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Critical Levels of Zinc in Wheat at Different Stages of Growth

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Considerable variation exists in the critical levels of Zn and index part of wheat used for plant analysis. Wheat cv WH-147 plants were grown in a greenhouse using Zn-deficient soil amended with 0.50, 1.25, 2.5, 5, 7.5, 10, 20, 40 and 100 ppm Zn. Critical Zn deficiency levels were established at 25, 30 and 21 ppm at tillering, boot growth and earing stages of wheat growth. The corresponding Zn toxicity levels in wheat shoot were determined as 160, 215 and 126 ppm, respectively. Leaf blade or whole shoot at tillering stage and middle leaves at boot growth stage should be sampled for tissue analysis to evaluate the Zn status in wheat.

Key Words - Boot Earing Growth Shoot Tillering Wheat Zinc

Plant analysis indicates the accessibility or nutrients from soil to plant and being a direct approach it seeks an answer from the plant itself about its nutritional problem. Ulrich (1952) proposed the basic concept that the nutrient concentration within a specific plant part is related to plant growth. According to this concept, growth is not affected as long as the nutrient concentration remains above the critical concentration.

Detailed information relating to the changes that occur with age in the concentration of the micronutrients in different organs of plants is lacking. This is also a prerequisite for choice of the plant part and the time of sampling for any diagnostic purpose.

Much variation exists in the critical deficiency level of Zn and index part of wheat used for plant analysis by several workers (Agarwala *et al.*, 1977; Melsted *et al.*, 1979; Rathore *et al.*, 1978 and Sakal *et al.*, 1981). Therefore, this study was conducted to investigate the critical levels of Zn in wheat at different stages of growth.

MATERIALS & METHODS

An experiment was conducted in greenhouse by using surface sandy soil (Typic Torripsamment) containing 0.36 ppm DTPA extractable Zn. Wheat cv WH-147 was grown in polythene lined earthern pots filled with 4 kg air-dried sandy soil, at 9 levels of added Zn i.e. 0.50, 1.25, 2.5, 5, 7.5, 10, 20, 40 and 100 ppm supplied as Zn SO4. 7H2O and with 9 replications. The soil had the following characteristics:

pH 8.3 EC 0.26 ms/cm, $CaCO_3$ trace, organic carbon 0.05%, available N, P and K, 31.0, 4.2 and 63.0 ppm, respectively. Its sand, silt and clay fractions were 93, 3 and 4%, respectively. Each Zn treatment was uniformly provided with a basal dose of N, P and K @ 100, 50 and 50 ppm and that of Mg, Fe, Mn and Cu @ 10, 5, 5, and 1 ppm respectively. All the chemicals used were of analytical grade. The pots were irrigated with distilled water.

Three replicates selected at random from each treatment were harvested at the tillering stage. At second sampling, two whole plant tops at the boot stage were cut at the ground surface and from the rest of the plants, younger, middle and older leaves and stem were collected separately. Likewise, the remaining three replicates were harvested at earing stage. The harvested plant parts were washed successively in acidified distilled and redistilled water. The excess water was removed by gently shaking and plant samples were kept in paper bags for air-drying and oven drying at 60-70 C for 72 h. After recording the dry matter yields, the samples were ground in a wiley mill with stainless steel interior. Zn was estimated in acid digests of various plant samples on a Varian Techtren atomic absorption spectophotometer.

