Effect of Chemical Treatment on Respiration of Sugar Beets

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The reduction of losses of sugar in sugar beets between lifting and processing has been attacked by various means. Of first importance is the prompt efficient handling of the beets from the time of lifting until they are in the factory or in the storage pile. Of second importance is the reduction in temperature within the storage piles by use of forced-air ventilation. Reduction in storage losses has also been sought by means of chemical treatment. The studies made with maleic hydrazide are probably the most widely known.

This paper covers results obtained with 3-amino 1, 2, 4-triazole[2] as an anti-respirant for sugar beets. In preliminary trials involving seven materials the amino triazole appeared to be the most promising in reducing the respiration rate. The other six materials were identified only by code number and after one preliminary trial all six materials were dropped from current investigations. Thus, the results given here are confinded to amino triazole.

What effect amino triazole would have on respiration rate was investigated first by dipping momentarily transverse sections of sugar beet roots into aqueous solutions varying in concentration. After dipping, the excess solution was allowed to drain off. The evaluation of respiration rate was then identical with a procedure previously published (1)[3]. Samples from ten roots were analyzed for each concentration. A treated and untreated sample from each beet was evaluated simultaneously. (See Table 1.)

Table 1.—Decrease in Respiration Rate Obtained on Root Sections[1]. Dipped in Solutions Varying in Concentration of Amino Triazole.

Concentration (ppm)	10	50	250	500	1000	2000
Percentage decrease from check	0.8	4.2	12.0	19.6	24.7	13.4
LSD 5% pt.	NS[2]	1.9	7.0	4.2	7.1	5.6
LSD 1% pt.	NS[2]	2.8	10.1	6.0	10.3	8.0

[1] Carbon dioxide production was measured over an 18-hour period immediately after slicing and dipping.

[2] Difference between check and treated not significant at indicated level.

The results of Table 1 indicate a very definite decrease in respiration rate for all treatments except the 10 ppm treatment. Only a limited amount of solution adhered to the freshly cut sections, approximately three percent by weight. Assuming a three percent gain in weight of sections on dipping, and equal distribution, the concentration of amino triazole within the treated beet tissues would have been 0.3, 1.5, 7.5, 15, 30 and 60 parts per million, respectively.

After obtaining results in Table 1, a trial was made dipping three samples of whole beets. A solution of 8000 ppm amino triazole was used. After solution had ceased to drip off the beets, it was estimated amino triazole on weight of beets would be less than 40 parts per million. Three

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[2] Commercial firms furnishing amino triazole were American Chemical Paint Company and American Cyanamid Company.

[3] Numbers in parentheses refer to literature cited.

comparable samples were left untreated. Each sample was then placed in a water-proofed bag and stored for two weeks in the root cellar at approximately 40° F. before being sliced and analyzed. Results appear in Table 2.

Table 2.—Respiration Rates at 70° on Sliced Sections of Roots Two Weeks After Roots Had Been Dipped in 8000 ppm Aqueous Solution of Amino Triazole. Values are mg. CO_2/kg./hr.

Treatment	Replicate 1	2	3	Mean	Reduction in Respiration
Control	127	144	140	137.0	—
Dipped	111	131	128	123.3	10%
LSD 5% pt.				5.2	
LSD 1% pt.				12.0	

Surface treatment of roots gave a significant reduction in respiration rate as indicated by results in Table 2 based on carbon dioxide production measured on transverse beet root sections approximately 1/12 inch in thickness and 1 1/2 inch in diameter.

To further evaluate the effect of amino triazole on respiration rate of beets a second method of measurement was used. In this case 100-pound samples of beets were placed in sealed drums and oxygen consumption measured according to method previously described (2). Beets were dipped just before placing in drums. Treatments and results are given in Table 3.

Table 3.—Oxygen Used by Beets of Each Treatment as an Average of Six Replications for a 17-day Period at 70° F.

Treatment	O_2 at V_0 used per 100 lb. beets/day	CO_2/kg./hr.[1]	Respiration rate in % of control
	cu. ft.	mg.	
A) Control	.4546	23.38	—
B) Roots dipped in sol. 3,000 ppm amino triazole	.6056	31.14	133
C) Roots dipped in sol. 13,000 ppm amino triazole	.7261	37.34	159
LSD 5% pt.	.0720		
LSD 1% pt.	.1024		

[1] A respiration quotient of one was assumed in calculating CO_2 from O_2 measurements.

The results of oxygen measurements on whole beets (Table 3) show a definite increase in respiration rate due to treating beets by dipping in amino triazole solutions. This is in direct contrast to results obtained by measuring CO_2 production on sliced tissues and reported in Tables 1 and 2.

To check whether a difference in source of roots could have accounted for this reversal in results representative beets were taken from the sealed drums at the end of the 17-day period and measurements made of carbon dioxide production from sliced sections. Again the results obtained for tissue sections followed the trends established in Tables 1 and 2. The reduction in respiration rate for the 3,000 and 13,000 parts per million treatments compared with the control were 18 and 29 percent, respectively. A value of 17 was required for least significant difference at odds of 99 to 1.

