Effect of Some Growth-Regulating Substances on Sugar Beet Development

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The course of development of sugar beets is affected materially by climatic and soil factors, especially with regard to sugar content. A high level of nitrates in the soil and large, rapidly growing tops at time of harvest are associated with low sugar content in the beet root. In practice it is frequently impossible to balance fertilization and irrigation methods so that both high yield and high sugar content will be obtained. A need for supplemental treatments exists which cannot be fulfilled without expanded information. Beginning with results obtained in 1947, this report presents data on several treatments other than the major nutrient elements.

Material and Methods

Two tests conducted near Gering, Nebraska, in 1947, included growth-regulating substances and other treatments aimed at promoting root development and in some cases lessening of top development. The tests, similar in design, each having six replications, were conducted on two fields on plots 6 rows wide and 28 feet long. For harvest results, the four center rows of each plot were used. All materials used as a spray were applied in rather large volumes of water at low pressure with hand-operated sprayers. Subsequent tests were conducted near Longmont, Colorado, in 1948 and 1949.

The treatments used in tests conducted during 1947 and 1949 are given in Tables 1 and 2, respectively. The treatments used in a single small trial conducted during 1948 are mentioned with the harvest results in the following sections.

Table 1.—Treatments used in tests at Gering, Nebraska, 1947

Tr. No.	Treatment
1	Check.
2	Sprayed 2,4-D on leaves at the rate of 1/8 pound (70 percent sodium salt) per acre, July 21.
3	Same as No. 2, except application 1/16 pound per acre.
4	Sprayed in solution 10 pounds Borax per acre onto crowns of beets, July 21. No attempt was made to cover all the leaves.
5	Manually trimmed outside leaves from beet crowns on July 21, August 9, and August 27 to about 10 leaves per beet.
6	Sprayed in suspension 3 quarts Sprout Inhibitor per acre (44 percent methyl ester of alpha naphthalene acetic acid) September 12-
7	One-half rate of treatment 6.
8	Sprayed at the rate of 100 gallons per acre a solution containing 40 PPM 1, naphthalene acetic acid (1 pound Apple Set—Dow A-214 per acre) July 21, August 9, and August 27.
9	Removed, by cutting, center leaves and portion of crown (supposedly active growing point) on August 27.

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Table 2.—Amount of growth-regulating substance, in rate per acre, applied as sprays (80 gallons per acre) in tests at Longraont, Colorado, 1949.

Tr. Nos.[1]	Treatment[2]
1	Check, no treatment
2, 10 and 18	10 grams (1/45 lb.) 2,4-D acid, as sodium salt (.045 gram molecule)
3, 11 and 19	20 grams (1/23 lb.) 2,4-D acid, as sodium salt (.091 gram molecule)
4, 12 and 20	8.4 grams p-chlorophenoxyacetic acid (.045 gram molecule)
5, 13 and 21	16.9 grams p-chlorophenoxyacetic acid (.091 gram molecule)
G, 14 and 22	10 grams 2,4-D + 8.4 grams p-chlorophenoyacetic acid
7, 15 and 23	10 grams 2,4-D + 20 grams indol 3 acetic acid
8, 16 and 24	20 grams sodium salt of 4-chloro-o-toloxyacetic acid
9, 17 and 25	20 grams 2.4- dibromophenoxyacetic acid (as sodium salt)

[1] Treatments 2-9 were applied about June 1
Treatments 10-17 were applied about July 1
Treatments 18-25 were applied about August 1
[2] No plot was treated more than once.

Results and Discussion

The tests conducted at Gering, Nebraska, were placed on fields which had a history of producing low-sugar-content beets. Yields, however, had always been good, suggesting no particular nutritional deficiency. The top growth on beets in the area frequently approaches the weight of the roots. Treatments were selected with an aim to promote root growth or discourage top growth, as the latter had appeared to flourish at the expense of root development and sugar storage. The results obtained are given in Table 3.

Table 3.—Yield of beets, sugar percentage, total sugar, and yield of tops in percent of root yield for different treatments (mean values of six replications per farm).

	Weber Farm				Grassmick Farm			
Tr.[1] No.	Beets per Acre	Sugar	Sugar per Acre	Top Wt./ Root Wt.	Beets per Acre	Sugar	Sugar per Acre	Top Wt./ Root Wt.
	(tons)	(percent)	(pounds)	(percent)	(tons)	(percent)	(pounds)	(percent)
1	18.96	15.4	5,840	63	19.07	16.1	6,141	55
2	17.46	12.7	4,435	39	15.29	13.5	4,129	38
3	18.50	13.5	4,995	47	17.68	14.6	5,168	38
4	19.37	15.4	5,966	62	18.08	16.0	5,786	54
5	15.39	13.3	4,094	50	15.32	15.3	4,688	47
6	18.88	14.1	5,324	85	17.81	15.2	5,414	50
7	20.86	14.4	6,008	58	18.48	15.1	5,692	52
8	18.54	14.6	5,414	61	19.35	15.6	6,037	54
9	17.51	14.3	5,008	52	16.49	15.5	5,112	38
Gen. Mean	18.39	14.2	5,223	55.2	17.51	15.2	5,351	47.3
LSD 5% pt.	2.50	.72	754	....	1.89	.49	602	....
LSD 1% pt.	3.08	.97	1,009	...	2.53	.66	806	....

