Chapter I

INTRODUCTION

Of the nutrients which are required by plants in extremely small quantities, manganese, zinc and copper are known to play key roles in their cellular metabolism. In the absence of these micronutrients, the plants succumb to deficiency diseases and result in subnormal yields leading to great economic losses to the farmer. With increased use of synthetic fertilizers directed towards obtaining higher per-acre return, there is a possibility that some of these micronutrients which are present in soil today in optimum amounts may fall short of the plant requirements, resulting in general decline in yields. Finally, a time may come, when these nutrients may limit the production of crops.

It is not the total quantity of a nutrient present in the soil which is important from the point of view of plant nutrition, but the available fraction which is easily accessible to the plants. The availability of copper, zinc and manganese in the soil is controlled by a host of factors like rainfall, parent material, soil reaction, physical and chemical properties of the soil, crop ecology, soil environment and the soil management practices. For a fuller understanding
of the concept of 'availability' it is essential to know the forms in which these three micromutrient cations are present in the soil.

In general, manganese, zinc and copper are postulated to occur in the soil as (a) ions electrolytically bound by the base exchange complex, (b) insoluble hydroxides, carbonates, phosphates and silicates, (c) chelates of organic compounds, and (d) ions trapped within the crystal lattice of the clay minerals. Recently, Viets (1962) has given an exhaustive account of the different forms in which micromutrient cations are present in the soil and their availability with the help of his celebrated pool theory. According to this theory, not only are the water-soluble or weakly-adsorbed zinc, copper and manganese available to the plants, but also the fraction of these cations that are held with greater affinity by clay and humus of the soil. All these fractions are considered by him to be in equilibrium with each other. For the extraction of the loosely adsorbed cations of copper, manganese and zinc, weak cation exchangers like neutral normal ammonium acetate are employed. The fraction of these micromutrients extracted by this solvent is called exchangeable which is believed to be available to plants (Epstein and Stout, 1951).

The other fraction of these cations, which is held in the soil with greater force, can only be removed by using
chelating agents. In addition to the above two available forms, the soil is supposed to contain reserves of less readily available manganese, copper and zinc presumably in the secondary minerals, primary minerals and in the lattice of the clay minerals. In order to get an idea about the magnitude of the potential reserves, the soil is usually extracted with concentrated acids. Although great strides have been taken in the recent past in understanding the chemistry of manganese, zinc and copper in the soil, very little has been known about the concept of 'plant available' fractions of these three cations and their requirement by different types of plants.

The State of Maharashtra has been broadly divided into six zones on the basis of the differences in the rainfall, parent material and consequently on the nature and distribution of different kinds of soils and crops. The rainfall is an active factor of soil formation. Hence, any variation in the precipitation is likely to alter the physical and chemical properties of the soils which in their turn would affect the availability of zinc, copper and manganese. Similarly, any variation in the parent material may also affect either the easily available or potentially available fractions of these three micronutrients. The main objective behind the sonal classification of the soils is to charac-
terize the soils of the State into different zones and to know how, the soils from one zone differ from those of the others, not only in their general fertility but also in their contents of copper, manganese and zinc.

Although a large variety of crops are grown in the Maharashtra State, the extent and the distribution of these crops follow a definite pattern which is controlled not only by differences in soil but also by rainfall. In other words, each of these zones principally grows one or two typical crops. It is well known that the feeding habits and hence the capacity to absorb and utilize the different macro- or micro-nutrients vary from one crop to the other. For instance, the rice can absorb and utilize as high as seven times the quantity of manganese that is removed by barley plants, although both of them come under the general class of cereals (Vlamis and Williams, 1964). In view of these differences in the nature of cropping, it was necessary that the soils occurring in each of these zones were examined for their contents of different fractions of the above three micronutrients so that the data obtained could be utilized for formulating a programme of fertilization with manganese, copper and zinc, consistent with the crop requirements in each zone.

The application of liming materials to correct the soil acidity is an age-old practice. Such an application not only
corrects the acidity but also counteracts the evil effects of the toxic concentration of some elements present in the acid soils. Apart from directly supplying the plants with calcium and magnesium, the addition of limestones results in increased availability of major nutrients like nitrogen, phosphorus, and potassium and in the enhancement of microbial activities and improvement in the texture of the soils. In spite of the above beneficial effects, reports are often received that the liming of acid soils has produced no effects on the yields of crops. In certain instances, it is found to have adversely affected the crop growth. Such adverse effects of liming may be caused by the decreased availability of micronutrient cations like zinc, copper and manganese either as a result of increase in pH values or by their immobilization through adsorption and other processes not yet clearly defined. It is generally agreed that application of lime to the acid soils decreases the availability of manganese. However, different views are expressed as regards the effect of liming on the availability of copper and zinc.

In the Maharashtra State, attempts have been made in the past to study the manganese, zinc and copper contents of the soils collected from different parts of the State (Bendale et al., 1951; Duarte et al., 1961; Sanadive et al., 1964; Kavimandan et al., 1964; and Zende and Pharende, 1964). A review
of the work carried out during the last ten years by the Department of Agriculture, Maharashtra State, has revealed that at none of the experimental farms did the application of these microelements, either singly or in combination, produce any significant effect on crop yields. No systematic studies have been carried out in the State to assess the zinc, copper and manganese status of the soils from different agro-climatic zones with a view to establishing a relation between differences in soils and climate on the one hand and the amounts of different fractions of these micro-nutrient cations on the other. Likewise, no attempts have been made so far to study the effect of liming of acid soils on the availability of applied manganese, zinc and copper. In view of the above, a detailed investigation was undertaken to elucidate the following problems:

1. To characterize and compare the soils from different agro-climatic zones of the Maharashtra State on the basis of their manganese, zinc and copper contents and to find out the effect of variations in the rainfall and the parent material on the contents of the above micronutrients.

2. To establish quantitative relationship between the different fractions of zinc, copper and manganese on the one hand and factors like rainfall, physical and chemical properties of the soils on the other.
3. To find out the effect of the application of graded doses of CaCO₃ on the uptake of applied zinc, copper and manganese by paddy plants in four acid lateritic soils formed on two different parent materials by conducting a Neubauer's test.