SOME EFFECTS OF STANNOUS SULPHATE AND STANNIC CHLORIDE ON SEVERAL HERBACEOUS PLANTS

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(WITH THREE FIGURES)

Introduction

Until recently it was thought that boron, manganese, copper, zinc (4), and iron (7) were the only essential trace elements necessary for plant growth. Investigators now believe that other elements also are essential. Young (14) observed that additions of rare elements, including tin, stimulated the growth of timothy and algae. Arnon (2) suggested that such elements as Mo, V, Ti, W, Cr, Cd, and Co are essential to maximum growth of lettuce and asparagus. Micheels (9) reported that solutions of colloidal tin had a marked effect upon the early growth of wheat, oats, peas, and buckwheat. Allison, Hunter, and Bryan (1) noted slight favorable responses with additions of tin and other elements in sixty crop plants grown on the peat soils of the Florida everglades. In growing wheat, rye, maize, and tobacco in water culture Schropp and Scharrer (11) found that traces of tin chloride with other elements induced favorable responses.

In the experiments reported here, stannous sulphate was added to nutrient solutions and observations were made of its effects upon corn and peas. The effects of varying concentrations of stannic chloride were observed for the sunflower only.

Procedures

Sunflowers, corn, and garden peas were grown in glazed pots, six plants to each pot. Quartz sand was used as the growth medium. The cultures were supplied with nutrient solutions twice daily, and flushed twice weekly with distilled water to prevent accumulation of salts in the sand. Solutions were prepared from half-molar stock solutions of calcium nitrate, dipotassium phosphate, and magnesium sulphate, purified as first suggested by Steinberg (12) with the modifications adopted by Arnon and Stout (3). Calcium carbonate (65 gm.) was added to 5 liters of stock solution, which was then autoclaved for 20 min. at 15 lb. (120.5° C.). Nutrient solutions were made from the purified stocks by diluting 12 ml. of calcium nitrate, 9 ml. of dipotassium phosphate, and 9 ml. magnesium sulphate with distilled water (copper still) to 1 liter. In addition to the trace elements, Cu, B, Mn, and Fe, tin in the form of stannous sulphate was supplied to the nutrient in concentrations of 0.2, 1, 5, 20, and 100 p.p.m. In the sunflower tests, tin was added as stannic chloride in concentrations of 0.01, 0.05, 0.1, 0.5, 1, 10, and 100 p.p.m. No attempt was made to purify the trace element solu-
tions since these were present only in minute quantities. Stock solutions were brought to pH 6.5; and to prevent contamination, glassware was cleaned with 25 per cent. HCl.

A method of detecting tin in distilled water was necessary because the distilled water used was carried in tin piping. The flame color test suggested by MEISSNER (6) and FEIGL (5) was used. To increase the sensitivity of the test, the test-water was reduced to one-half its volume by boiling. This concentrated sample was then acidified strongly with HCl, and a few pieces of zinc added. A test-tube containing cold water was used to stir this mixture; it was then placed in a nonluminous bunsen burner flame. In this test the blue mantle which forms around the test-tube in the presence of tin was absent, thus eliminating tin as a contaminant of the distilled water to one part in three million. Distilled water leached through the sand and recovered also failed to show the tin test.

To detect the presence of bivalent tin in plant tissues, the spot test method suggested by FEIGL (5) was modified. Thin sections of plant stems were acidified in 20 per cent. HCl by dropping the acid upon a glass slide holding the sections. A drop of dilute ferric chloride, and after a few minutes, a crystal of tartaric acid were added. When the tartaric acid crystal had dissolved, a drop of dimethylglyoxime was used on the sections, followed by ammonia. A red coloration, developed in the presence of reduced iron, indicates that stannous tin is present in the plant tissues.

