of 110 gallons per acre September 4, and no rain occurred before harvest September 17. Before harvest one beet was cut out and discarded between the ends of adjacent sections. The beets were uniformly topped, washed, sampled and placed in the respiration chambers September 18-19. Each sample for analysis or respiration study was selected to consist of 16 beets weighing a total of 18 kg.

The data in Table 2 show that there were no significant differences between treatments in beets per 100 feet of row, tons per acre, sugar or purity at harvest. There was no significant difference between treatments in respiration rate.

At the conclusion of the test all samples were reweighed, analyzed and the analyses calculated to the original weights of the samples. The calculated losses in Table 2 show there were no significant differences in sugar percentage, purity or increase in invert sugar during the 38-day period that the beets were stored in the respiration chambers.

Table 2.—Effect of Preharvest Sprays of Maleic Hydrazide on Yield and Quality of Beets at Harvest and Respiration and Spoilage Losses During Storage at 72° F. for 38 Days. Beets Grown in 1951 at Swenson Farm.

Spray concentrations	Yield beets per 100 feet	Tons per acre	Dry substance	Sugar	Purity	Invert	Residual M.H. in pulp
P.P.M.	No.	Tons	%	%	%	%	P.P.M.
Check	72.4	24.60	15.74	13.15	83.45	.11	0.0
1,250 ppm.	71.7	25.27	15.57	13.09	83.94	.11	3.0
2,500 ppm.	73.3	24.82	16.16	13.64	84.30	.12	6.7
5,000 ppm.	75.2	25.56	15.87	13.52	85.00	.11	12.8
Diff. for Sig.	4.0	2.53		1.05	1.97		

Spray concentrations	Respiration rate at 73° F. O_2 per Kg. per hour during period 1[1]	2[2]	3[2]	4[2]	Calculated losses during 38-day period at 72° F. Sugar	Purity	Invert Increase	Sugar by resp.
	mg	mg	mg	mg	%	%	%	%
Check	12.86	10.73	9.65	10.30	.95	3.59	.248	.87
1,250 ppm.	12.78	11.13	10.20	10.88	.72	3.55	.223	.90
2,500 ppm.	13.47	11.01	10.26	11.26	1.43	6.22	.374	.89
5,000 ppm.	13.91	11.06	9.54	9.63	.74	4.43	.276	.90
Diff. for Sig 5% point		0.87			.92	3.05	.149	.07

[1] = 5-day period.
[2] = 10-day periods.

The calculated loss of sugar based on the respiration rates during the second period of the test required only 0.07 percent for statistical significance at the 5 percent point. The loss due to spoilage (increase in invert sugar) required only .149 for significance. The sum of the losses by respiration and spoilage probably is more nearly accurate than the loss of sugar by direct analysis due to the greater variation between samples in sugar content.

Discussion

The fact that preharvest sprays of maleic hydrazide failed to cause any observable effects on sugar beets in the 1950 tests might be explained on the basis that the amount which reached the storage tissues was inadequate to be effective. However, the beets which were dipped in a solution containing 2,500 ppm. of maleic hydrazide were affected to the extent that all subsequent growth of leaves turned dark in color and apparently died after growing less than one-half inch. The amount of regrowth of leaves on the beets given other or no treatment was not large or sufficiently different to be noticeable.

The untreated beets in the 1951 test were thought to have a little more regrowth on them than those sprayed with maleic hydrazide. The amount of regrowth was small, however, and further observations of samples of all lots stored for more than 110 days in the root cellar failed to show any appreciable regrowth or consistent differences between treatments. The gradation of the amounts of residual maleic hydrazide found in the tissues of beets which received different concentrations of spray indicated that there should have been some response to the chemical if it had any appreciable effect on storage.

Although sampling errors were relatively large for loss of sugar as determined by direct chemical analysis, the loss of sugar as calculated from respiration rates was very much less variable. The difference necessary for statistical significance as calculated from respiration rates amounted to only 0.07 percent sugar. This lower variation between samples in respiration rate measurements may be due to several factors. Previous studies (5) have shown that soil fertility affects respiration rate only to a minor extent, but affects sugar percent and purity much more. The whole beet was used in samples for respiration rate while only the small section cut by the rasp was used for sugar analysis. Sampling after storage is subject to even greater errors because of the irregular occurrence of spoilage. The adoption of the multiple saw sampling technique would probably reduce sampling errors on stored beets.

There was no evidence in the present tests that maleic hydrazide affected sugar accumulation. If the chemical stopped foliar growth or reduced foliar or root respiration it should result in increased sugar accumulation. However, Currier et al (3) cited considerable evidence that maleic hydrazide prevents carbohydrate translocation in plants. Such an effect would prevent sugar accumulation in the root rather than increase it.

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