

Responses of Wheat to Zinc Fertilization in Some Calcareous Soils of Iran

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INTRODUCTION

Zinc deficiency limits wheat production in some countries, including Australia (Rengel and Graham 1995), India (Sharma and Lal 1993) and Turkey (Cakmak et al. 1996). Usually, Zn- deficiency problems exist in calcareous soils of arid and semi-arid regions. Most of the soils in Iran are highly calcareous and deficient in Zn. Crops grown under such deficient conditions have low yield and produce seeds with a low Zn content. Wheat (*Triticum aestivum* L.) is the most strategic crop in Iran. It is the main staple crop and supplies more than 45% of the protein and 55% of the caloric requirement in humans. Despite a domestic production of 11 million tons a year, Iran is an importer of wheat. Zinc plays a major role in wheat production (Kashirad 1970, Rengel and Graham 1995, Cakmak et al. 1997, Yilmaz et al. 1997). Positive effects of Zn application on growth of corn have been reported for calcareous soils in Southern and central Iran (Makakouti et al. 1992, Karimian 1995). There is little information about the micronutrient nutrition of wheat available for Iranian soils. The purposes of this investigation were to determine i) the effects of Zn fertilization on yield and grain quality of wheat, and ii) critical Zn-levels in highly calcareous soils.

METHODS

To study the effects of Zn fertilization on wheat production, a greenhouse experiment was conducted in selected highly calcareous soils in Iran. Soil were sampled at 25 sites in the province of Fars. Selected physico-chemical soil properties are presented in Table 1.

Table 1. Ranges and Means of selected soil properties.

Soil Characteristic	Range	Mean
P available (mg kg ⁻¹)	5.0 – 41.0	17.2
K available (mg kg ⁻¹)	120 – 536	289
Zn available (mg kg ⁻¹)	0.44 - 1.65	1.04
Organic carbon content (%)	0.3 – 1.7	0.8
Clay (%)	24 – 46	34
Calcium carbonate equivalents (%)	31 – 49	38
CEC (cm kg ⁻¹)	12.0 – 21.5	16.6
pH	7.1 – 8.1	7.8

In a randomized complete design with three replications, 0 and 10 mg kg⁻¹ Zn were applied as ZnSO₄ to 5-kg soil to each pot. Fifteen wheat seeds were planted in each pot, and the number of seedlings was reduced to eight after 2 weeks. The above-ground parts of four plants were removed at the soil surface after 8 weeks. The plant samples were cleaned and dried. The dried samples were weighted and analyzed for selected elements. After 168 days, the above-ground parts of the four plants remaining in each pot were harvested. The weight of straws and grains was measured analyzed for selected elements separately. The critical limits were calculated based on Cate & Nelson (1965). To statistically analyse the data, F

tests and Least Square Different tests were performed and regression equation were developed using MSTATC computer programs.

RESULTS AND DISCUSSION

The results indicated that an application of ZnSO₄ increased dry matter, total and grain yield significantly. Wheat grain yield is a function of the number of spiklet per m², number of grains per spiklet and the weight of 1000 grains. Thus, factors that can affect these parameters could change grain yield. The results showed that Zn application resulted in a significant increase in the number of grains per ear and in the weight of 1000 grains. The results also show that Zn concentrations and total uptake in shoots and grains increased significantly with Zn supplements. These results are in agreement with Yilmaz et al. (1997) and Agrawal (1992). In addition, Zn application resulted in a significant increase in protein content. Marschner (1995) reported that Zn-deficient plants reduce the rate of protein synthesis and protein content drastically but increase the accumulation of amino acids. Marschner (1995) believed that enhanced rates of Ribonucleic Acid (RNA) degradation were due to higher rates of RNase activity. Based on the DTPA extraction, the critical Zn level was 0.74 mg kg⁻¹. Based on Agrawal (1992), critical limits of DTPA-extractable Cu, Zn, Fe and Mn were 0.78, 0.80, 5.0 and 5.5 mg kg⁻¹ soil, respectively. Regression equations show that soil characteristics, especially Calcium Carbonate Equivalent (CCE), affected plant responses significantly. In general, the combination of high pH, CaCO₃ and clay in soils with a low annual precipitation can be considered as major factor causing micronutrient deficiencies, especially Zn, in plants grown in these soils.

Table 2. Mean wheat responses to micronutrients.

Plant Responses	Control	Control + Zn	% increase	LSD 5%
Grain yield (g pot ⁻¹)	7.1	8.3	+17	0.8
Grain-Zn concentration (ug g ⁻¹)	17.5	39.8	+127	3.4
Zn uptake by grains (ug pot ⁻¹)	127	325	+153	29.9
Grain protein concentration(%)	11.6	13.1	+13	0.9
Weight of 1000 grain (g)	44.0	48.4	+10	2.6
No. of grains in spiklet	32.6	35.8	+10	4.0
Total yield (g pot ⁻¹)	18.2	20.8	+14	1.2
Dry matter yield (g pot ⁻¹)	11.1	12.5	+13	0.8
Leaf-Zn concentration (ug g ⁻¹)	15.3	28.8	+88	2.4
Zn uptake by leaves (ug pot ⁻¹)	170	361	+112	31.7

ns : no significant, *: Significant in 5% Statically, **: Significant in 1 % Statically.

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