Comparison of Various Chloride and Sulfate Salts as Fertilizers for Sugar Beets

R. R. Wood and R. T. Nelson[1]

Early studies in plant nutrition generally upheld chlorine as an unessential element in spite of its presence as chlorides in practically all plants. Subsequent investigations have indicated that the results one might get with chlorides will be dependent to no small extent on the plant under consideration. Sugar beets are among the crops which have appeared to use chlorides to some advantage (4)[2]. Other studies reported (1,2,3) have shown definite response of sugar beets to sodium chloride applications. However, in these studies little significance was given the chloride ion and the responses were generally credited to the cation or sodium element.

An analysis of cosettes from six factories of The Great Western Sugar Company in 1945 revealed that the chloride content of beets in the Lovell, Wyoming, district was distinctly low in comparison with beets from other factory districts in northern Colorado and Nebraska. At Lovell the percentage of chloride in beets was 0.0228 compared with an average at the other locations of .0591 or approximately 2½ times as much as at Lovell. In 1946, sodium chloride was applied to beets at the rate of 70 pounds per acre in the Powell area of the Lovell district. Application was by solution in irrigation water to 12-row strips. There was some indication in this test of a possible increase in tonnage resulting from the sodium chloride application, but the results were not conclusive and further study was deemed desirable. The results of experiments conducted in 1947 are reported here.

Design of Experiments

Four tests were planted, three of which were harvested experimentally. The design used was a randomized complete block with six replications of each of nine treatments. The salts used were of high purity and the rates per acre were adjusted so that each treatment represented an equivalent quantity of salt based on their equivalent molecular weight. Application was by side dressing with Planet Jr. hand drills the second week of July. A calculated amount of each salt was weighed for each plot and all of that quantity applied to the plot. Plots were 6 rows wide x 28 feet in length. Four center rows, 25 feet in length, were harvested from each plot for yield, October 13-15, and one row was analyzed for sugar content.

A distance of 25 feet was allowed between series to prevent carry-over of salts between plots by irrigation water, but observations during the

[1]Agronomist, The Great Western Sugar Company, Billings, Montana, and Agronomist, The Great Western Sugar Company Experiment Station, Longmont, Colorado, respectively.

[2]The numbers in parentheses refer to literature cited.

season would indicate that this precaution was probably not necessary and only served to increase variability by spreading the plots over a greater area in the field.

Results and Discussion

The treatments and rates per acre are given with the harvest results for three respective locations in tables 1, 2, and 3.

Table 1. Summarized results, salt study, Laurel, Montana, 1947.

Treatment description and rates per acre	Roots per acre (tons)	Sugar content (percent)	Gross sugar per acre (pounds)	Beets per 100 feet (number)
300 pounds sodium sulfate (Na_2SO_4)	19.42	17.24	6696	104
367 pounds potassium sulfate (K_2SO_4)	18.09	17.14	6201	94
312 pounds potassium chloride (Kcl)	19.51	17.44	6805	103
245 pounds sodium chloride (Nacl)	18.24	17.38	6340	98
226 pounds ammonium chloride (NH_4cl)	19.26	16.54	6371	99
279 pounds ammonium sulfate ($NH_4)_2SO_4$)	17.62	16.20	5709	97
156 pounds potassium chloride and 122 pounds sodium chloride	17.62	17.50	6167	97
Check—no treatment	18.27	16.84	6153	98
Machine check drill run empty over plot	16.07	16.88	5425	91
General mean	18.23	17.02	6207	97
CV (percent)	10.87	4.17	11.64	
F value	NS	NS	NS	

Table 2. Summarized results, salt study, Powell, Wyoming, 1947.

Treatment description and rates per acre	Roots per acre (tons)	Sugar content (percent)	Gross sugar per acre (pounds)	Beets per 100 feet (number)
300 pounds sodium sulfate (Na_2SO_4)	20.83	17.38	7241	73
367 pounds potassium sulfate (K_2SO_4)	21.53	17.20	7406	77
312 pounds potassium chloride (Kcl)	21.62	17.15	7416	76
245 pounds sodium chloride (Nacl)	21.05	17.03	7170	74
226 pounds ammonium chloride (NH_4cl)	21.80	16.47	7181	73
279 pounds ammonium sulfate ($NH_4)_2SO_4$)	21.45	16.48	7070	78
156 pounds potassium chloride and 122 pounds sodium chloride	21.04	17.25	7259	73
Check—no treatment	21.58	17.13	7393	78
Machine check—drill run empty over plot	20.69	17.05	7055	71
General mean	21.29	17.02	7243	75
CV (percent)	6.23	2.15	6.58	--
LSD 5 percent point	NS	.43	NS	
LSD 1 percent point	NS	.57	NS	

Table 3. Summarized results, salt study, Bridger, Montana, 1947.

