Some Effects of Plant Growth Regulators on Bolting and Other Responses of Sugar Beets

CHARLES PRICE, WILLIAM S. STEWART, AND LOUIS C. ERICKSON[1]

Introduction

In a sugar beet crop grown for the production of sugar, development of seed stalks by the plants, called "bolting," is highly objectionable. Commercial varieties of sugar beet are biennial in growth habit but in fall and winter plantings, as made in California, enough thermal induction may occur to bring about bolting in a very considerable percentage of plants. If the bolting occurs early in the growing period the roots remain relatively small and become so fibrous or woody as to make slicing at the factory for processing into sugar very diflicult. If the plants produce tall stalks and seed there is usually a decrease in the sugar content of the root. If mature seed is produced then in subsequent seasons sugar beets may persist as weeds. A most serious objection to the occurrence of bolting in sugar beets grown for sugar is the interference of the seed stalks, which may be three to six feet or more in height, with the operation of mechanical harvesters.

Control of bolting by breeding varieties low in bolting tendency has been undertaken and with very encouraging results. Other means of controlling bolting may also have some value in meeting the problem.

Flowering appears to be a hormone-controlled process (5)[2]. It has been observed that high auxin concentrations in plants can inhibit flowering (2, 4) . Inhibition of bud growth by auxin and other plant growth regulators is well known (1) . A 50 ppm. 2,4-D spray was reported to slightly retard elongation of seedstalks of celery plants which had been thermally induced (3) . On the basis of these considerations, experiments were initiated to study the effect of plant growth regulators on bolting of sugar beets.

Method and Results

Exploratory tests were made in 1947 to determine the effects of various growth regulators on bolting of sugar beets. The regulators used in various forms and concentrations were: 2,4-dichlorophenoxyacetic acid (2,4-D) ; ortho-chlorophenoxyacetic acid; para-chlorophenoxyacetic acid; and tri-iodobenzoic acid. The most promising results were obtained with the lower concentrations of 2,4-D.

On the basis of these results more extensive trials were made with 2,4-D in 1948 on sugar beet variety U. S. 22 (S. L. 622), which bolts readily, and strain S. L. 753, which does not bolt readily. The beets were planted July 6, 1948, so that no bolting occurred until the following spring. Drenching

[1] Agronomist, Division of Sugar Plant Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture; associate plant physiologist; and assistant plant physiologist, Division of Plant Physiology, University of California, respectively.

[2] Numbers in parentheses refer to literature cited.

foliage sprays of 2,4-D, as the triethanolamine salt, were applied to separate groups of plants on September 24, October 21, December 2, January 28, and March 18. These were replicated five times with approximately 100 plants per replicate or 500 per treatment. The September application was made at 50 ppm. 2,4-D; subsequent applications were at 5 ppm.

When the results were recorded on April 11, 1949, plants classed as "early bolting" were those which had seedstalks at least three feet in length; those classed as "late bolting" had seedstalks less than three feet. "Non-bolting" plants showed no evidence of seedstalk formation but were completely vegetative.

Table 1.—Effect of 2,4-dichlorophenoxyacetic acid Foliage Spray on Bolting, Growth, and Sucrose Content of Sugar Beet Variety U. S. 22 (S. L. 622). Bolting counts based on 500 plants, other determinations on average of 50 plants. Sugar beets planted July 6, 1948; harvested July 7, 1949.

	Spray applied on—						L. S. D.[1]	
	None	9-17-48	10-21-48	12-4-48	1-28-49	3-18-49	5%	1%
Concentration 2,4-D, ppm.	0	50	5	5	5	5		
Early bolting plants, percent	97.0	58.4	80.2	75.6	72.2	89.2	13.8	18.9
Late bolting plants, percent	3.0	36.2	19.8	24.4	27.8	10.8	13.8	18.8
Total bolting plants, percent	100.0	94.6	100.0	100.0	100.0	100.0	3.6	5.0
Non-bolting plants, percent	0.0	5.4	0.0	0.0	0.0	0.0	3.6	5.0
Fresh weight, tops, per plant, gms.	1230	669	1045				90	131
Fresh weight, roots, per plant, gms.	763	601	693				83	121
Sucrose in root, percent	10.02	9.56	10.52				0.54	0.79
Sucrose per root, grams	76.1	57.3	73.0				8.8	12.8
Apparent purity coefficient, percent	85.1	79.5	87.5				1.8	2.6

[1] Least difference required for significance.

The counts for the two varieties as made on April 11, 1949, for numbers of plants bolting and the type of bolting are given in Tables 1 and 2. On the basis of the performance of the unsprayed check, early bolting of U. S. 22 was reduced significantly by the 50 ppm. spray, the data showing a reduction from 97.0% to 58.4%. The 5 ppm. sprays applied in October, December, or January, reduced early bolting from 97.0% to about 75%, an amount significant at the 5% level. The data for variety S. L. 753 (Table 2) showed that the 50 ppm. spray reduced early bolting from 37.4%, for the non-sprayed check to 5.8%, a highly significant effect. The 5 ppm. sprays in October, December, or January, reduced early bolting of this variety from 33.4% as shown by the check to about 14%, the effects being highly significant.

