ABSTRACT

STUDIES ON THE MICRONUTRIENT UPTAKE AND UTILIZATION IN PLANTS

WITH PARTICULAR REFERENCE TO ZINC AND MOLYBDENUM

By

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It is only three score years before that the importance of micronutrients in crop productivity became more conspicuous, and thus the need to understand the mechanisms operating to make the elements available to plant, was greatly felt.

The work described in this thesis is directed towards understanding of the physiological characteristics of absorption and utilization of Zn and Mo in plants, the former being essential for vital functions in catalysing the oxidation processes and transformation of carbohydrates, and the latter, a prosthetic group of enzyme nitrate reductase, which in turn is very specific for the element.

Plant material was used either in the form of excised roots (for absorption), intact plants (for transport), and leaf systems (to study the absorption by leaves). The path of the elements was traced using the radioisotopes of zinc and molybdenum viz., $^{65}$Zn, $^{99}$Mo respectively. The plant material employed were different cultivars of sorghum, maize, bean, tea and peanut.
Sorghum and maize were used to study the utilization aspects of the two elements.

Absorption and transport of zinc was higher for ZnCl$_2$ than for other sources of Zn (i.e., ZnEDDHA), in different cultivars. A positive heterosis in uptake was noted. Elements like Fe, Cu and P reduced the uptake of Zn. Study with drought resistant M-35 and drought susceptible M-47 sorghum cultivars revealed that the rate of absorption and transport in M-47 was higher than that in M-35. P and Zn interaction showed mutual inhibition in these two cultivars.

Absorption and transport in different cultivars of maize revealed varietal differences. A hyperbolic pattern of absorption and transport is typical of uptake against a concentration gradient, showing that the uptake of Zn is energy mediated. A negative heterosis i.e., a greater reduction in uptake by hybrids was found in maize contrasting to that in sorghum. Zn uptake and translocation were much higher in tea than in monocot plants like sorghum. Similar results were obtained in peanut also.

The distribution of Zn from the maize seeds, fed with labelled Zn showed that during the period of 9 days, there was a gradual decrease in Zn content of the seed and a simultaneous increase in the root and shoot, the former having more than in the latter. The retranslocation of Zn in bean revealed that the
source for Zn retranslocation was the stem and not the primary leaves.

Results obtained in the experiments to identify the Zn-deficiency stress tolerant plants revealed the reduction of pH of the nutrient medium with the onset of interveinal chlorosis, in the tolerant cultivars. Sorghum hybrids showed hybrid vigour in the recovery of chlorosis. Cotton and peanut cultivars differed in their susceptibility and tolerance towards Zn deficiency. Further, Zn concentration above 50 μM showed severe yellowing of leaves reflecting the unavailability of Fe because of high Zn concentration, in sorghum.

In support of the Zn-Fe interactions, the effect of ZnCl₂, ZnEDTA and ZnEDDHA in the absence and presence of FeSC₄ in chlorophyll synthesis was studied in maize cultivars. It was found that the chlorophyll synthesis was enhanced due to the presence of Zn and Fe as compared to Zn alone. In general, it was found that the content of chlorophyll-b was more than that of chlorophyll-a. The male parents dominated over others for their chlorophyll content. The effect of the presence of Zn chelate was insignificant.

The absorption of Mo in several sorghum and maize cultivars was found to be an active process. The transport of Mo followed a biphasic pattern and the absorption by roots was perhaps the rate limiting factor in transport. Sorghum hybrid,
CSH-7 had greater affinity for Mo than other cultivars. The Mo absorption and transport in both sorghum and maize showed a biphasic pattern with the plateau formed above 50 μM concentration. The effect of ZnCl₂ on Mo absorption differed among the maize cultivars and Zn had a stimulatory effect in Ganga-5 and its parents. Time course of Mo absorption in maize leaf slices showed inflections at different absorption periods, confirming the active nature of the process. The results also showed that the age of the leaf is an important factor for absorption.

The activity of nitrate reductase and chlorophyll synthesis were studied using sorghum and maize seedlings. Plants were grown in light and dark for 7 days with different concentrations of Mo and the nitrate reductase activity was assayed in endosperm and shoot. Mo+Zn&Mo ± KNO₃ interactions were carried out and the results revealed that at 100 μM and 200 μM Mo, sorghum hybrid CSH-7 showed an increase in nitrate reductase activity. The activity enhanced with increasing incubation periods. Absence of KNO₃ was insignificant but its presence increased the nitrate reductase activity. Light grown seedlings had less nitrate reductase activity compared to the dark grown ones, due to the possible interference of chlorophyll synthesis.

Cultivars, in initial stages of growth showed little difference in their chlorophyll content. However, in 10 day old seedling of maize, cultivar CM-202 x CM-111 showed a significant increase in chlorophyll content as compared to other cultivars. Mo+Zn treatment increased the chlorophyll content compared to the Mo treated ones.