RESULTS & DISCUSSION

In order to estimate the critical levels of Zn in various plant parts of wheat at different stages of growth, total dry weight of tops versus Zn in plant parts were plotted (Fig. 1). The critical Zn levels were determined by the empirical approach with physiological considerations where the Zn level in leaves and shoot was related to dry weight of tops. The lower critical concentration or the critical deficiency level has been defined by Ulrich & Hills (1973) as the nutrient concentration in the tissue associated with a 10 per cent reduction in growth from maximum due to deficiency. However, other terminology for lower critical deficiency

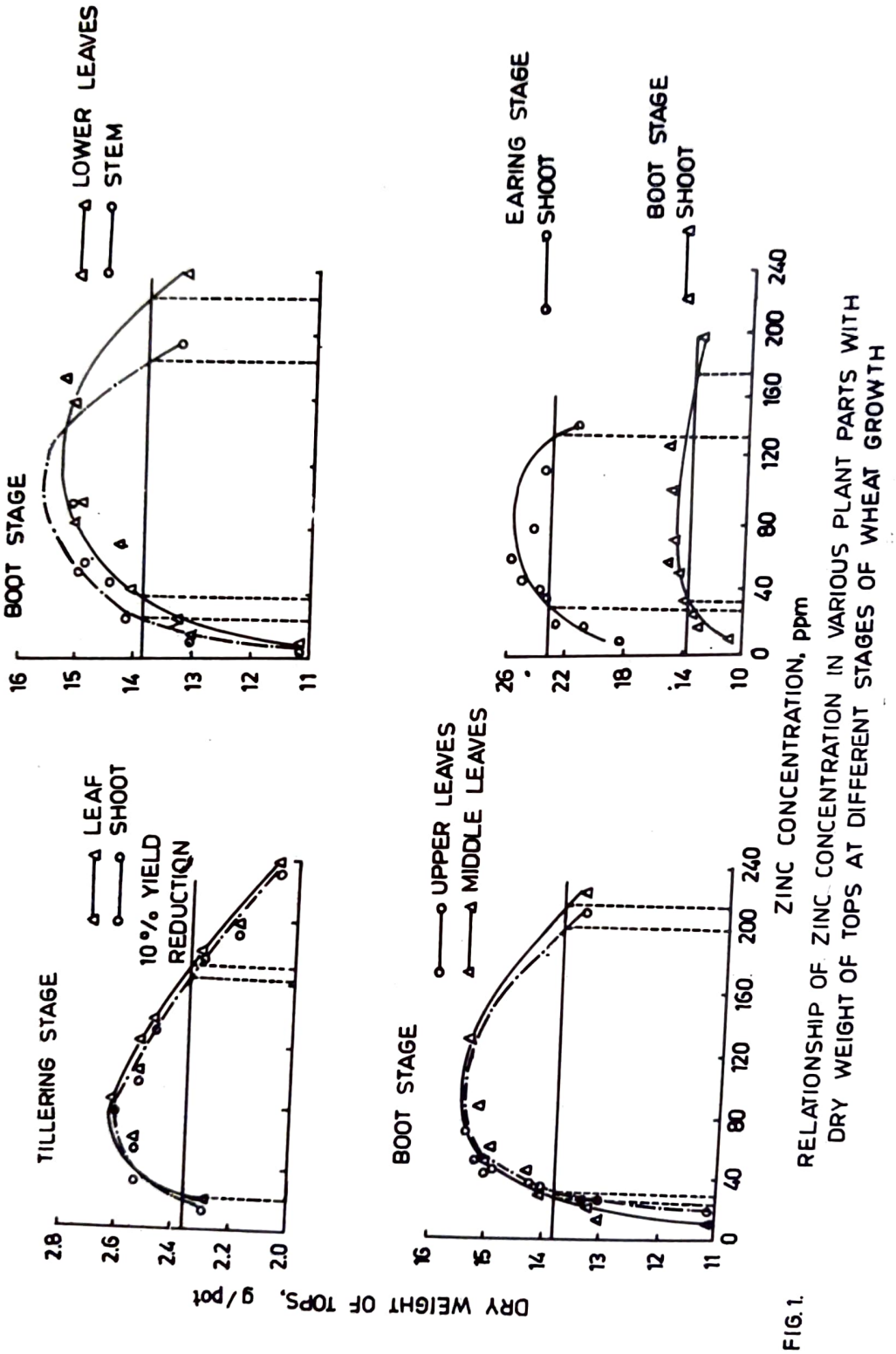

FIG. 1. RELATIONSHIP OF ZINC CONCENTRATION IN VARIOUS PLANT PARTS WITH DRY WEIGHT OF TOPS AT DIFFERENT STAGES OF WHEAT GROWTH

