Gibberellic Acid Effects on Seed and Seedlings of Sugar Beets

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Gibberellic acid, a plant growth regulator produced by the fungus *Giberella fujikuroi,* has been tested on a wide variety of agronomic, horticultural, and forest plants during the past two years. Growth response has been varied some plants have responded to minute quantities of the acid, and others with heavy dosages have showed lesser response. Marth et al (1)[2] states "Elongation of seed stocks of beet plants was stimulated but it is not known at this time whether seed production was accelerated." Gaskill (2) has reported that reproductive development was hastened in one variety of sugar beets.

The experimental results reported in this paper are from a series of greenhouse tests of seed treatments, foliage sprays, and soil applications, for the purpose of determining in some measure, the value of this chemical in the sugar beet crop.

Materials and Methods

The experimental work herein reported can be divided into four sections: (A) Seed soak and cotyledon treatments, (B) Seed soak and cold germination treatments, (C) Dust and seed soak treatments and, (D) Variety and treatment tests. A monogerm hybrid, 108 MS mm x 308 inbred, was used for the first two tests. SLC No. 15 (a monogerm) was used for (C) experiments. American Crystal variety American No. 3 S, and the U.S.D.A. variety NB1 were used for the (D) test. Greenhouse pots of 4-inch size were used for (A), (B), and (D) tests. The (C) test was in greenhouse flats. Since the (D) test included soil treatments, pots were lined with light polyethelene plastic so that none of this type of treatment would drain from the pots. The greenhouse soil used was rather sandy in type. Test (C) had three replications per treatment (greenhouse flats) and test (D) had three replications (pots) per treatment.

In test (D) both varieties were given 30 days of photo-thermal induction (continuous light at 45° F.) in comparison with no photo-thermal induction. Commercial fertilizer as ammonium phosphate was applied twice during the five-month growing season to each pot in amounts of approximately 100 pounds per acre. A complete nutrient solution was applied once to all pots. Artificial light was used continuously throughout the growing season.

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[1] Plant Breeder, Agricultural Research Station, American Crystal Sugar Company, Rocky Ford, Colorado.

[2] Numbers in parentheses refer to literature cited.

Experimental quantities of gibberellic acid obtained from Eli Lilly and Company were used for the (A) and (B) tests; "Gibrel," obtained from Merck and Company was used for the (C) test, and "Brellin" obtained from S. B. Penick and Company was used for the (D) test.

All seed soak treatments reported are from a four-hour soak.

Experimental Results

(A) Seed Soak and Cotyledon Treatment Results.

The treatments used in this test were as follows:

Seed Treatment (four hour soak)	Cotyledon Treatment (drops applied to the growing tip)
Gibberellic Acid, 10 p.p.m.	10 p.p.m. once
Gibberellic Acid, 10 p.p.m.	10 p.p.m. twice
Gibberellic Acid, 10 p.p.m.	100 p.p.m. once
Gibberellic Acid, 10 p.p.m.	100 p.p.m. twice
Gibberellic Acid, 100 p.p.m.	10 p.p.m. once
Gibberellic Acid, 100 p.p.m.	10 p.p.m. twice
Gibberellic Acid, 100 p.p.m.	100 p.p.m. once
Gibberellic Acid, 100 p.p.m.	100 p.p.m. twice
Water Soak	100 p.p.m. once
Water Soak	No Treatment

At the end of four weeks, slight elongation of stem had occurred where the 100 p.p.m. cotyledon treatment had been made once and twice on all the seed treatments. There appeared to be very little difference between the 100 p.p.m. cotyledon treatments once and twice. The water soaked check, treated once with 100 p.p.m. was approximately the same in stem elongation as the other 100 p.p.m. cotyledon treatments. No visible effect was obtained from any of the 10 p.p.m. treatments.

(B) Seed Soak and Cold Germination Results.

In this test 400 seeds were soaked for four hours in 100 p.p.m. gibberellic acid and placed on germination trays, along with a check of distilled water soak. The trays were allowed to germinate at 72° F. until approximately three-fourths of the seed had sprouted, at which time the trays were placed in a cold chamber at 39° F. for 24 hours and lowered one degree each 24 hours until 32° was obtained. At this temperature freezing occurred, and the two trays were removed after six hours. Forty of the longest sprouts from each tray were planted in the greenhouse. The results were negative. At the end of six weeks no evidence of stem elongation or of bolting was seen in either the gibberellic acid or the water soak treatment.

(C) Dust and Seed Soak Treatment Test.

