QUANTITIES OF BORON AND ZINC FOUND IN SALTS USED IN THE PREPARATION OF CULTURE SOLUTIONS

ALVIN D. AYERS AND JOHN T. HATCHER

Reprinted from SOIL SCIENCE SOCIETY OF AMERICA
Proceedings 1939, Vol. 4

QUANTITIES OF BORON AND ZINC FOUND IN SALTS USED IN THE PREPARATION OF CULTURE SOLUTIONS[1]

ALVIN D. AYERS AND JOHN T. HATCHER[2]

IN SETTING up sand cultures on a relatively large scale, the use of technical and fertilizer grades of salts is' often an economic necessity. These salts usually contain impurities such as boron and metals, principally zinc, and if present in sufficient quantities they may limit plant growth. The danger of reduced growth or toxicity resulting from an excessive amount of these impurities may not be great in ordinary culture solutions. However, if the solutions are made to contain high concentrations of one or more constituents, in addition to the ions commonly present in nutrient solutions of the Hoagland type, for example 100 to 200 milliequivalents per liter of chlorides or sulfates, then the danger of obtaining toxic concentrations of boron and metal impurities becomes much greater. In order to guard against such a possibility, a number of samples of the various salts to be used were tested for boron and metal impurities before the stock salts were purchased. Data on the range in amounts of these impurities found in fertilizer and technical grades of a group of common salts are presented in this paper.

The dithizone test used for metal impurities was that outlined by Stout and Arnon (3),[3] based on results obtained by Hibbard (2). The reddish purple color obtained in the chloroform layer was compared with standards containing known amounts of zinc and the results are reported as parts per million of zinc. If copper or some other metal, such as nickel, cobalt, lead, mercury, cadmium, thallium, or bismuth reacts with the dithizone, the reddish purple color characteristic of zinc will be altered. Such color interferences were almost entirely lacking in these analyses and thus zinc was assumed to be the dominant metal impurity in these salts. Furthermore, it is believed that salts are more likely to be contaminated with zinc in the manufacturing process than with the other metals mentioned. Boron was determined by the electrometric titration method (1) with modifications to care for the type of salt being analyzed; or by the distillation procedure (4).

Data representative of 93 samples and the principal stocks of salts in the western United States are shown in Table 1.

Boron impurities run highest in those salts which are obtained from natural sources high in borax. The sodium sulfate sample No. 18 and the potassium chloride sample No. 63 are examples of this. At least part of the metal impurities, on the other hand, appear to have been picked up in the manufacturing processes. In this connection, it is interesting to note that the more refined salt is frequently higher in zinc than the technical or fertilizer grade of the same material. Examples of this are shown in the analyses of potas-

TABLE 1.-*Amount of boron and zinc found in salts used in culture solutions.*

Lab. No.	Salt	Grade	B, p.p.m.	Zn, p.p.m.
2	$(NH_4)_2SO_4$	Technical	—	20.0
3	$(NH_4)_2SO_4$	Fertilizer		12.0
4	$(NH_4)_2SO_4$	Fertilizer	0.6	5.6
5	$(NH_4)_2SO_4$	Technical	0.2	4.8
7	NH_4NO_3	Technical	2.0	5.6
8	NH_4NO_3	Technical	0.4	4.0
12	Na_2SO_4	Technical	—	24.0
14	Na_2SO_4	Technical	29.0	2.0
18	Na_2SO_4	Technical	24.0	1.2
19	NaCl	Technical	12.0	1.2
23	NaCl	Commercial	0.8	1.2
24	NaCl	Technical	1.0	2.0
28	$Ca(NO_3)_2.2H_2O$	Fertilizer	6.0	1.0
33	KNO_3	Technical	1.0	0.4
35	KNO_3	Fertilizer	1.5	0.4
37	KNO_3	c. P.		20.0
45	KH_2PO_4	Technical	0.4	34.0
46	KH_2PO_4	Technical	13.0	100.0
43	KH_2PO_4	Technical	—	200.0
48	$CaCl_2.2H_2O$	Technical	21.0	1.2
49	$CaCl_2.2H_2O$	Technical	4.0	Trace
76	$MgCl_2.6H_2O$	Technical	- -	6.0
77	$MgCl_2.6H_2O$	Technical	2.5	5.0
57	$MgSO_4.7H_2O$	u. s. P.	—	16.0
58	$MgSO_4.7H_2O$	Technical	0.8	6.0
88	$MgSO_4.7H_2O$	Technical	1.0	6.0
63	KCl	Technical	680.0	0.0
64	KCl	Technical	10.5	0.0
69	KCl	c. P.	—	0.8

[1]Contribution from Bureau of Plant Industry, U. S. Dept. of Agriculture.

[2]Agent, Regional Salinity Laboratory, Division of Fruit and Vegetable Crops and Diseases, and Agent, Division of Irrigation Agriculture, respectively.

[3]Figures in parenthesis refer to "Literature Cited", p. 315.

sium nitrate and magnesium sulfate. Measurable amounts may sometimes be picked up simply from contact of the salts or solutions with metal surfaces.

The amounts of the impurities found in the salts analyzed were not enough to be of a serious nature for an ordinary nutrient solution. However, with very concentrated salt solutions, such as are used in plant tolerance experiments, the amounts of the impurities introduced might be unfavorable to plant growth. For instance, if a solution containing 200 M.E. per liter of sodium sulfate were prepared from stocks represented by sample No. 12, 0.34 p.p.m. of Zn would be added by this salt. This amount of zinc in itself might not give trouble, but if more zinc were added intentionally or were derived from the water, other salts, or containers, the total might be enough to limit the growth of some plants. A solution of 100 M.E. per liter of potassium chloride made up from sample No. 63 would contain over 5 p.p.m. of boron — enough under certain conditions to be injurious to some plants.

In conclusion, it may be stated that as a group the fertilizer and technical grades of salts investigated did not contain enough zinc or boron to be harmful when used in ordinary culture solutions. However, when concentrated solutions are to be employed, only those stocks low in these impurities should be considered. It is always desirable to analyze the salts to be used in culture work to guard against injury from impurities and in order to regulate the addition of these constituents when they are lacking.

LITERATURE CITED

1. American Public Health Association. Standard Methods for the Examination of Water and Sewage. Ed. 8. 1936.

2. Hibbard, P. L. A dithizone method for measurement of small amounts of zinc. Ind. & Eng. Chem., Anal. Ed., 9:127-131. 1937.

3. Stout, P. R., and Arnon, D. I. Experimental methods for the study of the role of copper, manganese, and zinc in the nutrition of higher plants. Amer. Jour. Bot., 26: 144-149. 1939.

4. Wilcox, L. V. Determination of boron in natural waters and plant materials. Ind. & Eng. Chem., Anal. Ed., 2: 358-361. 1930.