levels has been reported such as deficient range (Jones, 1967), critical composition value (Melsted *et al.*, 1969), and sufficiency range (Small & Ohlrogge, 1973). The upper critical concentration or the critical toxicity level as an extension of the above concept has been defined by Ohki and Ulrich (1977) as the nutrient concentration in the tissue associated with a 10 percent growth reduction from the maximum due to toxicity.

The critical Zn deficiency levels for leaf and shoot Zn was about 25 ppm (Fig. 1) in relation to dry weight of tops at tillering stage of wheat growth. The critical Zn toxicity levels for leaf and shoot was about 155 and 160 ppm, respectively.

The critical Zn deficiency levels for upper, middle and lower leaves, stem and whole shoot were 34, 30, 36, 24 and 32 ppm respectively, in relation to dry weight of tops at boot stage. The corresponding critical Zn toxicity levels were 105, 216, 235, 210 and 215 ppm, respectively. The deficiency and toxicity critical limits for shoot Zn concentration were about 21 and 126 ppm at earing stage of growth.

The critical Zn levels for deficiency and toxicity at tillering stage for both leaf and shoot were 25 and 160 ppm, respectively, on dry weight basis, indicating that any one of these plant parts sampled would reflect equivalent Zn status of the wheat. A quite high value of 36 ppm has been reported for middle leaves at tillering stage of wheat (Agarwala *et al.*, 1977). Further, 18 ppm Zn in third leaf of wheat taken from top of the plants was found critical value by Rathore *et al.* (1978) below which response to applied Zn was expected. Therefore, it is evident from the present study that responses to applied Zn would be expected when Zn concentration in the leaf or shoot of wheat was less that 25 ppm, sampled at tillering stage of growth. Growth reduction also resulted when Zn level was higher than 160 ppm due to toxicity.

The results from this investigation also indicated that the critical Zn deficiency level related to top dry weight were greater for the lower leaves than for the other plant parts when sampled at boot growth stage. Sampling from middle leaves at boot growth stage would enable in appropriate sampling for tissue analysis to evaluate the Zn status. The Zn concentration of the sample, can then be compared with the critical deficiency level of 30 ppm to determine if plants are deficient or not. This value is higher than 18 and 20 ppm critical levels reported in earlier studies (Rathore *et al.*, 1978 and Shukla & Raj, 1974) and nearly identical to the 29 ppm critical value established by Sakel *et al.* (1981) for wheat. There is good agreement from several studies (Malsted *et al.*, 1969 and Ward *et al.*, 1973) indicating that 15 ppm is a representative critical Zn level but it varies with cultivars, seasons and soils.

As older tissues were sampled during the later period of growth, Zn concentration decreased with a resultant fall in the critical concentration which was 21 ppm. Essentially the same critical Zn level for 60 days old wheat plants has been proposed by Bansal & Sekhon (1976).

Information on Zn toxicity values in plants is scanty. The critical toxicity level in leaf and shoot was 160 ppm at tillering stage of growth. Similarly, critical toxicity levels for shoot Zn at boot growth and earing stages can be set at 215 and 126 ppm, respectively. The maximum concentration for sufficiency as reported by Ward *et al.* (1973), for wheat was 70 ppm whereas Keisling *et al.* (1977) obtained tentative critical toxicity value of 220 ppm for tissue analysis. Therefore, the present critical toxicity level (160 ppm) is between the upper sufficiency value and toxicity level indicating that the 160 ppm is a reasonable estimate for the critical toxicity level for wheat at tillering stage of growth.

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