THE EFFECT OF CALCIUM AND POTASSIUM ON THE ABSORPTION OF IRON AND MANGANESE BY PLANTS

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INTRODUCTION

Active plant growth is a result of the interaction of the hereditary constitution of the plant with its environment. In addition to light, moisture, heat, oxygen, carbon dioxide and water, plants require from their environment a number of metallic and non-metallic elements to facilitate the proper functioning of their metabolic processes. The elements used by plants have been classified as major and minor elements according to the quantities in which they are used by plants. Among the major elements are found potassium and calcium, both of which are absorbed in fairly large quantities. On the other hand, iron and manganese which are of the minor element group are absorbed to a far lesser extent, but nevertheless they have been shown to be indispensable for normal plant development.

The object of the present investigation was to determine the action of the two major elements (Ca and K) on the absorption of the two minor elements (Fe and Mn). Lime induced chlorosis due to insufficient absorption or improper iron metabolism, as well as manganese deficiency in highly limed soils (5,28,36,15) are practical demonstrations of the action of one element on the absorption and accumulation of an other.

The absorption of iron and manganese in connection with calcium and potassium supply have been studied by a

number of investigators. Swanback, (43) in his studies on the antagonistic phenomena and cation absorption in tobacco in the presence and absence of manganese and boron, has made some observations related to the subject.

In this investigation an attempt has been made to study the absorption by tomato and oat plants of iron and manganese in culture solutions containing different levels of calcium and potassium and to compare the results thus obtained with the conclusions drawn by Swanback ~~in~~ (43) from his studies on Nicotiana. To facilitate adequate comparison the compositions of the solutions used were essentially similar to those of the solutions used by Swanback (43). Some alterations, however, were made, primarily with regard to the microelements used to enable simultaneous investigation on manganese deficiency (grey speck disease). This was done with a view to continuing the work previously carried out on this subject in the Department of Botany, The University of Manitoba, by Miss Ruth Bulman and which has already been described in her thesis(3).

REVIEW OF LITERATURE

Absorption of Manganese by Plants in connection with Ca and K Supply.

Manganese occurs in the soil in several forms, i.e. as exchangeable manganese, as a cation attached to clay particles, as a part of organic matter and as a constituent of certain minerals. Manganese deficiency symptoms in plants may be due to a scarcity of this metal in the soil in the vicinity of the plant root or the manganese may be present in the soil in a non-available form. To be available to plants manganese must exist as an exchangeable manganese, as part of organic matter or in an inorganic easily reducible form. In nature manganese is very readily oxidizable thus made not available for the vegetation. Therefore factors affecting the manganic-manganous status in the soil are of great importance. Sherman and Harmer (37) stated that the manganic-manganous equilibrium in the soil depends on its acidity, lime and phosphate content, clay content, aeration temperature and the presence of reducing or oxidizing agents. They showed that neutral or alkaline conditions favor the formation of manganous manganese and acid conditions of manganic manganese. Sulfur retarded the oxidation of manganese.

When strongly acid soils which were rich in soluble manganese were limed the oxidation reduction equilibrium was shifted toward the manganous side and the soils became manganese-deficient with respect to available manganese for plant growth. Generally winter conditions favor the formation of the manganous ion and summer conditions the manganic ion. Manganese is leached easily from acid soils but not so from alkaline soils because of its greater solubility in the former.

Gilbert (10) found that manganese deficiency is linked with soil alkalinity, but the pH range in which chlorosis may occur varies with crop and climate and not with the soil type. Generally, however, manganese deficiency symptoms have been found in organic highly limed soils, or sandy soils, as pointed out by Sherman and Harmer (37). Gisiger (12) believed on bases of analyses of straw that the availability of manganese is greater in acid and very alkaline soils than in neutral or slightly alkaline soils.

Olsen (31) held that different plant species absorb different amounts of manganese from the same soil and that different species can tolerate different amounts of manganese with varying optima.

Microbiological activity may affect the state of soluble manganese to some extent. Gerretsen (8)

thought that precipitation of manganic oxide in the soil was caused by specific microorganisms when the pH was between 6.5 and 7.8. MacLachland (26) was able to isolate manganese oxidizing bacteria and fungi and attributed the deficiency of available manganese in the soil to microbial activity.

Morris and Pierre (30) carried out experiments with Lespedeza which is very sensitive to manganese and shows manganese toxicity symptoms at a concentration of 5 p.p.m. They found that by increasing the calcium concentration in the culture solutions from 12 p.p.m. to 60 p.p.m. or 300 p.p.m. there was no effect in reducing manganese toxicity. There was even some indication that manganese toxicity was increased in the higher calcium levels. No evidence was found to show that calcium reduced the toxicity of manganese as reported by Hewlitt (15). However, liming has been found to be beneficial to the growth of Lespedeza in acid soils and this probably might be due, at least in part, to the fact that liming decreases the amount of soluble manganese present in the soil. It was found that ~~all~~ water-soluble manganese was diminished on liming soils and bringing the pH up to values of 5.5 to 6.0.

Swanback, (43) in a study of cation absorption by tobacco plants, observed that there was an antagonism