Relationship among Zinc Deficiency, Cyst Nematodes Population and Wheat Yield in Calcareous Soils

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INTRODUCTION

Zinc deficiency seems to be the most critical micronutrient deficiency in crop production and human nutrition. Millions of hectares of cultivated soils in Iran are affected by Zn deficiency (Alloway 2004). Wheat (*Triticum avestium* L.) is important in improving daily calorie intakes in the developing world, but the crop is inherently low in micronutrients such as Zn due to imbalanced fertilization practices, high pH, low organic matter, and high calcium carbonate and bicarbonate in the irrigation water (Cakmak et al. 1996, Davoudi et al. 2001). Zinc is important for the stability of biological membranes (O'Dell et al. 1984). Plants with balanced fertilization have the highest resistance to infectious diseases (Marschner 1993). Wheat yield is low in arid and semi-arid regions. One hypothesis is that membranes of Zn-deficient plants leak carbohydrates and amino acids (Graham and Webb 1994). Thus, pathogen populations, especially nematodes, increase in the rhizosphere of Zn-deficient plants. Although Zn has been known to be an essential plant nutrient since the 1920s, little work has been done on the effect of Zn deficiency on plant susceptibility to cereal cyst nematodes such as *Heterodera avenae*. This nematode is the most commonly recorded species of importance to cereals and has been associated with economic damage, especially in sandy soils (Nicol 2002). The aim of this study was to investigate the relationships between available soil-Zn, cyst nematode populations (*Hetereodera avenae* Woll.) and wheat grain yield in irrigated or rainfed calcareous soils.

MATERIALS AND METHODS

Twenty wheat growing fields in West Azerbaijan and 12 fields in Yazd province were selected randomly in the late spring of 2006 to test the effect of available soil-Zn on cyst nematode populations and wheat grain yield. Soil samples, including samples from the rhizosphere of wheat plants, were taken during the flowering stage of wheat, when cyst nematode populations were maximized. Cyst nematodes of the samples were separated following the Fenwick Can method and counted. The available Zn in soils was measured in 0.005 M DTPA extracts. Other soil properties (Tables 1) were determined by standard methods as recommended by the Soil and Water Research Institute.

RESULTS AND DISCUSSION

The results for soil analysis, cyst nematode populations and wheat yields are shown in Tables 1 and 2. Relationships between available Zn concentrations and cyst nematode populations, cyst nematode populations and yield, and available Zn concentrations and yield were determined (Fig. 1 a,b,c). There was no significant relationship between cyst nematode population, available soil-Zn concentrations and wheat grain yield in West Azarbaijan and in Yazd.

Table 1. Characteristics, Fe and Zn concentration, cyst nematode population and yield of West Azarbaijan soils.

Field Number	Field condition	pH	O.C %	T.N.V %	Clay %	Fe mg kg^{-1}	Zn mg kg^{-1}	Cyst nematode 100gsoil	Grain yield ton ha^{-1}
1	irrigated	8.1	0.58	14.4	16	6.82	0.26	10	4
2	irrigated	8.6	1.78	20.1	34	10.5	0.56	1	4.5
3	rainfed	8.2	0.17	4.2	8	6	0.1	0	1
4	rainfed	7.8	0.91	3.7	14	5.64	0.18	3	3
5	rainfed	7.8	0.81	15.7	28	4.96	0.64	0	3
6	rainfed	7.7	0.52	24.4	32	4	0.58	10	1.5
7	rainfed	7.7	1.29	8.7	29	8.4	0.38	0	2
8	rainfed	7.6	1.7	8.2	36	9.86	0.98	3	3.5
9	Rainfed	7.7	1.29	6.5	49	13.5	0.42	0	4.5
10	irrigated	8.1	2.22	30.1	44	20.48	0.54	1	7
11	irrigated	8.1	1.2	13.2	28	9.64	0.64	0	6
12	irrigated	7.9	1.41	6.5	31	14.24	0.64	1	6.5
13	irrigated	8	1.49	24.1	49	16.38	0.1	5	6
14	irrigated	7.5	1.16	3.2	25	31.06	1.08	2	7
15	irrigated	7.5	1.12	4.7	27	9.96	0.46	6	4.5
16	irrigated	7.6	0.12	6.2	24	3.4	0.88	10	4.7
17	rainfed	7.8	0.46	6.5	10	4.3	0.2	0	2.5
18	irrigated	7.8	1.25	7	24	20.56	1.42	1	4
19	rainfed	7.6	2.03	7.7	27	9.92	1.4	1	3.5
20	rainfed	7.7	1.31	8	40	8.58	0.36	0	3.5

Table 2. Wheat grain yield, Zn concentration and cyst nematode population in fields of Yazd province.

Field No.	Grain yield (ton ha^{-1})	Zinc conc. (mg kg^{-1})	Cyst nematode pop. (100 g soil)
1	6.0	0.06	3
2	5.0	0.12	7
3	7.0	0.14	5
4	5.5	0.06	0
5	6.0	0.12	2
6	5.0	3.58	0
7	5.0	0.74	0
8	4.5	0.14	8
9	3.5	0.66	4
10	3.0	0.5	5

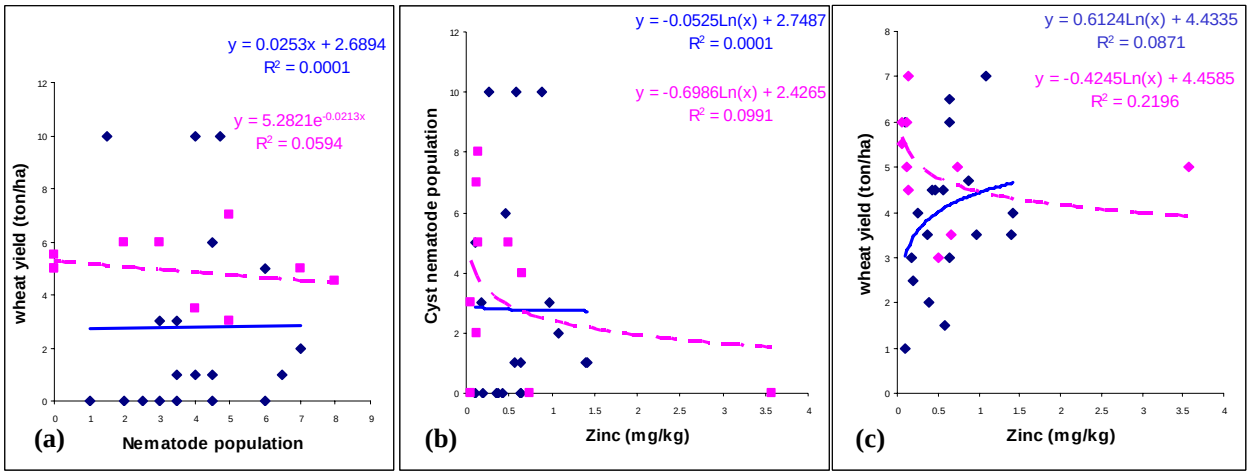

Fig. 1. (a) Nematode population and wheat yield (b) Available Zn and nematode population (c) Available Zn and wheat yield in Azarbaijan (line) and Yazd (dots).

CONCLUSIONS

A positive relationship between Zn deficiency, cyst nematode population and wheat grain yield was not found in the studied calcareous soils. There might be other factors that affect the wheat grain yield. An experiment under controlled condition with different levels of Zn and cyst nematode population will be conducted in the near future.

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