Effect of Growth Regulators on Yield and Quality of Sugar Beets[1]

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The development of sugar beets in Manitoba is impeded by the short growing season. From seeding to harvest a bare 135 days constitute the average growing period and sugar beets are, in many seasons, immature at harvest. This is reflected in a lower sucrose content and lower purity.

According to Stoklasa's (1)[4] classical table for the development of sugar beets in Europe, foliage dry matter reaches a maximum the last week of August, that of the root by the end of September. Root and foliage weights become equal (the inflection point) by the end of August or approximately 5 weeks prior to harvest. It is during this last 5-week period that 48% of the sucrose is accumulated in the root.

Rainfall data (2) for the Red River Valley of Manitoba in 1951 and 1952 demonstrate the typical anomalies in nature for this area. In 1951 the crop received 3.75 inches more rain during August and September than it did during the same period in 1952.

Foliage and root weights for sugar beets in 1951 (3) show that the inflection point was reached on September 20, a bare 10 days before harvest. This was reflected in a satisfactory yield of low quality beets. In 1952 with insufficient rainfall for normal development during the late summer the inflection point was reached 28 days before harvest. Yields were 2 tons lower on the average than in 1951 but the lower yield was more than compensated for by a 2.5% higher sugar content, 1.88 better purity and an additional 62 lbs of white sugar extracted per ton of beets.

The data of Stoklasa and the facts observed under Manitoba conditions suggest that the start of metabolic ripening begins when the root and foliage weights are equal and that this should occur 4 to 5 weeks before harvest. Any deviation from this development pattern will result in poorer yields or lower quality sugar beets.

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[4] Numbers in parentheses refer to literature cited.

In an attempt to manipulate the relative rate of foliage to root development, various organic regulators were applied as foliage sprays at different stages of growth. The objective was to stimulate a more rapid development of the foliage early in the season so that the photosynthetic potential of the plant would be at a maximum by the last week of August. Then by inhibiting or slowing down new foliage growth at this point, carbohydrate storage in the tap root would be accelerated and metabolic ripening more nearly completed by harvest.

Materials and Methods

Experiments were conducted during the years 1960, 1961, 1963 and 1964 to test the effect of various growth regulators on yield and quality of sugar beets. Tests could not be made in 1962 because of adverse weather conditions.

In 1960 and 1961 the materials tested included hydrogen dicyanamide (H_2CN_2), maleic hydrazide (MH-30), CCC (2-chloroethyl)-trimethyl-ammonium chloride, a solution containing PO_4 and a trace of copper, ammonium nitrate (33.5-0-0), gibberellic acid (GA), barban 4-chloro-2-butynyl N-(3 chlorophenyl) carbamate and potassium phosphate.

Experiments the first 2 years indicated that GA and MH-30 warranted more detailed testing. Accordingly trials were conducted in 1963 and 1964 to test rates and dates of application for GA with and without a followup treatment of MH-30.

Procedures each year had features in common as follows: 1) Monogerm seed (treated with Captan) of the variety CS-7 was used; 2) plots consisted of four rows 60 feet long spaced 22 inches apart and beets were thinned 12 to 15 inches apart in the rows; 3) the two center rows, trimmed to 50 feet were used for all determinations; and 4) all foliage treatments were sprayed at the rate of 15 gallons of solution per acre with Atlox sticker spreader added to sprays according to the manufacturer's recommendations.

Results and Discussion

Two separate experiments were conducted in 1960. In one, beet foliage was sprayed with solutions of hydrogen dicyanamide (0.25%), CCC (0.25%), MH-30 (0.30%), GA (10 and 100 ppm) and a solution containing 0.83% P_2O_5 and a trace of copper. Sprays were used alone and in certain combinations on fertilized (75 lbs 33.5-0-0 per acre) and unfertilized plots. The GA treatments and fertilizer applications were made on July 6 and the others on August 29.

Details of treatment, yields per acre and sugar data are given in Table 1.

Table 1.—Test with various growth regulators—1960.

