5-13-1948

Minor Elements in Plant Growth

Vangy A. Tilton

MINOR ELEMENTS ON PLANT GROWTH

Submitted in partial fulfillment of the requirements for honors in Biology.

Submitted by:

Vangy A. Tilton

Vangy A. Tilton

Approved by:

J.H. Brownback

J.H.Brownback, Sci. D.

Ursinus College
May 13,1948

MINOR ELEMENTS IN PLANT GROWTH

From analysing the tissue and ash of plants it has been found that they are composed of more than forty elements. Of these, only fourteen are known to be essential, using the word "essential" in the strict sense that in the absence of the element in question growth is inhibited. Carbon, hydrogen and oxygen are obtained from the air, while the rest are obtained from the soil. Seven elements, magnesium, boron, zinc, iron, sulphur, manganese and copper, are termed trace elements because they are needed in such minute quantities, but they are, nevertheless, essential to the growth of the plant and the production of seeds.

If there is a high concentration of one of these essential elements in the soil, a greater amount than is needed by the plant may be absorbed and such quantities may prove to be toxic. In some cases a trace element is absent from the soil and must be added or it may be present in an insoluble compound and hence an adjustment has to be made in order to insure healthy growth.

An isolated function of a trace element in the growth of a plant cannot be given. Shive (11) issued a much needed warning against this tendency: "While it is, at present, impossible to assign any one particular process as the special function of a given trace element it is probably safe to assume that each of these elements is a critical factor in every important physiological process involved in the nutrition of a plant." However experiments have shown that an element generally has one major function, even though it is not the only one necessary for that given process and though it may take minor roles in other processes.

Plants vary in their chemical composition and absorbing ability due to the individuality of the plant, the availability of the element, soil moisture content and the pH. With a minimun percentage of mineral salts, a reaction of the soil with a pH of about 6 produces the best growth for most garden vegetbles (16).

Most of the recent research on trace elements has had to do with boron. Due to the various mineral and organic forms in which boron may be found in the soil, its availability is more clearly shown by tissue analysis of the stems and the leaves than by soil analysis (2). Heavier doses of fertilizer increases the demand for boron (13). It was clearly recognized, and recent work has confirmed the fact, that there is an association between calcium and boron in the metabolism of the plant (15). Excess lime inhibits the uptake and the utilization of boron (10). There is an optimum ratio which varies with the species and boron-starvation results when this balance is upset(3). A symptom of this starvation is that the young buds and leaves become brittle and break off easily (16). This is due to the fact that boron is necessary for proper cell division and differentiation. In boron-starved leaves the cambium and the phloem are replaced by undifferentiated parenchyma. Boron deficiency and toxicity seem to be dependent also on the potassium level. Indications of deficiency are increased by a high potassium content, as are tendencies toward toxicity (8). It has been stated that potassium appears to influence the response of the plant to boron indirectly through its determinative effects upon the processes involved in the absorbtion and accumulation of calcium(9).

Manganese has long been accepted as an essential element. One function of manganese is to catalyse the reduction of nitrates to amino-compounds and manganese-deficient plants therefore tend to exhibit high concentrations of nitrate (6). The direct physiologic action is in the synthesis of chlorophyll and so plants with this element lacking show chlorotic leaves and the young shoots die (16). Iron and manganese are definitely inter-related in their metabolic functions, the biologic effectiveness of one being determined by the proportionate presence of the other. Symptoms of iron toxicity corresond to those of manganese deficiency and vice-versa (14).

It is becoming more certain that there is a need for traces of zinc for adequate growth, but the amount required is exceptionally small. The requirements and tolerance vary not only between species but between varieties of the same species. Absorbtion of zinc from the soil is heavy and hence a great concentration in the soil easily leads to toxic effects (5). Lack of zinc will allow growth of many plants, but they will not develope seed (7).

Other elements such as molybdenum(1), thorium and vanadium have been shown to have stimulating effects on certain plants and further work will have to be done to determine whether thay are really essesntial elements.

The writer experimented with lead solutions to determine the effect of that ion on plant growth. Elodea was put into solutions of lead acetate (sugar of lead) of concentrations of .1 N, .01 N, .002 N, .001 N and .0001 N. Controls were grown in spring water.

The lead solutions had no stimulating effect upon the Elodea, in fact within a few days the specimens turned brown and died. The leaves were then immersed in a saturated solution of hydrogen sulfide to precipitate any lead that had been absorbed by the leaves. Under microscopic examination there was no lead sulfide to be found deposited in the cell, however, there was quite a bit on the surface, with the greatest accumulation being at the base of the epidermal hair on the lower surface.

From this work it has been concluded that lead at such concentrations is toxic. This agrees with the results obtained by other workers, although they worked with higher plant types. It was reported that dissolved salts were carried into a river by a mine dump varied from a trace to.3 mg./lit, and no plants grew in this part of the river and there was no micro-flora (4). Another worker reproted antagonism was observed in a solution of 10^{-4} $PbCl_2$ and the intake of the lead into the plant was in inverse relation to the growth of the plant (12).

Work on the relations between minor elements and plants has made considerable progress in recent years, although the has very little in the way of discovering any new essential elements. Much attention is being paid, however, to a problem of just as great importance - that of discovering what elements and in what concentrations prove toxic to plants and inhibit their growth. This is of immeasurable value in plant economy. There is still a vast field open for the investigation of the functions of minor elements in the metabolism of plants.

BIBLIOGRAPHY

1. Brenchley, W.E. and Warington, K. Value of molybdenum for lettuce. Nature 149: 196. 1942

2. Dewan, P.M. Boron in soils. Ont.Dept. Agr., Rep. 1941-2: 10. 1942

3. Jones, H.E. and Scarseth, C.D. The calcium-boron balance in plants as related to boron needs. Soil Sci. 57: 15-24. 1944

4. Jones, J.R.Erichsen Jour. Animal Ec. 9(2):188-201

5. Knowles, F. The poisoning of plants by zinc. Agr. Prog. 20:16-19. 1945

6. Leeper, G.W. Manganese deficiency and accumulation of nitrates in plants. Jour. Aust. Inst. Agr. Sci. 7:161-2. 1941

7. Reed, H.S. The relation of zinc to seed production. Jour. Agr. Res. 64:635-644. 1944

8. Reeve, E.and Shive, J.W. Potassium-boron relations in plants. Better Crops 27:14-16, 45-48. 1943

9. Reeve, E. and Shive, J.W. Potassium - boron and calcium-boron relationships in plant nutrition. Soil Sci. 57:1-14

10. Roach, W.A. and Bolas, B.D. Biochemistry. East Malling Res. Sta., Rep. 1940:22-23. 1941

11. Shive, J.W. Significant roles of trace elements in the n nutrition of plants. Pl.Physiol. 16:435-445. 1941

12. Silveter Prat, Charles University, Prague, Checkoslakia

13. Sokolov, A.V. The influence of boron on unlimed podzolized soils in relation to the soil fatigue. Chem. Soc. Agr. U.S.S.R. 10:30-35. 1940

14. Somers, I.I. and Shive, J.W. The iron-manganese relation

in plant metabolism. Pl.Physiol. 17:582-602. 1942

15.Warington, K. Studies in the absorbtion of calcium from nutrient solutions with special reference to the presence or absence of boron. Ann. Bot. 48:743-776. 1934

16.Yocum, L.E. Plant Growth, Jacques Cattell Press, Lancaster, Penna. 1945