Effect of tillage system and nitrogen on micronutrient uptake by wheat and weeds grown in a calcareous soil

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Summary Micronutrient deficiencies limit wheat production in calcareous soils in the southern Iran. A field experiment was conducted to compare micronutrient uptake by wheat (*Triticum aestivum* L. cv. Chamran) and weeds grown under different tillage systems and nitrogen levels in a calcareous soil. The concentration of micronutrient (Fe, Cu, Mn and Zn) in both the crop and weeds increased under conservation tillage systems compared to the conventional tillage. Nitrogen had a significant ($P < 0.05$) and positive effect on micronutrient uptake by the crop and weeds under all tillage systems. The results of this study suggest that conservation tillage systems (minimum and no tillage) facilitate micronutrient uptake for both the crop and weeds. However, for the micronutrients examined in this study, weeds were better accumulators of micronutrients than the wheat.

Keywords Micronutrient, minimum tillage, no tillage, conventional tillage, weeds.

INTRODUCTION

Tillage systems affect the physical, chemical and biological properties of the soil and hence the growth and development of crops and weeds in agroecosystems. While micronutrient deficiencies, and especially of Fe and Zn, are serious problems of calcareous soils of Iran (Najafi Ghiri *et al*. 2013), the tillage system may mitigate this problem. Stanisławska-Glubiak and Korzeniowska (2009) concluded that the concentrations of Cu, Zn, Mn and B were higher in the aerial parts of lupin and peas grown in conventional tillage system than in no tillage system. However, under drought conditions these concentrations were higher in plants in the no tillage system. Mahler *et al.* (1985) concluded that tillage affected DTPA-extractable Fe and Mn levels in northern Idaho soils, as the surface 30 cm of conventional and minimum tillage plots contained greater amounts than no till plots. Research shows that even a reduction in tillage leads to increased chemical, microbial activity and biomass in contrast to soils under conventional tillage (Feng *et al*. 2003). Santiago *et al*. (2008) found that Mn, Cu, and Zn in plants were all higher under no tillage than under conventional and minimum tillage systems. The difference was related to the increase in soil organic matter in the no tillage systems.

In conventional tillage and conservation tillage systems, nitrogen (N) fertilisation is also a factor that can modify soil quality and fertility thereby affecting the uptake of micronutrients by the crop and weeds. Hao *et al*. (2007) indicated that the concentrations of Fe, Mn, Cu, and Zn in brown rice (*Oryza sativa*) increased at first and then decreased with increasing N fertiliser application, reaching the highest levels at 160 kg N ha^{-1} application. However, N supply had no influence on the concentrations of Mn, Zn, Cu, and Fe in the ear leaf of maize (*Zea mays* L.); except for the Mn concentration, which increased as the N fertilisation rate increased up to 150 kg N ha^{-1} (Ogunlela *et al*. 1988).

The aim of this study was to examine the effects of tillage systems (conventional and conservation tillage systems), and nitrogen, on the uptake of micronutrients by a wheat crop and associated weeds in a calcareous soil.

MATERIALS AND METHODS

The experiment was carried out using a strip plot design with three replicates in a calcareous soil in southern Iran at Darab Faculty of Agriculture and Natural Resources in the 2011–2012 growing season. The treatments were a factorial combination of three tillage systems; conventional (CT), minimum (MT), and no tillage (NT) and five nitrogen levels (0, 50, 100, 150, and 200 kg N ha^{-1}). The plot size was 3 m × 6 m. The source of nitrogen was urea fertiliser containing 46 % nitrogen. The nitrogen was added to the experimental plots during three different wheat-growing stages: planting, jointing and ear emergence.