Treatments	Gross sugar	Yield tons/acre	Percent sugar
1. Untreated check	6,252	16.38	19.06
2. Nitrogen (N), sidedressed July 6	6,689	17.55	19.06
3. 100 ppm GA + Nitrogen "	6,426	16.83	19.08
4. 10 ppm GA + Nitrogen "	6,598	17.21	19.20
5. As in 3 + MH-30	6,553	16.61	19.76**
6. As in 4 + MH-30	6,561	16.72	19.66**
7. 100 ppm GA - July 6	6,421	16.66	19.28
8. 10 ppm GA - "	6,768	17.73	19.08
9. N + Dicyanamide	6,649	17.47	19.02
10. N + CCC + MH-30	6,403	16.56	19.30
11. N + MH-30	6,390	16.07	19.86**
12. N + PO_4 + $CuSO_4$	6,573	17.21	19.10
Average	6,524	16.92	19.29
L.S.D. 5%	NS	NS	0.29
L.S.D. 1%	NS	NS	0.38

Nitrogen as 33.5-0-0 at the rate of 75 lbs. per acre.

MH-30 at 0.30%
$(H_2CN_2)_2$ at 0.25%
CCC at 0.25%
PO_4 as 0.83% superphosphate plus $CuSO_4$ at 0.015 mg
} All applied as foliage sprays, August 29

** Treatments containing MH-30 are highly significant over all other treatments.

Yield of beets and gross sugar recovery were not affected by treatments but in three of four instances where MH-30 was applied the sugar percentages were markedly increased; the exception occurring where CCC and MH-30, two regulators with apparently opposite affects, were applied on the same plot at the same date.

In the second test three rates of GA (100, 250 and 500 ppm) were applied on August 27. The effect of treatment on yields, percent sugar and gross sugar is shown in Table 2.

Table 2.—Gibberellin test—1960.

Treatments	Gross sugar	Yield tons/acre	Percent sugar
100 ppm of GA - Appl. 27/8	6,350**	18.46**	17.20
Checks	4,606	12.57	18.37**
250 ppm of GA - Appl. 27/8	5,934	17.07**	17.37
Checks	5,661	15.17	18.67**
500 ppm of GA - Appl. 27/8	6,341**	18.89**	16.77
Checks	4,661	12.57	18.53**
Mean	5,592	15.79	17.82
L.S.D. 5%	936	2.70	0.46
L.S.D. 1%	1,331	3.83	0.66

** Highly significant differences.

The results of this test was very striking. Foliage of the treated beets grew more rapidly and was much more vigorous at harvest. This top vigor was reflected in higher yields and lower sugar percentages.

The reasons why GA had no effect on growth of beets in one test and yet had such a striking effect in another experiment the same year were not apparent at first. In one case GA was applied on July 6 and in the other on August 27. In the latter case the spraying was delayed because the beets were poorly developed as a result of late seeding. Two possible explanations were considered: 1) The development of the foliage relative to that of the root at the time of treatment; and 2) the date of spraying in relation to harvest date. Experiments in 1963 and 1964 demonstrated the correctness of the second assumption.

The materials used in 1960 plus barban (2 lbs/acre) and potassium phosphate (20 lbs/acre) were tested in 1961.

Treatments are listed and results of the test are given in Table 3.

Table 3.—Test with various growth regulators—1961.

Treatments	Gross sugar	Yield tons/acre	Percent sugar
1. CCC	5,659	17.43	16.25
2. Dicyanamide + CCC	5,624	17.09	16.17
3. K_3PO_4 at 20 lb - Aug. 22	5,623	17.46	16.10
4. Dicyanamide	5,570	17.06	16.33
5. Nitrogen (N)	5,557	17.45	15.92
6. Untreated check	5,548	17.17	16.15
7. 100 ppm GA	5,527	17.20	16.08
8. PO_4 + $CuSO_4$	5,510	17.14	16.08
9. Barban at 2 lbs. - Aug. 22	5,501	17.24	15.97
10. 100 ppm GA + MH-30	5,487	16.33	16.83**
11. N + CCC	5,478	17.05	16.07
12. 100 ppm GA + CCC	5,433	16.98	16.02
13. N + MH-30	5,419	16.12*	16.62**
14. MH-30	5,318	15.83*	16.80**
15. Dicyanamide + MH-30	5,251	15.66*	16.76**
Average	5,494	16.88	16.28
L.S.D. 5%	NS	1.02	0.33
L.S.D. 1%	NS	NS	0.44

Nitrogen as 33.5-0-0 at 30 lbs. per acre, sidedressed July 7.
MH-30 at 0.30%, foliage spray - August 24.
$(H_2CN_2)_3$ at 0.25% " " - July 7.
CCC at 100 ppm " " - August 23.
GA " " - July 7.
PO_4 as 0.83% superphosphate plus $CuSO_4$ at 0.015 mg } foliage spray - August 22
* Significant under checks.
** Highly significant over check.