Due to the lack of stimulation from seed treatment at concentrations of 10 and 100 p.p.m., it was decided to use for this test, dust treatments of 1000 p.p.m., with talc, and with the seed protectant Orthocide; and to use 100 and 1000 p.p.m. as soak treatments. Three flats were planted with 100 seeds each of the treatments and checks, and placed at random in the greenhouse. The germination results of this test are given in Table 1.

Table 1.—Greenhouse Germination Results from Dust and Soak Treatments.

	Percent Germination (8 Days)
Dust Treatment	
Orthocide—alone	80.0
Talc—alone	82.3
Orthocide + 1000 p.p.m. gibberellic acid	82.3
Talc + 1000 p.p.m. gibberellic acid	80.0
Check—no treatment	82.0
F. value	.24 Non-significant
4 Hour Soak Treatment	
100 p.p.m. gibberellic acid	82.3
1000 p.p.m. gibberellic acid	80.0
Check—distilled water	80.0
F. value	.37 Non-significant

(D) Variety and Treatment Test Results.

Since growth stimulation had not been obtained with seed treatment nor on foliage at dilutions of 10 p.p.m., and only slight effects with 100 p.p.m. on foliage, it was decided to conduct a test using only 1000 p.p.m. on two varieties—a fast bolting variety American No. 3 S and a slow bolting variety NB1, both with and without photo-thermal induction. Five gibberellic acid treatments were set up as follows: one foliage spray, three foliage sprays, 5, 10, and 25 ml. applied to the soil, along with a no treatment check. Three four-inch pots with three plants each were used for each treatment. The pots were lined with light polyethelene plastic and approximately 6.5 cubic inches of soil placed in each pot.

When the second true leaves were beginning to appear, the plants in the 36 pots not receiving thermal induction were treated with gibberellic acid, and the remaining 36 pots were placed in a photo-thermal room at 45° F. for 30 days. The three spray treatment for the plants not receiving thermal induction was sprayed on at 10-day intervals. All the soil applications were made at one time. At the end of 30 days the thermally induced

plants were treated using the same procedure as used for the plants not thermally induced.

Some difficulties were experienced in the application of the 15 and 25 ml. quantities of acid to the soil; as wilting was obtained with both these treatments and with the 25 ml. treatment some plants died. In 10 days after treatment however, these heavy soil treatments showed definite growth stimulation to the plants of American No. 3 S, and to a lesser degree to NB1. Final measurement of stem elongation was made five months after the experiment was started, on both non and thermally induced plants of both varieties, at which time it was considered that growth stimulation was complete.

This test had been planned to determine if bolting could be induced by use of gibberellic acid with or without partial thermal induction. Only three plants in American No. 3 S thermally induced produced normal seed stalks and flowers. One was in the three spray treatment, one in the five ml. treatment and one in the non treatment check. Since one bolter had appeared in the non treated check it could not be assumed that the other two bolters were due to gibberellic acid treatments. Further, every plant of both varieties, in both the thermal and non thermal induction and for the 15 and 25 ml. soil application, showed no sign of a bud at the end of the elongated stem. After stem elongation was complete on these plants new leaves appeared to be normal.

Table 2.—Stem Elongation Effect of Gibberellic Acid Treatments on Sugar Beet Seedlings.

Treatment				Treatment			
Variety	Gibberellic Acid 1000 p.p.m.	Photo Thermally Induced	Stem Elongation Inches	Variety	Gibberellic Acid 1000 p.p.m.	Photo Thermally Induced	Stem Elongation Inches
Am. No. 3 S	Spray 1	None	.68	NB1	Spray 1	None	.60
Am. No. 3 S	Spray 3	None	1.27	NB1	Spray 3	None	.95
Am. No. 3 S	Soil 5 ml.	None	1.09	NB1	Soil 5 ml.	None	.70
Am. No. 3 S	Soil 15 ml.	None	1.43	NB1	Soil 15 ml.	None	1.45
Am. No. 3 S	Soil 25 ml.	None	5.38	NB1	Soil 25 ml.	None	1.52
Am. No. 3 S	Check	None	.59	NB1	Check	None	.52
Am. No. 3 S	Spray 1	30 Days	.66	NB1	Spray 1	30 Days	.41
Am. No. 3 S	Spray 3	30 Days	1.06	NB1	Spray 3	30 Days	.77
Am. No. 3 S	Soil 5 ml.	30 Days	1.37	NB1	Soil 5 ml.	30 Days	.57
Am. No. 3 S	Soil 15 ml.	30 Days	2.16	NB1	Soil 15 ml.	30 Days	.90
Am. No. 3 S	Soil 25 ml.	30 Days	7.84	NB1	Soil 25 ml.	30 Days	1.34
Am. No. 3 S	Check	30 Days	.54	NB1	Check	30 Days	.43

Stem elongation data (Table 2) were obtained by measuring each stem or crown from the cotyledon scar to the growing tip of the stem or crown. Data were averaged by pot, with the three pots per treatment used as replications. The three plants which had bolted and flowered were not measured. Statistical analysis of the data is given in Table 3.

