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The Effect of Arbuscular Mycorrhiza Fungi on Iron and Manganese Concentration of Berssem Clover by Cadmium Stress

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ABSTRACT: In this study, a factorial experiment was performed in completely randomized design (CRD) with three factors: arbuscularmycorrhizal fungi with two levels (inoculated and non-inoculated soil) and cadmium with six levels (0, 5, 10, 20, 40 and 80 ppm). The results showed that effect of cadmium levels on iron and manganese concentration was significant in one percent level of statistical. In80 ppm cadmium concentration in soil, a reducediron were on concentration of Iron (39% and 53%) and manganese (48% and 48.5%) in root and aerial respectively. Butarbuscularmycorrhiza fungi increasediron concentration 30.2% and 26.7% in theroot and aerial, and manganese concentration36% and 30.9% in root and aerial plant respectively.

KEYWORDS: Arbuscularmycorrhiza,Soil contamination**,** Cadmium

INTRODUCTION

Soil contamination with heavy metals represents a potential risk to the biosphere and leads to increase concentration in the ground or surface water; therefore metals mobility in soil has been extensively studied in the last decades [1]. Human activities have resulted in soil pollution, which has led to adverse ecological impacts [2]. In China, about 20 million hectares of farmland has been contaminated by metals, and 12 million tonnes of grains have been polluted by metals each year [3].Use of agrochemicals such as synthetic fertilizers and pesticides has resulted into soil and water pollution, and loss of biodiversity [4]. Toxic heavy metal contamination in soils and crop plants is of major importance due to their health effects on humans and other animals [5]**.** Cadmium is a heavy metal with a strong effect on crop quality. Moreover, it is a very mobile element in the environment. Plants can easily uptake cadmium and transfer it to other organs [6]. Experiments on the effect of cadmium on contents of macro elements in plants are scarce and therefore the mechanism of its effect has not yet been fully explained [7]. Contaminated soil can be remediated by chemical, physical or biological techniques [8]. Immobilization of inorganic contaminants is also a possible strategy [9]. Immobilization can be achieved by complexing the contaminants [10]. Mycorrhiza is the mutualistic symbiosis (non-pathogenic association) between soil-borne fungi with the roots of higher plants [11].

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active agent was prepared by the Plant Protection Clinic in Iran – Hamedan.

Sample preparation and treatments

Soil fromarable land was collected at a depth of 0-20 cm in University of Zanjan. After a complete soil analysis, 6 kg of soil were weight for each pot and then the soil was contaminated. Cadmium sulfate salt was used to contaminate soil samples with different amounts. The salt was dissolved in distilled water and sprayed on the soil. After drying the soil, 150 grams of mycorrhizal fungi inoculant was mixed with the soil, after mixing the soil with mycorrhizal fungi, Put the soil in.0.5 gram of clover seeds was disinfected with 10% hydrogen peroxidesolution. The plant was watered with distilled water during the experiment. After 70 days, plant aerial and roots were harvested, washed with distilled water and dried in the oven for 72 hours.Plant samples were grinded and digested to measure iron and manganeseconcentration in samples.

Arbuscularmycorrhizal fungi are obligate biotrophs, which can form mutualistic symbioses with the roots of around 80% of plant species [12]. Many workers have reported enhancement of phosphate uptake and growth of leguminous plants by vesicular arbuscularmycorhizal fungi [13].

MATERIALS AND METHODS

Time and place of experiment

The experiment was conducted under greenhouse condition in the Agriculture Faculty of Zanjan University, Iran. A factorial experiment was performed in completely randomized design (CRD) with three factors: arbuscularmycorrhizal fungi with two levels (inoculated and non-inoculated soil) and cadmium with six levels (0, 5, 10, 20, 40 and 80 ppm). Each treatment was replicated three times. The mycorrhizal inoculant containing Glomusmosseae as

Table 1.Chemicalandphysicalpropertiesofsoil

Soil depth	EC	pH	Soil texture	N	P	K	Cd	Fe	Mn
cm	**dsm^{-1}**			**%**			**(ppm)**		
1-20	2.3	7.27	Sandy loam	o.19	21	224	1.2	0.4	1.4

According to analysis of variance table [2], the effect of cadmium levels on iron and manganese concentration was significantin one percent level of statistical. With increasing cadmium concentrations in soil, iron and manganese concentration reduced in root and aerial plant (Figures 1 and 2). 80 ppm cadmium concentration in soil reduced diron concentration 39% and 53%. and manganese concentration48% and 48.5% in root and aerial and respectively.

