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BORON NUTRITION OF FIELD-GROWN SUNFLOWERS

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INTRODUCTION

With the increasing interest in sunflower seed production, factors affecting the growth of this crop have been subjected to increasing scrutiny. Fertilization is one aspect of crop production that can be regulated by the farmer to effect increased yields. But as yields increase and the major nutrient requirements are more efficiently met through macronutrient fertilization, micronutrient deficiencies are more likely to become limiting for production. Boron is one such element in sunflower production since sunflowers have an apparently high boron requirement (Schuster and Stephenson, 1940).

In spite of the apparently high B requirement of sunflowers, there has been relatively little information on the B requirements of the field-grown crop. Bradford (1966), in an extensive review on the B nutrition of plants, cited only one glasshouse study (Tanada and Dean, 1942) where sunflower seedlings showing B deficiency symptoms contained from 8 to 23 μg/g B in the tops while, in the same study, 12 to 150 μg/g B indicated an adequate supply.

During recent years, further research has been conducted on the effect of boron on crop growth, and it is the aim of this paper to review information relating to the B nutrition of sunflowers with emphasis on the field-grown crop.

BORON DEFICIENCY SYMPTOMS

Although the exact role of B in the plant has not been conclusively elucidated, a shortage of B has been shown to adversely affect

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the meristematic region of the plant as well as the plant's reproductive capability. In field trials, Blamey (1976) described B deficiency symptoms in the mature plant. Although symptoms of B deficiency similar to those described by Schofield, Wilcox and Blair (1940) were recorded in severe cases in sunflower seelings, the extent of the severity of B deficiency was only evident when the plants reached the flowering stage. At this stage, symptoms of B deficiency were described as a hardening, malformation and necrosis of the upper leaves. In affected plants, the peduncle had a corky appearance, and subsequent observations have led to the conclusion that this corkiness led to a high proportion of heads breaking off. Malformations of the flower head were observed where no B fertilizer had been applied and this malformation affected the dried capitulum. This deformation of the flower head resulted in areas of no seed set which appeared to be the cause of the low seed yields in the absence of B fertilization. The poor yields did not appear to be as a result of inefficient metabolism in the vegetative stage.

Drought has been found to decrease B uptake by plants, and thus increase the severity of B deficiency. In sunflowers, Blamey, Mould and Chapman (1979) found B deficiency symptoms to be more severe in a drier season. Shatilov and Ikonnikov (1969) found that B applications to sunflowers decreased the harmful effects of drought on pollen viability, the fertilizing capacity of the pollen, and decreased the percentage empty achenes. Blamey (1976) also found a reduction in the percentage empty achenes to result from the application of B to the field-grown crop.

In pot experiments, sunflowers grown on soils containing 0,39 μg/g B contained 13-31 μg/g B and exhibited B deficiency symptoms (Majewski and Janiszewska, 1970). In field-grown sunflowers, Blamey, Mould and Nathanson (1978) were able to relate the percentage deformed heads to the B concentration in the seedlings and in the topmost mature leaf. The latter tissue appeared the more reliable as index tissue, and 29 and 57 μg/g B in the leaf corresponded with 10 and 5% deformed heads.

Below 29 μg/g B, deficiency symptoms increased markedly in severity, and above 57 μg/g B there was no appreciable further reduction in the percentage deformed heads.

Sunflower cultivars have also been found to vary in the severity of B deficiency symptoms exhibited. In six-week-old seedlings of two cultivars of similar B-uptake ability, Smena ans SO 320, 13% of the Smena seedlings exhibited B deficiency symptoms whereas 35% of the SO 320 seedlings were affected (Blamey, Chapman and Mould, 1978).

UPTAKE AND RESPONSE TO APPLIED BORON

It has been proposed that B moves passively in the transpiration stream (Kohl and Oertli, 1961; Oertli and Roth, 1969) which accounts for the increased severity of B deficiency with limiting moisture supply. Although this may be so, it appears that it is the roots which govern B absorption (Eaton and Blair 1935).

Sunflowers, in common with other crops, have shown the ability to absorb markedly different amounts of B from different soil types to which the same quantities of B had been applied. Blamey *et al.* (1979) found that an application of 1 kg B/ha to the Doveton (38% clay in the A horizon) and Avalon (13% clay in the A Horizon) soils increased the B concentration in the topmost mature leaf at flowering by 9 and 31 g/g B, respectively. In keeping with this finding, the optimum rate of B fertilization was appreciably lower on the Avalon than on the Doveton soil.