In both varieties it appears that the 50 ppm. 2,4-D sprays prevented seed stalk formation in some plants. The 5 ppm. 2,4-D sprays applied to U. S. 22 apparently delayed but did not prevent seed stalk formation since 100%, of the plants eventually produced seed stalks. Similarly, S. L. 753 plants receiving 5 ppm. did not differ in total plants bolting from those not sprayed, but initiation of bolting was later.

The plots were harvested on June 7, 1949. Samples of 50 plants per treatment were taken at random from the non-sprayed, and from the plots sprayed September 17, 1948, and October 21, 1948, for determinations of top and root weights and for sucrose determinations. Top weights in both varieties of the plants sprayed in September with 50 ppm. 2,4-D and in October with 5 ppm. 2,4-D, were reduced significantly in comparison with non-sprayed plants. Root weights were reduced significantly by the 50 ppm. spray given in September, but this reduction was not in proportion to the severe effects on the tops. Root weights were significantly different from those of non-sprayed plants as a result of the 5 ppm. 2,4-D spray applied in October.

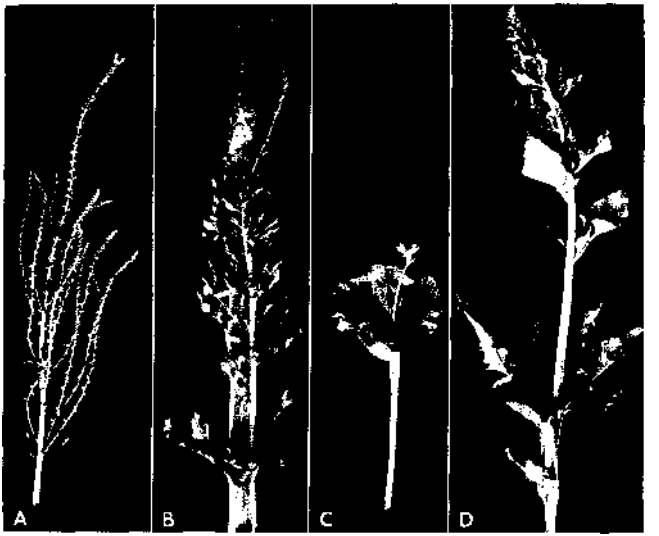

Figure 1. Seed stalks of sugar beet strain S. L. 759. A is normal; B, C, and D show various types of fasciation in response to a 50 ppm. 2,4-dichlorophenoxyacetic acid foliage spray applied December 2, 1948. Seed planted July 6, 1948. Stalks photographed May 9, 1949.

The sucrose percentage of roots of the sugar beets sprayed in October with 5 ppm. 2,4-D did not differ significantly from that of the non-sprayed beets; in both strains, plants sprayed in September with 5 ppm. 2,4-D had their sucrose quality reduced significantly. The same types of response are shown when comparisons are made with respect to total sugar per root; however, reduction in size of root for variety S. L. 753 was not compensated adequately by increase in sucrose percentage, so that the sugar per root is significantly less (5% level) than in the unsprayed check. Analyses were not made of the beets sprayed at other dates.

Table 2.—Effect of 2,4-dichlorophenoxyacetic Acid Foliage Spray on Bolting, Growth, and Sucrose Content of Sugar Beet Strain S. L. 753. Bolting counts based on 500 plants, other determinations on average **of 50 plants. Sugar beets planted July 6, 1948; and harvested June 7, 1949.**

	Spray applied on—						L. S. D.[1]	
	None	9-17-48	10-21-48	12-2-48	1-28-49	3-18-49	5%	1%
Concentration 2,4-D, ppm.	0	50	5	5	5	5		
Early bolting plants, percent	33.4	5.8	13.4	13.0	15.8	12.2	7.2	9.9
Late bolting plants, percent	57.8	24.2	76.2	77.2	74.4	81.0	9.2	12.5
Total bolting plants, percent	91.2	30.0	89.6	90.2	90.2	93.2	6.9	9.5
Non-bolting plants, percent	8.8	70.0	10.4	11.8	9.8	6.8	7.7	10.6
Fresh weight, tops, per plant, gms.	1374	462	1159				132	192
Fresh weight, roots, per plant, gms.	770	638	690				83	121
Sucrose in root, percent	13.52	10.94	13.64				0.45	0.66
Sucrose per root, grams	103.6	69.7	91.4				10.6	15.4
Apparent purity coefficient, percent	89.4	77.7	89.6				0.9	1.3
Net sucrose per root, grams	92.5	54.2	81.7				25.4	36.9

[1] Least difference required for significance.

Among the 500 plants receiving the 50 ppm. spray, two showed no visible response. These were marked for further study of possible 2,4-D resistance. On December 2, 1948, approximately 1,200 plants of strain S. L. 759 were sprayed with 50 ppm. 2,4-D and 28 plants which showed no visible response were selected for further study and possibly for breeding for 2,4-D resistance.

