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Brief Article

Compare Cadmium Accumulation Trend between Cultivated Soil and Wheat (*Triticum aestivum* L.) Tissue Affected Different Cropping Pattern and Growth Stage

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ABSTRACT

This research was conducted to evaluate the trend of cadmium accumulation in wheat tissue and cultivated soil affected conventional cropping systems and different growth stage via split plot experiment based on randomized complete block design with three replications during 2014-2015 seasonal year. The main factor included two cropping systems (wheat-rice, fallow-wheat) and growth stage at three level (Tillering, flowering and ripening) belonged to subplots. ANOVA results indicated that the effect of different cropping systems and growth stages on soil and crop cadmium concentration traits was significant at 1% probability level, but interaction effect of treatments was not significant, also soil phosphorus content only affect cropping systems at 5% probability level. Compare effect of cropping systems on cadmium accumulation in cultivated soil and wheat tissue have similar trend (Ascending to descending). In other words the rice-wheat cropping system has more amounts of cadmium (1.71 $mg.kg^{-1}$ in soil and 1.83 $mg.kg^{-1}$ in wheat tissue) than to fallow-wheat cropping pattern (1.37 $mg.kg^{-1}$ in soil and 1.32 $mg.kg^{-1}$ in wheat tissue). Compare cadmium accumulation between soil and wheat crop tissue revealed an opposite trend. Because of leaching and absorb by plants, trend of soil cadmium accumulation from tillering to ripening stage had down trend. But crop cadmium accumulation due to developed biomass and absorb cadmium had risen trend. Finally management fertilizer consumption of cultivated field according result of soil test and use of phosphate fertilizers by attention to the standards of soil and water research institute led to reduced cadmium accumulation in crop tissue.

Keywords: *Cropping System, Growth stage, Heavy metal.*

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INTRODUCTION

Soil pollution with heavy metals leads to accumulation of these elements in plant tissues and reduces the quality and quantity of agricultural products and threatens humans and animals health (Li *et al*., 2011). Agricultural practices such as the use of phosphate fertilizers, sewage, sludge, waste and farming system are the factors that affect the rate of cadmium and its uptake from soil by plants. In Europe, the permitted limit of this element in wheat grain is equal to 0.2 mg.kg^{-1} seed. Food and Agriculture Organization (FAO) and the World Health Organization (WHO) have determined the daily permitted limit of cadmium in human body as 70 micrograms (CODEX Alimentrarius Commission, 1999). Cadmium has a high mobility and if it appears in the root zone, it will easily be absorbed by crops and will be transported into the aboveground parts of crops. Different species and cultivars are greatly different in terms of ability to absorb, accumulate and tolerate cadmium. Based on the amount of cadmium in crops that are cultivated commercially, sunflower, cotton, rice and durum wheat are known as crops that are highly capable of accumulating cadmium in their own tissues and often have over 0.1 cadmium mg.kg^{-1} of dry matter (Clarke *et al*., 1997). Crop rotation is another important factor affecting the solubility of cadmium in soil changing soil acidity and absorption of cadmium in plant tissue (Vali Zade *et al*., 2012). Since the beginning of the current decade control the quality of phosphate fertilizers has been raised by the Soil and Water Research Institute, in all imported phosphate fertilizers and zinc sulfate in domestic production, the concentration of these pollutants is controlled and the maximum cadmium content is 25 mg.kg^{-1} (Pirzade *et al*., 2012). This research was carried out to compare trend of cadmium accumulation affected cropping systems and growth stages in wheat tissue and cultivated soil.

MATERIALS AND METHODS

Field and Treatment Information

This research was conducted in Shavoor Research Station to monitoring cadmium concentration in soil and plant in two main cropping systems in Khuzestan Province (at south west of Iran) via a split plot in time experiment based on randomized complete block design with three replications during 2014-2015. The main factor included two cropping systems (wheat-rice, fallow-wheat) and growth stage at three level (Tillering, flowering and ripening) belonged to subplots. Shavoor Research Station is located in 70 km north of Ahvaz at longitude 48° 27′33″E and latitude 32"37' 0° N in Khuzestan (South west of Iran). The average annual rainfall, temperature, and evaporation in the region is 240 mm, 22 °C and 3000 mm, respectively. Soil properties of the land under test are listed in Table (1).

Measuring soil cadmium concentration

To do this 60 ml of 4 M nitric acid was added to 9.6 g of air-dried soil and the mixture was heated for 12 hours at 70°C.

Table 1. Soil properties of experiment site (depth: 0-30cm)

EC (ds.m^{-1})	pH	P_b (g.cm^3)	OC (%)	P	K	Fe	Cu	Mn	Zn
						(p.p.m)			
2.8	7.8	1.35	0.7	10.9	239	9.6	1.3	8.5	0.6

Then it was centrifuged for 15 minutes and was filtered by Whatman paper No.42 and the concentration of cadmium and the produced extract was measured by atomic absorption spectrophotometer (Model: Perkin Elmer 3010) (Sposito *et al*., 1982).

Measuring crop cadmium concentration

In order to measure the concentration of cadmium in wheat plant at first the plant seeds were washed three times with distilled water in order to remove dirt, dust, pollution and then the samples were dried in the oven at 75°C and for 72 hours. Also they were crushed into powder in the mortar. The same process was followed for stem and roots. Then the powder samples of each organ of plant were poured in paper bags and were kept in refrigerator at 4°C until the measurement time. Then, in order to determine cadmium concentration, the plant samples were digested via wet digestion (70% nitric acid, perchloric acid, and sulfuric acid). After the extraction and reaching the desired volume, the prepared samples were measured using graphic furnace atomic absorption (Model: Perkin Elmer 600) (Soltanpour, 1991).

Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.9) software and Duncan multiple range test at 5% probability level. All curves were drawn by Excel software (Ver. 2010).

RESULT AND DISCUSSION

According to table 2, the ANOVA results indicated that the effect of different cropping systems and growth stages on soil and crop cadmium concentration was significant at 1% probability level, but interaction effect of treatments on mentioned traits was not significant. Compare effect of cropping systems on cadmium accumulation in cultivated soil and wheat tissue have similar trend (Ascending to descending). Soil phosphorus content was significantly affected by cropping systems at 1% probability level, but effect of different growth stages and interaction effect of treatments was not significant (Table 2).

Table 2. ANOVA result of measured traits

S.O.V	df	Soil cadmium concentration	Crop cadmium concentration	Soil phosphorus content
Replication	2	0.0105^{*}	0.00038^{*}	0.0272^{**}
Cropping system	1	0.520^{**}	1.1755^{**}	12.835^{**}
Error a	2	0.0055	0.0025	0.0738
Growth Stage	2	0.0426^{*}	0.02337^{*}	0.1838^{ns}
Cropping system * Growth stage	2	0.00001^{ns}	0.0029^{ns}	0.0105^{ns}
Replication* Growth stage	4	0.0020^{ns}	0.0001^{ns}	0.0013^{ns}
Error b	4	0.0016	0.0048	0.0055
CV (%)	-	12.32	16.65	10.85

^{ns}, * and **: non significant, significant at 5% and 1% of probability level, respectively.

The rice-wheat cropping system has more amounts of cadmium (1.71 $mg.kg^{-1}$ in soil and 1.83 $mg.kg^{-1}$ in wheat tissue) than to fallow-wheat cropping pattern (1.37 $mg.kg^{-1}$ in soil and 1.32 $mg.kg^{-1}$ in wheat tissue) (Fig. 1). Jafarnejadi *et al*. (2011) said that the main source of cadmium in the soil of croplands in Khuzestan was the use of di ammonium phosphate fertilizer.

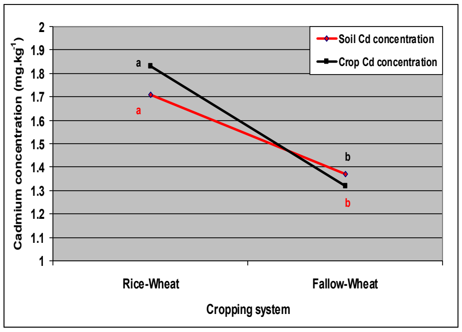

Fig. 1. Mean comparison effect of cropping system on soil and crop cadmium concentration via Duncan test at 5% probability level.

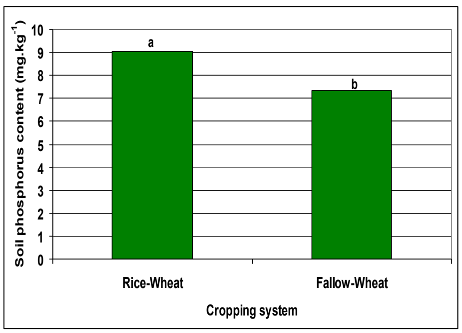

Fig. 2. Mean comparison effect of cropping system on soil phosphorus content via Duncan test at 5% probability level.

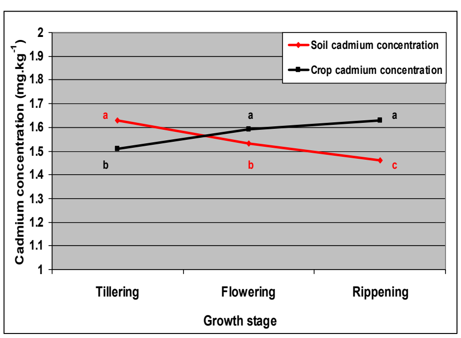

Fig. 3. Mean comparison effect of growth stage on soil and crop cadmium concentration via Duncan test at 5% probability level.

According the history of cultivation in the studied area indicated consumption non standard phosphorus fertilizer (Contain high amount of cadmium) greatly contributed to contamination with this element. Evaluate phosphorus content of studied soil indicated high phosphorus accumulation in field under rice-wheat cropping system (9.03 mg.kg^{-1}) via compare to fallow-wheat system (7.34 mg.kg^{-1}) and proved that matter (Fig. 2), also in rice planted situation due to the more level of ground water (Gooshe and Ghalebi, 2012) and accessibility of oxidation based flooding conditions, the content of cadmium in rice field soil was increased (Tsukahara *et al*., 2003). Compare cadmium accumulation between soil and wheat crop tissue revealed an opposite trend. Because of leaching and absorb by plants trend of soil cadmium accumulation from tillering to ripening stage had down trend. But crop cadmium accumulation due to developed biomass and absorb cadmium had risen trend (Fig. 3). Gao and Grant (2012) reported same result.

CONCLUSION

Finally management fertilizer consumption of cultivated field according result of soil test and use of phosphate fertilizers by attention to the standards of soil and water research institute led to reduced cadmium accumulation in crop tissue.

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