Treatment description and rates per acre	Roots per acre (tons)	Sugar content (percent)	Gross sugar per acre (pounds)	Beets per 100 feet (number)
300 pounds sodium sulfate (Na_2SO_4)	16.27	18.15	5906	96
367 pounds potassium sulfate (K_2SO_4)	17.20	18.10	6226	96
312 pounds potassium chloride (Kcl)	16.06	18.28	5872	94
245 pounds sodium chloride (Nacl)	16.78	17.98	6034	93
226 pounds ammonium chloride (NH_4cl)	17.28	17.53	6058	93
279 pounds ammonium sulfate ($NH_4)_2SO_4$)	16.04	17.61	5649	89
156 pounds potassium chloride and 122 pounds sodium chloride	15.96	18.45	5889	89
Check no treatment	15.90	18.00	5724	92
Machine check drill run empty over plot	16.21	18.05	5852	92
General mean	16.41	18.02	5912	93
CV (percent)	6.91	1.93	7.17	--
LSD 5 percent point	NS	.41	NS	
LSD 1 percent point	NS	.54	NS	

At Laurel, Montana, (table 1) the differences existing in yield of beets did not reach the 5 percent level of significance. Similarly the other two tests gave no significant response in yield to any of the treatments. At all three locations the lowest sugar content is associated with applications of nitrogen. These differences surpassed the 5 percent level of significance at Powell, Wyoming, and Bridger, Montana, (tables 2 and 3).

The average differential in yield obtained from different salts in the three tests as compared to the check is given in table 4. In this analysis the results of certain treatments were combined. The machine check and the one treatment which included both potassium and sodium chloride were omitted.

Table 4.—Three tests average increase or decrease over check for various salts.

Classification	Increase or decrease over check		
	Yield per acre (tons)	Sugar content (percent)	Gross sugar per acre (pounds)
Sulfate salts	+.13	−.05	+ 32
Chloride salts	+.48	−.01	+111
Sodium salts	+.18	+.20	+141
Potassium salts	+.42	+.23	+231
Ammonium salts	+.33	−.52	−156

Again in table 4 the reduction in sugar percentages caused by the application of ammonium salts is apparent. If one were to comment further on table 4, it seems that the chloride salts caused more favorable response in yield than did the sulfate salts. However, further study of tables 1, 2, and 3 shows that this apparent difference exists only in a comparison of the ammonium chloride with the ammonium sulfate. It may be observed that the ammonium chloride treatment yielded more than the ammonium sulfate in each of the three tests with no reversals in yield performance appearing. Combining this observation with a very definite visual difference in top growth resulting from the ammonium chloride treatment over that resulting from the ammonium sulfate treatment, it would seem unjust to discount completely this trend. Both ammonium salts produced larger tops than the check. Such a response in top growth was not evident from any of the other treatments. The rather late date of application of the fertilizers may have attributed to the low response in yield.

Summary

In comparisons of chloride and sulfate salts of sodium, potassium, and ammonium as fertilizers for sugar beets, greater top growth was apparent from the ammonium chloride treatment as compared with the ammonium sulfate treatment. Both treatments produced larger tops than did the check. A comparison of root yields revealed no conclusive differences between any of the treated plots or the check. A reduction in percentage of sugar resulted from the use of ammonium salts. This difference was highly significant for two of the three tests.

Literature Cited

(1) CROWTHER, E. M.
1947. Use of salt with sugar beet. Sugar Beet Review 16 (1): 19-22.

(2) HARMER, PAUL M.
1943. Salt with potash for some crops. Better Crops With Plant Food 27 (6): 6-10, 48-50.

(3) LEHR, J. J.
1941. The importance of sodium for plant nutrition: I. Soil Science 52: 237-244.

(4) TOTTINGHAM, W. E.
1919. A preliminary study of the influence of chlorides on the growth of certain agricultural plants. Jour. Amer. Soc. Agron. 11: 1-33.