[1] For description of treatments according to number, see table 1.

None of the results presented in Table 3 was significantly better than the check (treatment 1) . Some treatments caused a significant reduction in yield and several treatments caused a real reduction in sugar percentage. The 2,4-D applications (treatments 2 and 3) were obviously too heavy. The immediate growth of roots and old leaves following treatment appeared unusually rapid. This was followed by what appeared to be a prolonged inactive period of growth of about two-months' duration. Then, just before harvest, considerable leaf growth was again noticed but the total top growth remained

less than for the check. The latter is apparent from the top weights given in percent of the root weight, Table 3, treatments 1-3. Beets on plots receiving treatment 5, periodic removal of the older leaves, grew additional leaves rapidly to maintain rather high its top weight in relation to root weight. Massive tops were grown at the expense of total root yield, even though top weights of 35 to 40 percent of root weights at harvest time have been reported as apparently optimum. The methyl ester of alpha naphthalene acetic acid (treatments 6 and 7) and alpha napthalene acetic acid (treatment 8) had no visible effect on beet development or yield as measured at harvest. Cutting out the apex bud and central leaves, even though done rather late in the season, resulted in the activation of other buds and a reduction in root development.

During 1948, due to adverse weather conditions throughout the spring, stands of beets were not good and rather unsuitable for test purposes. Nevertheless, it was felt that from certain treatments observations on visible effects at least might be obtained. A test was made with 8 treatments (10 including checks) which were applied August 10. The treatments and harvest results obtained on October 14 appear in Table 4.

Table 4.—Harvest results (mean 2 replications) for various treatments. Longmont, 1948.[1]

Treatment and rate per acre of active ingredient	Beets per A	Sugar	Sugar per A	Stand of Beets per 100'
	(tons)	(percent)	(lbs.)	
150 grams 1 naphthalene acetic acid	16.88	14.05	4,743	87
1,500 grams 1 naphthalene acetic acid	17.01	14.50	4,933	77
0.7 grams p-chlorophenoxyacetic acid	19.06	14.45	5,508	90
7 grams p-chlorophenoxyacetic acid	14.83	16.12	5,199	67
Check	15.49	14.90	4,616	81
400 grams methyl ester of 1 naphthalene acetic acid	16.82	14.47	5,038	77
4,000 grams methyl ester of 1 naphthalene acetic acid	18.32	13.12	4,809	92
1.6 grams 2,4 dichlorophenoxyacetic acid	17.91	14.70	5,265	69
16 grams 2,4 dichlorophenoxyacetic acid	24.74	12.70	6,284	96
Check	16.77	14.95	5,014	83
General Mean	17.79	14.45	5,141	....
CV (%)	11.26	8.07	.....	....
Sm/Gen. M (%)	7.96	.....	. .	...
LSD 5% pt.	4.53	ns[1]	ns	....

[1] Differences not significant by F test.

As indicated in Table 4, rates up to 3.3 pounds alpha naphthalene acetic acid applied as a spray August 10 showed no response in yield. Similarly, applications of the methyl ester of alpha naphthalene acetic acid at rates up to 8.8 pounds per acre had no effect on yield or visual development of the beet. On the other hand, 16 grams (1/29 pound) 2,4-dichlorophenoxyacetic acid applied as the sodium salt in a spray August 10 resulted in a very definite visual response and an increase in yield of beets significant at odds of 19:1. Again the percentage of sugar was lowered and the total sugar per acre was not significantly higher.

Since 2,4-D did give an apparent stimulation in growth and p-chlorophenoxyacetic acid was suggestive of having a favorable effect on sugar percentage, it was felt that further testing should be done. Related substances p-chlorophenoxyactic acid, 4-chloro-o-toloxyacetic acid, 2,4-dichlorophenoxyacetc acid, and 2,4-dibromophenoxyacetic acid were tested on a close comparative basis in 1949. The rates of the phenoxy substances were in the order of 10 and 20 grams per acre but were adjusted slightly to give comparable rates on a gram molecular basis. The concentration of the sprays applied was of the order of 35 and 70 ppm. active ingredient. The percentage of the material striking the beet plants varied with the amount of foliage development, as the area between the rows was sprayed as well as in the row.

The results obtained at Longmont during 1949 are presented in Table 5.

