Effect of Soil-Injected Ethylene on Sugarbeet (*Beta Vulgaris* L.) Yield Parameters[1]

L. J. FRANCL, R. E. DENNIS, D. K. PARSONS, AND A. H. FREYTAG[2]

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The effects of ethylene on the physiology of higher plants has been intensively studied. Endogenous ethylene is known to play a role in abscission, seed germination, flower formation and sexual expression, root hair formation, fruit ripening, and other processes. Much less is known about the effect of exogenous ethylene in soil-plant relationships. The objective of this study was to determine the effects of soil-injected ethylene on sugarbeet yield parameters.

According to Burg (2)[3] ethylene is a natural product of metabolism, active in trace amounts throughout the plant's life cycle, and a gas at normal physiological temperatures. Chadwick and Burg (4) observed that exposure of root tissue to ethylene led to radial enlargement caused by inhibition of cell elongation. They also found that indoleacetic acid (IAA) inhibited cell elongation in intact roots and concluded that this occurred as a result of IAA-dependent ethylene production.

Burg (3) suggested that the response of roots to ethylene indicated an effect on the structure of cell walls. Abeles (1) stated that the induction of radial swelling of roots by ethylene probably plays a role in the increase of root hair formation. He concluded that there are more epidermal cells per unit length of root after exposure to ethylene, and therefore more cells from which root hairs may emerge.

Smith and Russell (7) demonstrated that ethylene occurred in soils and accumulated under anaerobic conditions. Smith and Restall (8) suggested that ethylene that accumulated under anaerobic conditions may inhibit root growth. They stated that increasing organic matter and plant roots and soil wetting resulted in increased amounts of ethylene in the soil.

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[2]Formerly Research Assistant, University of Arizona; now Instructor of Agronomy, Southeast Missouri State University; Extension Agronomist and Professor, University of Arizona; Assistant Agricultural Agent, Arizona Extension Service; and Senior Research Agronomist, Great Western Sugar Company, Longmont, Colorado.

[3]Numbers in parentheses refer to literature cited.

Freytag, Wendt, and Lira (5) obtained increased yields from cotton (*Gossypium hirsutum* L.) and sorghum (*Sorghum vulgare* Pers.) when ethylene was injected into the soil near growing plants. Freytag (6) also noted increased sugarbeet yield and improved storage characteristics of beet roots with furrow injections of ethylene when plants had a leaf canopy 25 to 35 cm in diameter.

Materials and Methods

Experiment I: Three sugarbeet plantings near Willcox, Arizona were used for this experiment. At Willcox beets are planted in the spring for fall harvest. When the experiment was initiated in late May, 1974, plants were 2 to 3 months old and had a leaf span of 25 to 35 cm. The soil at these locations was a sandy clay loam.

For ethylene applications, a cylinder containing technical grade ethylene was mounted on a tool bar attached to a tractor. The ethylene was delivered through a gas flow regulator and meter to a shank of the type used for anhydrous ammonia injection. The shank was hydraulically forced into the soil in the center of the treated furrows so that ethylene was emitted about 20 cm below the soil surface. The rate of ethylene application was 6.2 kg/ha for the first row, if one assumes no horizontal movement beyond this point.

Two 30.5 m lengths of row adjacent to each injected furrow were chosen for sampling and harvest. Additional 30.5 m strips, approximately perpendicular to the first selected length of rows, were measured in rows located 3.4, 7.2, and 37.7 m from the injected furrow. The four distances from injection in each plot corresponded to rows 1, 5, 10, and 50, counting from the injected furrow. It was assumed that plants at increasing distances from the injected furrow were exposed to decreasing concentrations of ethylene.

The sugarbeets were mechanically topped and then dug in November, 1974, using a single-row sugarbeet harvester. The harvester was specially modified in order to obtain yield data and representative samples from on-farm research plots. Beet weights from each plot were determined with a weighing bin mounted on the harvester. A sample of five randomly selected beets was collected from each plot and the average sugar percentage was determined.

Data from each field were statistically analyzed with sources of variance for location of injection within field (four replications), distance from injected furrow, location of injection x distance from injected furrow, and an error residual. A combined analysis for the three fields was then done, separating variances for fields, distance from injected furrow, fields x distance from injected furrow, and an error residual.

Experiment II: Four sugarbeet plantings in central Arizona were selected for this experiment. Sugarbeets in central and southwestern Arizona are planted in September or October for harvest in June or July of the following year. Ethylene was furrow injected in the same manner as in Experiment I with application in March, 1975 when plants had a leaf canopy of 25 to 35 cm in diameter. Soil type ranged from a sandy to a silty clay loam.

Harvest was accomplished in June and July, 1975 with two subsamples per plot taken for sugar analyses. Plots were the same length and the rows harvested were the same distance from the place of ethylene application as in the first experiment. Data were analyzed using the same statistical procedures as in Experiment I.