As in 1960 sugar percentages were significantly higher where MH-30 was used, and in three of four instances yields per acre were depressed. All other treatments had no effect on yield per acre or percent sugar.

Results of tests in 1960 and 1961 demonstrated that percent sugar in beets can be increased by applying MH to the foliage and there were indications that GA may be effective in promoting additional growth in sugar beets. More detailed tests to determine the optimum concentration and date of treatment were indicated.

In 1963 foliage sprays of GA at 500 ppm concentration were applied on 4 different dates both alone and in combination with MH-30 which was applied during the third week in August. In a second set of treatments within the same experiment GA and MH-30 were sprayed in plots that had received 100 lbs per acre of 33-0-0 as a sidedressing.

Treatment details and yield results are given in Table 4.

There were significant differences in yield per acre and percent sugar for treatments, dates of application and dates of treatment. Differences in gross sugar were not significant.

In general yields per acre increased and percent sugar decreased as the GA application date was advanced, with yield being highest and sugar percent lowest for August 15. Where MH-30 was added, yields tended to be somewhat lower and percent sugar higher than when GA was used alone. However, it will be noted that sugar percentages for the combined treatments on August 15 was still significantly less than for the corresponding untreated check (18.73 vs 19.48). This failure of MH-30 to raise the sugar content higher may have been caused by an incompatibility of the two regulators but also could have resulted from the dry weather which continued for 6 weeks prior to harvest. Vegetative growth was inhibited with the result that percent sugar was exceptionally high in all cases.

The effect of GA treatment as influenced by date of treatment both with and without MH-30 is well illustrated in Table 5 where yields and percent sugar have been arranged according to rank.

In 1964 GA was applied at concentrations of 100, 250 and 500 ppm on four dates during the month of August (5th, 10th, 20th and 27th).

Results of this experiment are presented in Table 6.

Table 4.—The effect of GA, MH-30 and nitrogen fertilizer treatments on yield and quality of sugar beets, 1963.

	Dates of spraying	500 ppm GA	500 ppm GA + 0.3% MH-30	Mean-treat.	Check	500 ppm GA + 100 lbs of 33.5-0-0	500 ppm GA + 100 lbs of 33.5-0-0 + 0.3% MH-30	Mean treat.	Check + 100 lbs of 33.5-0-0
Yield tons per acre	July 4	11.30	11.49	11.39	11.71	11.91	11.61	11.76	11.73
	July 17	10.85	11.39	11.12	11.05	11.69	11.58	11.63	12.29
	Aug. 1	12.43	11.83	12.13	11.87	12.18	11.84	12.01	12.29
	Aug. 15	12.99	12.64	12.81	10.52	12.78	11.93	12.35	11.71
	Average	11.89	11.84		11.29	12.14	11.74		12.01
% Sugar	July 4	19.60	19.72	19.66	19.50	19.57	19.42	19.49	19.48
	July 17	19.32	19.55	19.43	19.15	19.12	19.47	19.29	19.38
	Aug. 1	19.13	19.30	19.21	19.32	18.98	19.32	19.10	19.28
	Aug. 15	18.50	18.73	18.61	19.48	18.43	18.57	18.50	19.13
	Average	19.14	19.32		19.36	19.02	19.19		19.32
lbs. Sugar per acre	July 4	4,432	4,527	4,479	4,568	4,661	4,500	4,580	4,571
	July 17	4,199	4,468	4,333	4,235	4,483	4,506	4,494	4,755
	Aug. 1	4,763	4,565	4,664	4,587	4,624	4,569	4,596	4,754
	Aug. 15	4,808	4,726	4,767	4,096	4,714	4,426	4,570	4,503
	Average	4,550	4,572		4,372	4,620	4,500		4,646

		Treatment	Dates	Dates × Treatment
Tons/Acre:	5% (1%)	0.52 (NS)	0.35 (0.48)	1.47 (NS)
% Sugar:	5% (1%)	0.15 (0.19)	0.39 (0.54)	0.40 (0.53)

Table 5.—Gibberellic acid test—1963.