Table 5.—Yield of beets, sugar percentage, total sugar and stand for different treatments (mean values of six replications per field).

	Field 1				Field 2			
Tr. No.	Beets per Acre	Sugar	Sugar per Acre	Beets per 100′	Beets per Acre	Sugar	Sugar per Acre	Beets per 100′
	(tons)	(percent)	(pounds)		(tons)	(percent)	(pounds)	
1	26.27	14.67	7,708	99	26.48	18.01	9,538	79
2	27.65	14.77	8,168	95	26.05	18.00	9,378	85
3	26.89	13.94[1]	7,497	98	26.25	17.69	9,287	82
4	26.63	14.27	7,600	101	26.28	17.97	9,445	82
5	25.72	14.74	7,582	98	25.66	18.06	9,268	79
6	26.19	14.79	7,836	96	25.54	17.96	9,102	85
7	25.92	14.92	7,735	96	24.96	18.00	8,986	86
8	26.67	14.70	7,841	94	24.54[1]	18.01	8,839[1]	83
9	25.11	14.85	7,458	105	25.50	17.93	9,144	81
10	26.62	13.90[1]	7,400	101	23.65[1]	17.60[1]	8,325[1]	78
11	25.74	14.17	7,449	105	25.55	17.08[1]	8,728[1]	87
12	27.41	14.12[1]	7,741	96	24.68[1]	18.02	8,895[1]	82
13	26.52	14.84	7,781	99	25.07	18.15	9,100	82
14	26.35	13.60[1]	7,167	99	24.84	17.59[1]	8,739[1]	84
15	26.42	13.62[1]	7,197	101	25.01	17.64[1]	8,824[1]	87
16	26.68	14.65	7,817	93	25.53	17.88	9,130	83
17	27.98	14.75	8,254	95	25.23	17.85	9,007	80
18	26.87	13.86[1]	7,448	92	24.22[1]	17.58[1]	8,516[1]	80
19	28.36	13.03[1]	7,391	100	24.96	15.87[1]	7,922[1]	81
20	26.01	13.97[1]	7,267	98	24.09[1]	18.12	8,948	80
21	25.78	14.05[1]	7,244	94	24.42[1]	18.25	8,913[1]	82
22	26.27	14.18	7,450	90	24.77[1]	16.44[1]	8,144[1]	84
23	24.86	13.94[1]	6,931[1]	95	24.55[1]	17.22[1]	8,448[1]	77
24	26.56	14.13[1]	7,506	95	25.33	17.39	9,065	81
25	25.48	14.57	7,325	94	25.37	17.80	9,032	81
Gen. Mean	26.45	14.29	7,559	....	25.16	17.70	8,907	.
CV (%)	6.72	2.75	7.26	..	5.40	1.86	5.71	....
Sm/Gen. M (%)	2.74	1.12	2.96	....	2.21	.76	2.33	....
LSD 5% pt.	2.15	.49	667	....	1.68	.35	622	....
LSD 1% pt.	2.85	.65	883	..	2.23	.47	824	....

Statistically below check (tr. 1) at 5% level of significance.

The results with growth-regulating substances sprayed on the leaves of beets during the growing season of 1949 were, as in 1947, largely detrimental

to yield or sugar percentage, or both (Table 5). The effects seemed to be more harmful at the later dates of application. All the treatments used caused a significant reduction at odds of 19:1 in sugar percentage or yield of beets on one or both of the fields at one or more of the dates of application except the treatment including dibromophenoxyacetic acid, which produced neither a beneficial nor detrimental effect. On field 2, p-chlorophenoxyacetic acid treatments did not affect sugar percentage but did reduce yields. Conversely, 2,4-dichlorophenoxyacetic acid at the higher rate of application (treatments 11 and 19) caused a significant decrease in sugar percentage but not in yield of beets. The addition of indol 3 acetic acid to 2,4-D (treatments 7, 15 and 23) were equal, no better or worse, than the treatment of 2,4-D alone (treatments 2, 10 and 18).

Summary

Sprays containing alpha naphthalene acetic acid, 2-4-dichlorophenoxyacetic acid, and related substances applied to sugar beets during the growing season failed to give any conclusive favorable response in sugar content of beets or total sugar production. Several treatments with phenoxy compounds resulted in lower yields or lower sugar content of beets. Differences in response to growth-regulating substances were noted between fields and dates of application. Different end results obtained from treatment with strikingly similar compounds were noted. For example, p-chlorophenoxyacetic acid more frequently reduced the yield of beets without lowering the percentage of sugar, while 2,4-dichlorophenoxyacetic acid more frequently reduced the sugar percentage without lowering the yield of beets. That a change in end results could be obtained with such strikingly similar materials and in such small quantities, even though the reactions in these tests were mostly unfavorable, should serve to encourage additional studies in this unexhausted field of growth regulators as they affect sugar beet development.