STATISTICAL ANALYSIS

Data were analyzed with SAS (version 9) and MSTATC (version 2.10) software, and obtained variance analysis tables. Mean comparison of different treatments was conducted with duncan test. Charts were obtained by excel software.

RESULTS AND DISCUSSION

Effect of cadmium levels, on iron and manganeseconcentration

Table 2. Analysis of varianceof the traitsmeasured

Variation Resource	Degree of Freedom	iron $_{root}$	ironaerial	manganese $_{root}$	manganese aerial
		(ppm)			
Cadmium	5	39607.328**	89300.657**	254.600**	3764.609**
Mycorrhiza	1	99439.053**	120270.486**	2821.331*	6326.353**
Cadmium× Mycorrhiza	5	543.026**	1303.363**	23.533*	48.606 $^{n.s}$
Error	72	175.28	84.254	2.47	19.183
Coefficient of Variation (%)	_	5.12	3.65	7.04	7.94

Significant 1% and 5% level, and n.s is not significantisand ***

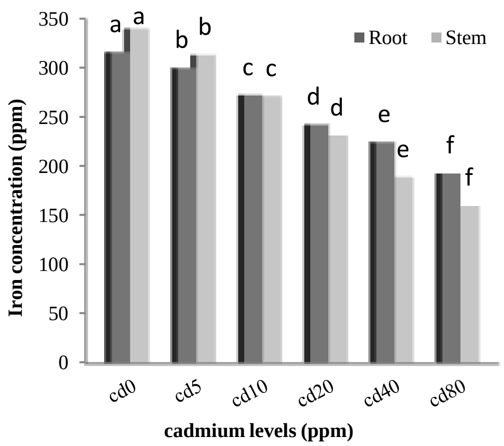


Figure 1.Effect of cadmium levels, on iron plant

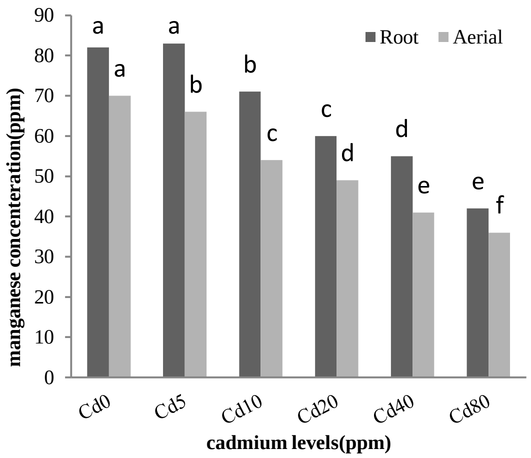
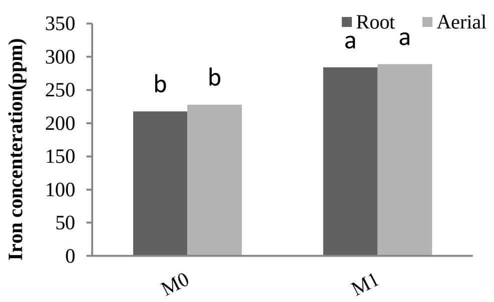


Figure 2.Effect of cadmium levels, on manganese plant

Effect of arbuscularmycorrhiza fungi on iron and manganeseconcentration

Effect of arbuscularmycorrhiza fungi on iron and manganese concentration was significant in one percent level of statistic (Table 2). Arbuscularmycorrhiza fungi increased diron concentration 30.2% and26.7% in the root and aerial plant and manganese concentration36% and 30.9% in root and aerial, respectively (Figures 3 and 4).