Results and Discussion

Experiment I: A statistical analysis of data indicated no significant differences in harvested beet weight, percent sugar, or sugar/ha (Table 1).

Table 1.—Sugarbeet root weight, percent sugar, and sugar yield of experiments in the Willcox area in 1974.

	Distance from ethylene injection			
Yield parameter	0.4 m	3.4 m	7.2 m	37.7 m
Beet weight (kg/plot)	120.8a[1]	114.0a	113.8a	110.3a
Sugar (%)	11.6a	11.8a	11.8a	10.7a
Sugar (kg/ha)	6201a	5824a	5966a	5178a

[1]Means within rows followed by the same letter are not significantly different at the 5% level according to the Student-Newman-Keul's test.

The mean sugar yield (6201 kg/ha) obtained from the row nearest to ethylene injection was 16.5% higher than the sugar yield from the 50th row (5178 kg/ha). Mean beet weight and sugar yield declined with distance from the place of ethylene application. Although these findings were not conclusive evidence of a positive effect of ethylene on sugar yield, they encouraged further studies in 1975.

Experiment II: There were no statistically significant differences among distances from ethylene injection in beet weight, sugar percentage, or sugar/ha, Table 2.

Mean beet weight and sugar yield declined from the first through the tenth rows, but due to high variability, this was not statistically significant. The mean sugar yield in the tenth row was 10% less than that of the first row. Mean sugar percentage varied by less than 1%.

Table 2.—Sugarbeet root weight, percent sugar, and sugar yield from beets in central Arizona field experiments in 1975.

Yield parameter in the Willcox area	Distance from ethylene injection			
	0.4 m	3.4 m	7.2 m	37.7 m
Beet weight (kg/plot)	123.0a[1]	118.0a	112.0a	121.2a
Sugar (%)	15.4a	15.4a	15.2a	15.1a
Sugar (kg/ha)	6338a	6071a	5684a	6057a

[1]Means within rows followed by the same letter are not significantly different at the 5% level according to the Student-Newman-Keul's test.

Combined Analysis Experiments I and II: Mean beet root weight, sugar percentage, and sugar yield for the two field experiments were determined. There were no significant differences among the means of these yield parameters, Table 3. The coefficients of variability for root weight, sugar percentage, and sugar yield were 18, 12, and 21%, respectively. A combined statistical analysis was also performed excluding data from the control, row 50. Again, there were no significant differences. The CV values were reduced by less than 1%. This result indicates that variability in the control did not mask the significance of an ethylene effect on rows 1, 5, or 10.

Variability due to differences between years was factored out in all cases; however, the differences were nonsignificant. Differences among fields were significant in all of the analyses. This might be expected because of differences in soil fertility, environment, and management. The interaction between treatment and field was not significant in any of the analyses.

Table 3.—Mean sugarbeet root weight, percent sugar, and sugar yield from experiments in central and southeastern Arizona in 1974 and 1975.

Yield parameter	Distance from ethylene injection			
	0.4 m	3.4m	7.2 m	37.7 m
Beet weight (kg/plot)	122.0a[1]	116.7a	112.6a	117.1a
Sugar (%)	13.8a	13.9a	13.7a	13.2a
Sugar (kg/ha)	7233a	6920a	6617a	6638a

[1]Means within rows followed by the same letter are not significant at the 5% level according to the Student-Newman-Keul's test.

Mean beet weight was highest in row one; 4, 8, and 4% higher than weights in rows 5, 10, and 50, respectively. The average sugar/ha was also highest in row one; 4, 9, and 9% higher than sugar/ha in rows 5, 10, and 50, respectively. There was less than a 1% range in sugar percentages.

The lack of statistically significant response to ethylene may have been due to soil heterogeneity within the test plots, a high degree of crop variability, climatic variability between experimental sites, or other factors typically encountered in field research. It is possible that the rate of application in the field experiments was not high enough to produce a response to ethylene in this study.

Summary

The first field experiment was located in southeastern Arizona in 1974. Ethylene gas was injected into a furrow 20 cm below the soil surface, at a rate of 6.2 kg/ha. Each test plot consisted of a row located 1, 5, 10, or 50 rows from the place of ethylene injection. The rows were 76 cm apart.

Beets in the first experiment were mechanically harvested, weighed, and sampled to determine the sugar content. Sugar/ha was 16.5% higher in the row nearest the applied ethylene than in the row located 37.7 m from the place of application. Although not statistically different, this finding prompted further field experiments.

In March of 1975, field experiments in central Arizona were initiated. The methodology used for these experiments closely followed that of the first field experiment. There were no significant differences at the 5% level among the ethylene treatments on beet weight, sugar percentage, or sugar/ha in any of these field tests because of high experimental variability.

The results in this study were variable and thus do not support the conclusion that soil injections of ethylene can be used to increase yield of sugarbeets under the described conditions. Further research should be directed toward finding the optimum rate and date of ethylene application, and optimum soil and environmental conditions.

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