Dates	Orders (ranks)							
	Yield—tons per acre				Sugar content			
	GA	GA + MH-30	GA + Fert.	GA + Fert. + MH-30	GA	GA + MH-30	GA + Fert.	GA + Fert. + MH-30
July 4	3	3	3	3	1	1	1	1
July 17	4	4	4	4	2	2	2	2
Aug. 1	2	2	2	2	3	3	3	3
Aug. 15	1	1	1	1	4	4	4	4

Table 6.—The effect of GA, MH-30 and nitrogen fertilizer treatments on yields and quality of sugar beets—1964.

	Dates	Check	GA 100 ppm	GA 250 ppm	GA 500 ppm	Means for treatments
Yield tons beets per acre	Aug. 5	14.26	13.06	13.74	14.76	13.82
	Aug. 10	14.23	13.94	14.11	14.41	14.15
	Aug. 20	13.50	14.21	14.43	14.78	14.47
	Aug. 27	12.85	14.53	14.72	14.64	14.63
	Average	13.71	13.93	14.25	14.65	
Sugar %	Aug. 5	15.30	15.34	15.26	14.79	15.13
	Aug. 10	15.58	15.46	15.16	15.30	15.30
	Aug. 20	15.82	15.32	15.05	14.75	15.04
	Aug. 27	15.55	14.69	14.34	14.07	14.37
	Average	15.56	15.20	14.95	14.73	
Sugar per acre	Aug. 5	4,370	4,007	4,188	4,367	4,187
	Aug. 10	4,436	4,318	4,280	4,413	4,337
	Aug. 20	4,275	4,329	4,378	4,360	4,356
	Aug. 27	4,011	4,265	4,223	4,126	4,200
	Average	4,273	4,230	4,267	4,316	

		Treatment	Dates	Dates × Treatment
Tons/Acre:	5% (1%)	0.64 (NS)	NS	NS
% Sugar:	5% (1%)	0.24 (0.32)	0.16 (NS)	0.32 (NS)

Except for minor deviations yields increased and percent sugar decreased as the concentration of GA was increased and as date of spraying was advanced. Yields were, on the average, significantly higher for the 500 ppm than for the 100 ppm treatment or the untreated check. Percent sugar was greater in beets treated with GA at 100 ppm than with the two higher concentrations but was significantly lower than the check.

Arranging the data according to rank as in Table 7 clearly illustrates the effect of treatment date and spray concentration on yield and sugar percentage.

Table 7.—Gibberellic acid test—1964.

Dates	Orders (ranks)					
	Yield—tons per acre			Sugar content		
	GA 100 ppm	GA 250 ppm	GA 500 ppm	GA 100 ppm	GA 250 ppm	GA 500 ppm
Aug. 5	4	4	2	2	1	2
Aug. 10	3	3	4	1	2	1
Aug. 20	2	2	1	3	3	3
Aug. 27	1	1	3	4	4	4

Summary

1. Experiments were conducted during the years 1960, 1961, 1963 and 1964 to test the effect of various growth regulating chemicals on yield and quality of sugar beets.
2. Gibberellic acid proved to be a growth promoting substance and foliar applications consistently increased yield and decreased sugar content when used at 250 - 500 ppm in 15 gallons of water per acre. Sprays of GA at 100 ppm were ineffective in some experiments.
3. Maleic Hydrazide (MH-30) when applied at a concentration of 0.3% (W/v) in 15 gallons of water per acre consistently increased sugar content but decreased yield.
4. Yield of sugar per acre was not materially effected by GA or MH-30 treatments either used alone or in combination.
5. Although the two regulators MH-30 and GA produce opposite effects the critical time of application for each appears to be in late August or approximately 5 weeks prior to harvest.

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Literature Cited

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