Considering that amino triazole solutions in concentrations used for treating whole beets could have been injurious to the epidermis, foliar applications were initiated the following fall as an alternate method of treatment. Assuming amino triazole would be translocated to the roots, applications were made at rates of 1/16 pound to 1 1/2 pound in 25 gallons water per acre as an over-all foliage spray. After several trials one learned to expect a somewhat lower respiration as measured on cut-root sections taken from beets showing chlorosis of the protected small center leaves. Chlorosis was usually first visible 5 to 10 days after spraying. The necrosis of the leaves hit directly by the spray was much sooner and much more noticeable.

Average respiration rates in percentage of control on sliced root sections, based on sixteen replications from field sprayed plots, were 94.8 and 94.9 for the one-half and one-pound rates of amino triazole. A difference of 3.7 was required for least significant difference at odds of 19 to 1. Since the reduction in rate approximated 5 percent, it is likely to be real and follows the trend established in Tables 1 and 2.

Respiration rates of whole beets and measurements for quality of beets from plots sprayed October 12 are given in Table 4. In this test there were four replications. Harvest of plots was completed November 7. Respiration rates on beets placed in sealed drums was completed on December 23 and oxygen consumed was measured daily for 44 consecutive days. The weight, sugar percentage, thin juice apparent purity, and raffinose determinations reported in Table 4 were made on December 27 and on the beets which were removed from the sealed drums December 23.

Table 4.—Results on Beet Roots Harvested from Field Plots Which Had Received Foliar Application of Amino Triazole (AT) Three Weeks Before Harvest.

Treatment	Respiration of Whole Beets	Results after 44 days storage at 70° F.			
		Weight	Sugar	Purity	Raffinose
	% of control	% of control	%	%	
Control	100	100	14.9	88.3	none
AT ½ lb/a	106	100	14.6	87.6	none
AT 1 lb/a	102	99.6	14.1	86.7	none
LSD 5% pt.	NS	NS	NS	NS	—

The results in Table 4 are not conclusive in themselves. The question remains unanswered as to whether treatment with amino triazole can be effected so as to reduce the respiration rate as measured on whole beets. However, current evidence is against gaining any practical benefits. The reduction in sugar percentage and purity parallel results of other tests if attributed to the slower development of the beet in the field after treatment and not as having occurred during storage.

Discussion

In reviewing the results, particularly Table 3 with those of Tables 1 and 2, one is faced with the problem of rationalizing the differences. Sucrose and purity evaluations on beets treated and stored have not suggested the respiration quotient was abnormal which otherwise could explain the difference. However, a simultaneous measurement of CO_2 and O_2 was not made.

It is possible the high concentration of amino triazole used for treating whole beets was injurious to the tissues first contacted. The injured tissues of the treated versus the untreated may have accounted for the relatively higher respiration in similar manner as weather-beaten roots respire at a faster rate than freshly stored beets.

In Table 3 one will note the calculated CO_2 per kilogram per hour ranges from 23 to 37; whereas, in Table 3 the range is 111 to 144. Thus, the respiration of the sliced sections was approximately five times the activity measured on whole beets. One might argue that the effect of amino triazole on respiration was secondary and only caused a reduction in respiration when the rate was several times higher than the rate common for whole beets.

Also, a possibility which appears presently quite feasible is that specific tissues react differently to amino triazole. On slicing beets one likely changes the relative role various tissues play in the total respiration. Thus, if amino triazole has a different effect on various tissues, a reversal in respiration rate as measured by the two methods could be realized. Of interest in this regard is the work of Heim, Appleman, and Pyform (3) where they observe a difference in effect on catalase activity between catalase of the blood versus that of liver or kidney tissue following injection of amino triazole into adult female rats.

Summary

Sugar beets were treated in an attempt to reduce the respiration rate. Preliminary results using amino triazole as an anti-respirant appeared highly successful. A reduction in CO_2 production was obtained when sliced root sections were used as material for measurements. The reduction in rate of CO_2 production was obtained when measured on sliced tissue, whether the sliced root sections or the whole roots were dipped directly into amino triazole solutions prior to CO_2 measurements; or if treatment of roots was by translocation of amino triazole from foliage applications made to beets growing in the field.

A definite increase in respiration rate was obtained when measurements were made on whole beets which had been treated by being dipped into solutions of amino triazole. Rate of respiration was based on measurements of oxygen consumed by samples of whole beets over a period of several days following treatment. Since the respiration rate as measured on whole beets is of prime importance, the current evidence is against any practical benefits from treatment with amino triazole. A discussion is given regarding the reversal in results between those obtained from sliced root sections and those of whole roots. There is a real need for a procedure that could be used to justly evaluate and screen the many chemicals that might serve as anti-respirants and reduce the losses from respiration in beets between lifting and processing. It is likely that two or more quick methods would need to be used in any adopted procedure.

References

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