![Figure 1](https://example.com/fig1.png)

**Fig. 1.** The effect of increasing concentrations of stannous sulphate on peas.

1. Control  
2. 0.2 parts per million  
3. 1.0 p.p.m.  
4. 5 p.p.m.  
5. 20 p.p.m.  
6. 100 p.p.m.
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Results

Figure 1 shows the effect on peas of stannous sulphate in concentrations from 0.2 to 100 p.p.m. The control, which was without tin sulphate, was slightly taller than plants grown in 0.2 p.p.m., although the difference is not marked since the branches and leaves were similar. One interesting result was that plants supplied with 0.2 p.p.m. of stannous sulphate showed increased root growth. Concentrations from 1 to 100 p.p.m. caused toxicity symptoms. These were reduced growth of internodes, reduction in size of roots, reduction in number of roots, absence of flowers in concentrations above 20 p.p.m., and yellowing of the lower leaves.

Figure 2 shows the effect of stannous sulphate on corn. The control, 0.2 p.p.m., and 1 p.p.m. plants were similar in structure, although the one receiving 1 p.p.m. appeared to be more vigorous. Other effects noted were a deeper chlorophyll green, and increased height. The plants which had received 0.2 and 1 p.p.m. of stannous sulphate (2 and 3, fig. 2) showed an increase in root growth. Greater concentrations (5, 20, and 100 p.p.m.) caused stunting and chlorosis, especially a yellowing of the lower leaves.

Figure 3 illustrates the effect of stannic chloride on the sunflower. The results with low concentrations (0.01, 0.05, and 0.1 p.p.m.) show that stannic chloride has a pronounced effect upon the growth of the sunflower. It is particularly effective on the roots, which were about twice the size of those
of the control. With additions of tin chloride above 1.0 p.p.m., stunting and reduced growth of leaves, internodes, and roots were observed. In concentrations of 100 p.p.m. sunflower was unable to reach a height of more than 12 in.

![Image of plant growth]

**Fig. 3.** The effect of stannic chloride in concentrations from 0.01 to 100 p.p.m. on the sunflower.

1. Control
2. 0.01 parts per million
3. 0.05 p.p.m.
4. 0.1 p.p.m.
5. 0.5 p.p.m.
6. 1 p.p.m.
7. 10 p.p.m.
8. 100 p.p.m.

**Discussion**

From the results obtained with trace concentrations of tin sulphate, it appears that its effects are limited to slight increases in the root growth of corn and pea. It also appears that corn and pea react specifically to this compound. In the corn plant 1 p.p.m. of stannous sulphate caused no unfavorable nor abnormal growth responses, while in the pea plant there was a decrease in the size, number of roots, and a stunting or top growth with this concentration. In concentrations of 100 p.p.m. the pea plant was barely able to exist; while corn, although stunted, was about the same size as the corn plants grown in much lower concentrations. As there are two nutrient ions to be considered, the slight stimulative effect on root growth might be caused by an increase in the concentration of the sulphate ion, but the added concentration in some cases is very small in proportion to the sulphate ion already present in the solution. The responses to high concentrations of stannous sulphate indicate the possibility that both sulphate and tin ions may cause changes in growth. It should be noted that in the higher con-
centrations there was a tendency toward precipitation of the tin salt. In the sunflower, trace additions of tin chloride caused striking changes in root growth, to about twice the size of the controls. The lack of marked favorable responses in root growth with additions of stannous sulphate to pea and corn may indicate that in some way the sulphate ion modifies the effectiveness of the tin ion, or that the plants are less sensitive to tin than sunflowers, or it may be that the chlorine ion in the presence of tin stimulates root development of the sunflower. Since it has been discovered very recently that tin increases the growth rate of certain aquatic animals, it seems more probable that the tin ion in very low concentrations is stimulatory to root growth. TOTTINGHAM (13) has reported some investigations with sodium and chlorine in which he found increased root development in the sunflower plant. He suggests that chlorine may function in some plants as a nutrient. This possibility must be kept in mind in interpreting the response of sunflowers to stannic chloride.

Conclusions

1. A method for the detection of bivalent tin in plant tissues has been devised.
2. In the sunflower, 0.01 and 0.05 p.p.m. of tin as tin chloride stimulates root growth.
3. Concentrations of tin, either as chloride or sulphate, in concentrations of 5 or more p.p.m. have toxic effects upon corn, pea, and sunflower.

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LITERATURE CITED

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