It is significant to note that sunflower cultivars have been found to vary markedly in their ability to absorb B from a soil low in boron (Blamey *et al.* 1978). On this soil, the 16 cultivars tested were found to contain between 14 and 23 g/g B in the topmost mature leaf. After fertilization with 2 kg B/ha, differences were also recorded, the cultivars containing from 23 to 34o g/g B in the topmost mature leaf.

In a pot experiment conducted in the U.S.S.R. with soils containing from 0.04 to 1.02 μg/g B, Majewski and Janiszewska (1970) found that only in soils with a pronounced B deficiency did B application increase sunflower yields. In field-grown sunflowers in South Africa, marked responses to applied B have been recorded. Blamey (1976) reported a 38% seed yield increase resulting from the application of 1 kg B/ha. In the subsequent two seasons (unpublished data) seed yield increases of 18% and 20% were recorded. In three trials on two different soils, Blamey *et al* (1979) reported seed yield increases of an average of 48%. Results of a subsequent season (unpublished) have indicated seed yield increases of up to 116% due to the B fertilization of a sunflower cultivar sensitive to B deficiency.

By relating sunflower seed yield to the B concentration in the topmost mature leaf at flowering, Blamey *et al.* (1979) were able to establish the critical B concentration in this tissue as 34 μg/g. Below this concentration, seed yield was increased by an average of 13% for each 10μg/g increase in B concentration in the leaf.

In order to correct B deficiency in crops, B may be applied to the soil or as a foliar spray. Because of the immobility of B in the plant, corrective B treatments for annual crops are usually applied to the soil. But Volkov (1970) found that spraying sunflower plants with boric acid and succinnic acid increased yields by 11 to 13%. The germination of seeds from plants sprayed with boric acid was greatly increased.

BORON TOXICITY

With many micronutrients there may be a narrow range between tissue concentrations indicating a deficiency and levels which are toxic to plant growth. Eaton (1944) found this to be applicable to the B nutrition of many plant species and, in fact, symptoms of B toxicity were recorded in many species at concentrations less than that required for optimum growth. Sunflowers, however, may be regarded as semi-tolerant to high levels of B in irrigation water, tolerating up to 2 μg/g B (Wilcox and Durum, 1967). But concentrations of 2 μg/g N or more in the irrigation water may be detrimental to the growth of sunflowers grown in pots (Pathak, Singh and Singh, 1975).

In a study on the effects of excess B on sunflower growth, Scott (1960) found three distinct regions in sunflower leaves suffering from excess B. In the apparently normal central region of the leaf, tissue concentrations of 807 μg/g B were recorded. In the outer part of the leaf where severe chlorosis and necrosis were observed, tissue concentrations of 2,177 μg/g B were recorded. Tissue concentrations of 1,110 μg/g B were recorded in the region between these two areas.

As indicated by Blamey *et al.* (1979), B concentrations in the leaf below 34 μg/g may be regarded as insufficient for the normal growth of sunflowers. In this study, tissue concentrations of up to 160 μg/g B in the leaf were not detrimental to growth, and further studies (unpublished) have indicated that concentrations of up to 250 μg/g B in the leaf have not been toxic to the growth of sunflowers in the field.

Thus, it appears that in contrast to many other plant species, sunflowers do not have a narrow range between deficient and toxic concentrations of B in the plant tissue.

CONCLUSIONS

As sunflower production spreads to areas of lower native fertility than the traditional production areas of the Northern Hemisphere, nutrient deficiencies in the field-grown crop are likely to become more prevalent. Furthermore, as the macronutrient requirments are more efficiently met, micronutrient deficiencies are more likely to become limiting. Sunflowers have a high boron requirement and dificiencies of this essential nutrient have been recorded over wide areas in South. Africa. Boron deficiency symptoms were identified and described in the field-grown crop, and yield increases due to applied boron varied from 18 to 166%. The critical B concentration in the topmost mature leaf at flowering was found to be 34 μg/g. Concentrations of up to 250 μg/g B in this tissue were not toxic to sunflower growth in the field. Although sunflowers are apparently insensitive to excess B applications, care should be exercised in applying B fertilizers because of other crops, possibly sensitive to B toxicity, grown in rotation with sunflowers.

ABSTRACT

Boron deficiency has been recorded in field-grown sunflowers in many areas of South Africa. Deficiency symptoms were identified as a necrosis and hardening of the leaves, a corkiness of the peduncle and a malformation of the capitulum. Yield increases of over 40% resulted mainly from the effects of B fertilization on reproductive performance. The critical B concentration, below which seed yields were markedly reduced, was established as 34 μg/g in the topmost mature leaf at flowering. Sunflower cultivars varied markedly in their ability to absorb B from the soil resulting in marked differences in cultivar response to applied B. Sunflowers appeared realatively insensitive to B toxicity.

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