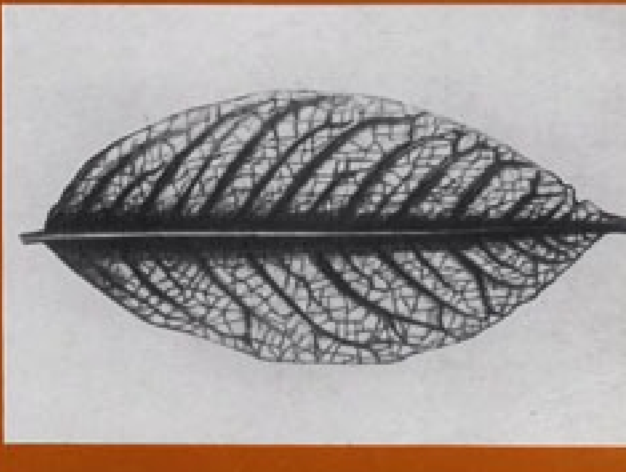
FAO SOILS BULLETIN 17

trace elements in soils and agriculture



FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS ROME

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I. INTRODUCTION

To meet the demand of the rapidly increasing population of the world, more and more food and fibre must be produced from each hectare of the world's arable land. Modern cultivation methods, improved varieties, better control of plant diseases, pests and weeds and increasing use of mineral fertilizers, increase in irrigated area, etc. are all factors responsible for the general increase in crop yields in recent decades and years (Table 1).

Table 1. Development of world average yields of nine commonly grown crops and consumption of three main fertilizer nutrients (120).

Periods	1948-52	1952-56	1963-67
Crop		Kilograms per hectare	
Wheat	990	1 080	1 280
Rice	1 630	1 820	2 070
Maize	1 590	1 700	2 280
Millet & Sorghum	510	560	740
Barley	1 130	1 250	1 560
Oats	1 140	1 190	1 530
Soybeans	1 000	980	1 180
Cottonseed	440	500	630
Potatoes	10 900	11 100	12 600
Nutrient		Kilograms per arable hectare	
N	3	4	12
P_2O_5	4	5	10
K_2O	3	4	8

In spite of the favourable development in fertilizer use, two to six times more of the main nutrients are still removed annually from the soil than are applied to it as mineral fertilizers. Some of the removed nutrients are replaced by those in straw, farmyard manure, etc. but on average the nutrient balance is likely to remain negative.

Trace elements are not regularly applied to soil by the use of the common fertilizers. Their removal from the soil has been going on for centuries without any systematic replacement. Trace element deficiency cases were first reported at the end of 19th century and today it is known that extensive areas of our soils are incapable of supplying plants with sufficient amounts of micronutrients. The one-sided development in the fertilizing of soils with only main nutrients stimulating increased yields, the loss of trace elements through weathering and leaching, the decreasing proportion of farmyard manure and other natural fertilizer materials used in comparison with chemical fertilizers, the increasing purity of chemical fertilizer materials and several other factors is contributing toward accelerated exhaustion of the available supply of trace elements in soils.

Around nine tenths of a fresh plant consists of water, and about 95 percent of the remaining dry matter of most plants is composed of four elements: carbon, hydrogen, oxygen and nitrogen. Potassium, phosphorus, calcium, magnesium, silicon, aluminium, sulphur, chlorine and sodium compose about four percent of the dry weight and the remaining one percent or less is accounted for by another dozen or more elements including all the essential micronutrients.

On the basis of the amounts in which they are required by plants and of their functions these elements are classified into different categories. Some authors, especially during recent years, have distinguished only two groups, i.e. macronutrients (N, P, K, Mg, Ca, S) and micronutrients (other nutrients), while most research workers have been using the following division into three categories:-

Primary or major nutrients, nitrogen, phosphorus and potassium, which are required in relatively large amounts (often expressed in percent of dry matter basis) and are regularly applied to the soil in mineral fertilizers.

Secondary elements or nutrients is the description given to silicon, calcium, magnesium and sulphur because of their relatively abundant existence in both soils and plants. They are frequently present as accessory elements in fertilizer materials or are applied to soils separately in soil amendments such as liming materials and gypsum. It is not certain that silicon is essential to all plants.

Trace elements (minor elements, microelements or micronutrients) which exist only in small amounts in ordinary soils and plants. Their proportions are usually given in parts per million (p.p.m.). Sometimes the name "nutrient" is used only for those elements which have been proved to be essential for plant growth or for the nutrition of animals to distinguish them from other, non-essential elements. This classification is not always practical, because some elements which are essential for plants are not required by animals and vice-versa and because, from time to time, further elements have been proved to be essential. Further, not all plant species require all the elements now listed as essential.

Today, more than half a dozen trace elements, including boron, chlorine, copper, iron, manganese, molybdenum, sodium, zinc, and possibly cobalt are known or suspected to be essential for the normal growth of plants. Some of these (chlorine, cobalt, copper, iron, manganese, molybdenum, sodium and zinc) are also essential for animal nutrition. Other trace elements required by animals are chromium, iodine, selenium and perhaps fluorine. Deficiencies of barium and strontium have been found in certain conditions to cause growth or other abnormalities but whether they are essential is still doubtful.

In addition to those mentioned above, there are a number of elements found in most soils and plants, which apparently are not essential for plant or animal nutrition. Some of these, like vanadium, may effect the growth of plants indirectly because of their importance in certain micro-biological functions and others like aluminium play an important chemical role in soils, especially in affecting the availability of phosphorus. The importance of many elements found in soils and plants is based on their harmful effects rather than on their role as growth stimulating factors. In general all trace elements are toxic to plants and animals if present in the soil in concentrations appreciably in excess of the normal or average. In some cases (e.g. boron, copper, fluorine, molybdenum and selenium) their toxic effects appear even with relatively low concentrations. These factors, together with the large number of trace elements and their complicated functions in biological processes, and the difficulties in identifying deficiency or toxicity symptoms, if not severe, make the correction of trace element problems often laborious and time consuming and in cases of toxicity even risky. To ascertain the exact nature of the problem, field experimentation is usually needed. However, in cases of slight deficiencies the only full symptoms may be lower crop yields or low production in animals without any visible external symptoms.

It is apparent that hidden trace element deficiencies are far more widespread than is generally estimated. Trace element problems, which today may be considered only local, in the relatively near future may well become more serious, occuring over extensive new areas and creating widespread and complicated production restrictions, if they are not properly studied and diagnosed in time. Even though much of the nature of trace element functions is known, the application of this knowledge is not easy. To avoid serious mistakes in this application, much research and especially extensive experimentation is still needed.

The purpose of this paper is to give the reader some general information on the importance of the numerous trace elements in agricultural production, their origin, existence and behaviour in different soils, requirements by plants and main biological functions and deficiency corrections. In addition, it is hoped to stimulate agriculturists into a clearer realization of the role of trace elements in agriculture. The bibliography, included, will furnish the reader with more detailed information not offered by this review.