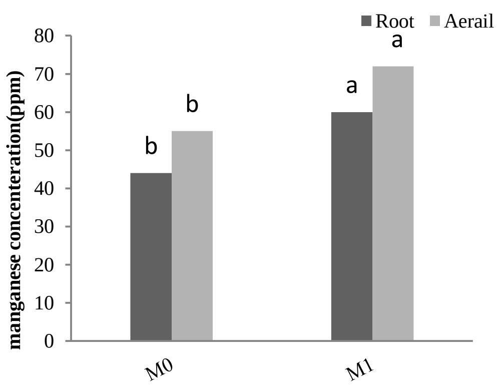


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Figure 3.Effect of mycorrhiza fungi on iron Figure

4. Effect of mycorrhiza fungi on manganese

Arbuscularmycorrhiza can provide the plant with supplemental phosphorus (P), nitrogen (N), and micronutrients such Fe, Cu, Zn, Mn,since the plant roots alone are not able to maximize the interception of nutrients [14]. Arbuscularmycorrhiza have reportedly increased nutrient uptake, salinity tolerance, drought tolerance, water uptake, root disease resistance, and photosynthesis [15]. Many workers have reported that nutrient uptake of mycorrhizal plants was higher when compared with non-mycorrhizal one [16].

Interactionbetweencadmiumlevelsandmycorrhizal fungi on iron and manganeseconcentration

According to analysis of variance table [3], interaction between cadmium levels and mycorrhizal fungi on iron concentration in root and aerial was significant in one percent level of statistic**,** the highest concentration of iron in aerial and root plant observed 387.3 and 342.7, mg. kg^{-1} respectively from inoculation and without cadmium treatment. The lowest concentration of iron in aerial and root plant observed 130.6 and 156.7 mg. kg^{-1} respectively from without inoculation and cadmium level of 80 $mg.kg^{-1}$ treatment. Interaction between cadmium levels and mycorrhizal fungi on manganese concentration in root was significantin 5% level of statistical. But no significant in aerial plant. The highest and lowest concentration of manganese in root plant observed 82.6 mg. kg^{-1} from inoculation and without cadmium treatment and 29.4, mg. kg^{-1} from without inoculation and cadmium level of 80 $mg.kg^{-1}$ treatment, respectively.

Table 3.Interactionbetweencadmiumlevelsandmycorrhizal fungi on iron and manganeseconcentration

Mycorrhiza	**cadmium levels**	**iron $_{root}$**	**iron$_{aerial}$**	**manganese $_{root}$**
		(ppm)		
	Cd_0	291 C	294.3 c	62.72d
	Cd_5	275.70 d	275.5 d	57.61 d
Without inoculation	Cd_{10}	267.60 e	236.7 d	53.03 e
	Cd_{20}	208.40 g	204.6 gh	44.29 f
	Cd_{40}	190.40 h	166.6 i	37.04 g
	Cd_{80}	**156.70 i**	**130.6 j**	**29.40 h**
	Cd_0	**342.7 a**	**387.3 a**	**82.6 a**
	Cd_5	328.5 c	352.6 b	77.26 b
inoculation	Cd_{10}	298.2 c	307 c	67.54 c
	Cd_{20}	277.6 d	258.9 e	58.5 d
	Cd_{40}	260 e	212.4 g	50.31 e
	Cd_{80}	229.90 f	190.5 h	40.72 fg

CONCLUSION

Arbuscularmycorrhiza fungi increased iron and manganese concentration in the root and aerial plant. But levels of cadmium in soil reduced iron and manganese concentration in plant. Arbuscularmycorrhiza have been observed to play a vital role in metal tolerance [17] and accumulation [18]. Beneficial effects of AM symbiosis on plant growth, nutrient uptake, and tolerance to environmental stressors have been extensively reported, however, these fungi show a preferential colonization to hosts and thus the extent to which the host benefit depends on the fungal species involved in the symbiosis [19]. Because of their high nutrient uptake capacity due to the increased absorption surface and possible enzyme activity [20], mycorrhiza fungi should be especially advantageous for vascular plants in nutrient-poor conditions and soil contaminated.

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