To measure micronutrients uptake in the crop and weeds, shoots of the crop and weeds were collected from two locations in each plot using a 1 m × 1 m quadrat. The dominant weeds were common fumitory (*Fumaria officinalis*), ryegrass (*Lolium rigidum*), wild safflower (*Carthamus oxyacantha*), wild oat (*Avena fauta*), wild barley (*Hordeum spomtaneum*) and some *Brassica* species. The crop and weed samples were then oven dried at 70°C for 72 hours. Total nitrogen

was determined by micro Kjeldahl method (Kjeldahl 1883). The concentrations of Zn, Cu, Mn, and Fe in the shoots of wheat and weeds were determined according to method of Lindsay and Norvell (1978) by adding 20 mL 0.005M diethylentriaminepentacetic + 0.1M triethanolamine + 0.01M $CaCl_2$ (pH 7.3) to 10 g soil. The solutions were shaken for 2 h at 25°C, centrifuged, filtered, and Fe, Mn, Zn, and Cu concentrations measured by an atomic absorption spectrophotometer (AAS; PG 990, PG Instruments Ltd, UK).

Statistical analysis was performed using SPSS software (v. 15). A comparison of means was performed using Duncan's Multiple Range Test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Results indicated that Fe concentration in wheat shoots increased significantly ($P < 0.05$) from 136 mg kg^{-1} under conventional tillage to 144 and 171 mg kg^{-1} under minimum and no tillage systems, respectively (Table 1). The same increasing trend with a reduction in tillage was also observed for Zn, Mn and Cu.

Micronutrient concentrations in weed shoots were also affected by the tillage system (Table 2). The concentrations of Fe, Mn, Cu, and Zn increased significantly ($P < 0.05$) in weed shoots when grown under minimum tillage and also under no tillage systems, compared to the conventional tillage system. In fact, it appears that weeds competed with crops for available micronutrients, especially in micronutrient deficient soils. A comparison of the micronutrient contents in wheat and weed shoots (Table 1 and 2) indicated that the uptake of micronutrients was greater in the weeds than wheat which is consistent with Qasem (1992). This shows how weeds compete with crops for available micronutrients, which may have an adverse impact on wheat performance especially in micronutrient deficient soils.

Nitrogen had a significant ($P < 0.05$) and positive effect on micronutrient uptake for both the crop and weeds under all tillage systems. However, the weeds accumulated more micronutrients than the crop for all rates of nitrogen applied (data not shown). The concentration of Fe in wheat and weed shoots as affected by nitrogen level is shown in Figure 1. This may be due to the effects of nitrogen on organic matter mineralisation and the release of micronutrients and/or an increase in the growth of root system and its activity and effect of NH_4^+ on rhizosphere reaction. This is in agreement with findings of Shi *et al.* (2010) who concluded that N fertilisation (130, and 300 kg N ha^{-1}) increased Fe, Zn, and Cu density in wheat grain compared to the control (0 kg N ha^{-1}).

The application of conservational tillage systems may increase the growth of both wheat and weeds in cropping systems where a micronutrient deficiency exists in the soil. Our results also show that a better understanding of the interacting effects of tillage systems and nitrogen on micronutrient uptake by weeds and the crop could improve the ecological management of weeds in agroecosystems.

Table 1. Micronutrient concentrations in wheat in three tillage systems. CT= conventional tillage, MT=minimum tillage and NT= no tillage.

Tillage systems	Micronutrient concentration (mg kg^{-1})			
	Fe	Zn	Mn	Cu
CT	136b	22c	44c	6.4c
MT	144b	25b	46b	7.4b
NT	171a	29a	49a	8.4a

Table 2. Micronutrient concentrations in weeds in three tillage systems. CT= conventional tillage, MT=minimum tillage and NT= no tillage.

Tillage systems	Micronutrients concentration (mg kg^{-1})			
	Fe	Zn	Mn	Cu
CT	201c	32c	85c	10.9c
MT	226b	35b	95b	13.0b
NT	266a	39a	114a	15.0a

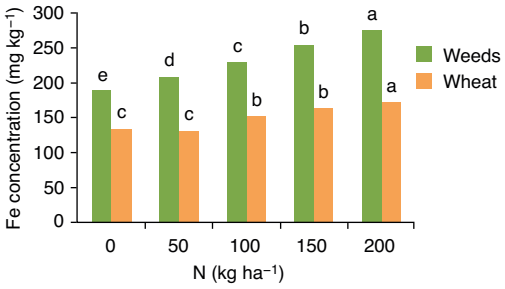

Figure 1. The effect of nitrogen (N) application on iron (Fe) concentration in wheat and weeds.

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