Table 3.—Analysis of Variance.

Variation	D.F.	Sum Squares	Mean Squares	F. Value
Total	71	23,886.73		
Replications (pots)	2	330.65	165.33	NS
Varieties	1	2,468.70	2,468.70	20.45*
Error (A)	2	241.41	120.71	
Climates[1]	1	38.43	38.43	NS
Climates x varieties	1	247.16	247.16	16.47*
Error (B)	4	60.05	15.01	
Treatment	5	10,595.49	2,119.09	26.64**
Treatment x varieties	5	6,009.38	1,201.88	15.11**
Treatment x climate	5	340.75	68.15	NS
Treat. x var. x climate	5	372.13	74.49	NS
Error (C)	40	3,182.28	79.56	

[1] Photo-thermal induction versus none.

From these results it is evident that growth stimulation was greater in American No. 3 S than in NB1, and that American No. 3 S did react somewhat differently than NB1 in different "climates." The comparison of "climates" as an average for both varieties showed a non-significant difference. It would appear therefore, that 30 days in photo-thermal induction was not enough to overcome dormancy, and none of the gibberellic treatments were effective in causing true bolting and flowering in either variety. The greatest differences obtained in this test were between treatments. The varieties also reacted differently to the different treatments.

Discussion

From the results obtained in this series of experiments it appears evident that the sugar beet requires heavy dosages of gibberellic acid for effective growth stimulation. It also appears that excessive application can cause stimulation which causes abnormal apical growth (see Figure 1). The lack of bolting in these tests is rather surprising. Previous work with American No. 3 S has indicated that 60 days in induction temperature is enough to cause nearly all plants of this variety to bolt. Heavy soil dosages of 1000 p.p.m. gibberellic acid (15 and 25 ml. per 6.5 cubic inches of soil) did not produce bolting in this variety with 30-days induction.

Figure 1.—American No. 3 S photo-thermally induced for 30 days at 45° F. Left: Soil application of 25 ml. of 1000 p.p.m. "Brellin." Right: No treatment check.

The varieties differed greatly in their growth response, but in so far as bolting stimulation is concerned the data obtained do not show any indication that dormancy could be overcome by the use of 30 day photo-thermal induction and gibberellic acid treatment on either variety. If such results are generally obtained, the value of this chemical may be limited to increasing the growth of plants following thermal induction for any benefit which might be obtained from increased seed production or other characters.

All seed treatment tests reported in this paper have given negative results. This applies to dust treatments at 1000 p.p.m. and four hours seed soak treatments at 10, 100, and 1000 p.p.m. It would be expected, however, that stimulation of some sort would occur if seed were sprouted in 1000 p.p.m. gibberellic acid media. However, continued application would have to be made to the soil at intervals and with a probable result similar to that obtained from the heavy soil applications as reported in this paper.

Summary

1. Four hour seed soak treatments of 10, 100 and 1000 p.p.m. gave no indication of any growth stimulation at emergence or later, in greenhouse experiments. Dust treatments at 1000 p.p.m. also gave negative results.

2. Gibberellic seed soak in 100 p.p.m. for four hours, germinated, and then "hardened off" in a cold chamber for 8 days, did not cause stem elongation or bolting when the plants were grown in the greenhouse.

3. Using stem elongation measurements after a five-month growing period in four-inch pots, two varieties were strikingly different in their response to 1000 p.p.m. gibberellic acid treatments, with one variety reacting in a different manner than the other from a different growth "climate."

4. Heavy treatments (1000 p.p.m.) gave greater stem elongation than light treatments, with one variety reacting in a slightly different manner than the other to the various treatments.

5. Thirty day's thermal induction followed by varying dosages of gibberellic acid failed to induce normal bolting.

Literature Cited

(1) MARTH, PAUL C., AUDIA, WILLIAM V., and MITCHELL, JOHN W. 1956. Effects of gibberellic acid on growth and development of plants of various genera and species. The Botanical Gazette Vol. 118, No. 2.

(2) GASKILL, J. O. 1957. A preliminary report on the use of gibberellic acid to hasten reproductive development in sugar beet seedlings. Jour. Amer. Soc. Sugar Beet Tech. IX (6) :521-528.