In addition to delayed bolting, it was also observed that: (1) Within 48 hours after spraying with 5 ppm. 2,4-D there was a slight twisting of some of the petioles; (2) the 50 ppm. 2,4-D spray induced severe epinasty and longitudinal cracking of some petioles; (3) plants sprayed with 50 ppm. 2,4-D in September or December, 1948, had various types of seedstalk fasciation when bolting occurred the following spring (Fig. 1). In some cases petioles were fused to varying degrees and occasionally formed a cylinder through which the seed stalk emerged. In other cases leaf blades were forked or multiple tipped (Fig. 2). On harvesting June 7, 1949, masses of branched lateral roots, which had died back nearly to the tap root, were observed on the plants sprayed with 50 ppm. 2,4-D in September or December, 1948 (Fig. 3).

Summary and Conclusions

Exploratory tests in 1947 on the effect of several plant growth regulators on bolting of sugar beets indicated that a foliage spray containing a low concentration of 2,4-D delayed bolting.

Additional studies were made in 1948 consisting of a foliage spray of 5 ppm. 2,4-D applied to replicated plots of sugar beets at each of the following dates: October 21, 1948; December 2, 1948; January 28, 1949, and March 18, 1949. Another set of plots was given a 50 ppm. 2,4-D spray on September 17, 1948. Beets of variety U. S. 22, which bolts readily, and of

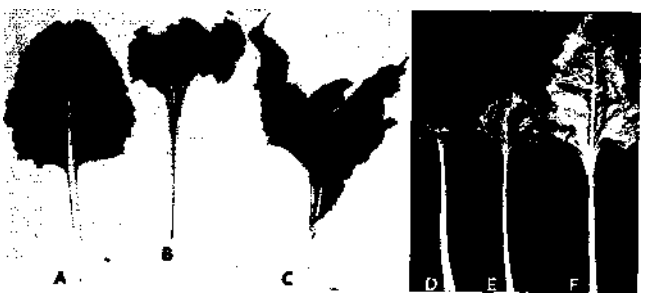

Figure 2. A and F, leaves from non-treated plants; B, C, D, E, various leaf deformities induced by 2,4-D applications to sugar beet variety U. S. 15.

strain S. L. 753, which does not bolt readily, were used in these tests. The plots were planted July 6, 1948, observed for bolting on April 11, 1949, and harvested June 7, 1949. All treatments delayed bolting significantly except the one applied in March to plants of variety U. S. 22, and even in that case the data closely approached significance. The 50 ppm. 2,4-D spray applied in September was the most effective in reducing bolting but it also lowered the sucrose percentage and the sucrose per root of plants of strain S. L. 753 and U. S. 22 below the values obtained in the unsprayed plots of these varieties. The differences were significant or approached significance. The 5 ppm. 2,4-D spray applied in October did not lower significantly the net sucrose per root of beets of variety U. S. 22 but it lowered significantly the net sucrose per root of plants of strain S. L. 753 below the values for the unsprayed plots. It is emphasized that further studies are necessary before growers' tests would be justified.

Along with the retarding effects on bolting, certain other plant responses were noted in the treated sugar beets. The 50 ppm. 2,4-D spray induced a severe epinasty and longitudinal cracking of the petioles on most of

the plants. In a few instances plants failed to have these responses. These individuals have been selected for further study and possible breeding for 2,4-D resistance. In addition, nearly all of the U. S. 22 and S. L. 753 plants sprayed with 50 ppm. 2,4-D in September, or the S. L. 759 plants sprayed in December with 50 ppm. 2,4-D, showed very striking seed stalk fasciations of various types. At harvest the beet root had masses of branched lateral roots which had died back nearly to the main root. Apparently 2,4-D is not specific for bolting. The reduction in the number of plants producing seed stalks is only one response to 2,4-D, and the other responses appear for the most part to have been undesirable from the standpoint of sugar production.

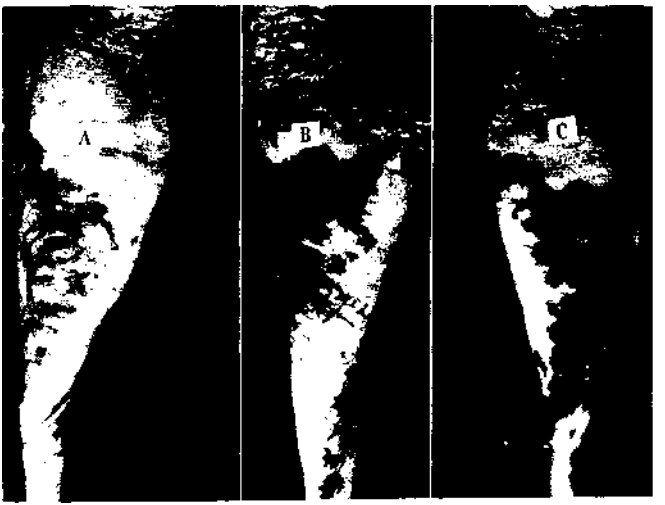

Figure 3. Beet from non-treated plant (A) and from a plant sprayed with 50 ppm. 2,4-D in September (B) or December (C), 1948, showing masses of branched lateral roots which died back nearly to the main root. Photographed on June 7, 1949.

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