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Cadmium effects on potassium content and pepper seedling growth in different peat ratios

Füsun Gülser*, Ferit Sönmez

Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Van, Turkey

Abstract

Effects of cadmium applications on plant growth and potassium contents of pepper seedlings were investigated in different mixtures of soil:peat ratios. This study was conducted with three different levels of Cd (Cd_0=0, Cd_1=2.5 and Cd_2=5.0 ppm) and three different ratios of soil:peat (Pt_0=soil:no peat, Pt_{10}=soil:10% peat and Pt_{20}=soil:20% peat) in a factorial experimental design with three replications. K contents of shoots and some criteria of pepper seedlings such as; shoot and root dry weights were significantly influenced with the soil:peat ratios. Interactions between soil:peat ratio and Cd significantly affected shoot and root dry weights and K contents of pepper seedlings. Application of 20% peat ratio significantly increased shoot dry weight. Mean root dryweights decreased with increasing Cd dose applications. The highest (7.0%) and the lowest (4.1%) K contents in shoots were determined in $Pt_{20}Cd_2$ and Pt_0Cd_2 applications, respectively. On the other hand, the highest (3.27%) and the lowest (2.12%) K contents in roots were determined in Pt_0Cd_2 and $Pt_{20}Cd_0$ applications, respectively. Mean Cd contentents in shoots were also significantly reduced with increasing K contents of shoots, especially in the mixture of soil:20% peat ratio.

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Introduction

Heavy metals are hazardous group of soil pollutants. The most common heavy metals in the environment are Cd, Cr, Hg, Pb and Zn. Cadmium is particularly a hazardous pollutant due to its high toxicity and great solubility in water. Different researchers reported that a variety of plant species including vegetable crops and grasses accumulate or immobilize heavy metals (Pichtel et al., 2000; Datta and Sarkar, 2005; Mills et al., 2006; Tie et al., 2006).

Most of heavy metals are considered as toxic since they cause deterious effect in plants, animal and humans. The metals are responsible for many alterations of some physiologic functions such as photosynthesis, chlorophyll production, enzyme activity and pigment synthesis in the plant cell (Vaillant et al., 2005; Kanoun Boule et al., 2008).

The availabilty of heavy metals for uptake by plant roots may differ between metals bound in soluble organic complexes and free metals. It was reported that organic matterials influence the binding of heavy metals in soil and speciation in soil solution (Lo et al., 1992; Dell Castillho et al., 1993) and plant uptake (Haghiri 1974; Mc Bride et al., 1981). The objectives of this research were to determine the effects of cadmium applications on plant growth and potassium contents of pepper seedlings in different mixtures of soil:peat ratios.

* Corresponding author.
Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, 65080 Van, Turkey
Tel: +90 432 2251104 Fax: +90 432 2551025 E-mail address: gulserf@yahoo.com
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Material and Methods

This study was conducted with three different levels of Cd (0, 2.5, 5.0 ppm) and three different mixtures of soil:peat ratios (soil:no peat, soil:10% peat and soil:20% peat) as growing media in a factorial design with three replications. The soil used in the study had a sandy loamy texture, non saline, alkaline, moderate in lime and organic matter contents, insufficient in phosphorus and sufficient in potassium content (Table 1). The peat used in the study had non saline, slighltly alkaline, high in phosphorus and potassium contents.

Table 1. Some properties of the growing media

	Texture	pH	Total Salinty (%)	Lime (%)	OM (%)	N (%)	P (ppm)	K (ppm)
Soil	Sandy Loam	8.66	0.013	14.8	2.40	0.192	4.56	176
Soil+10% Peat	-	8.54	0.022	9.38	27.9	0.210	5.67	184
Soil+20% Peat	-	8.37	0.026	8.38	30.2	0.215	6.78	287
Peat	-	7.76	0.030	-	69.8	0.311	25.67	495

After filling the each pot (300 cm^{-3}) without drainage holes with soil:peat mixtures, 270 pots were autoclaved. Three different levels of Cd (0, 2.5, 5.0 ppm) were applied into pots with three replications. Each replication was formed from ten pots. As a basic fertilizer treatment 90 mg kg^{-1} P_2O_5, 180 mg kg^{-1} K_2O and 250 mg kg^{-1} N were also applied into each pot from Triple Super Phosphate, K_2SO_4 and $(NH_4)_2SO_4$, respectively. Demre pepper variety was used as a plant material. Three pepper seeds were sown to each pot, and then the seedling were thinned to one. The pots were placed in a growth chamber at 22±1°C with 12 fluorescent illuminations with 8000 lux light intensity and the seedlings were irrigated with distilled water. The experiment was ended 8 weeks after the sowing. The levels of nutrients were analysed in dried and grinded plant samples according to the methods reported by Kacar and İnal (2008). Variance analyses of the experimental data were done by MSTAT statistic program and significantly different means numbered according to LSD test.

Results

According to the varience analyses for the seedling criterias, shoot and root dry weights were significantly (P<0.01) influenced by the different ratios of peat treatment (Table 2). The root dry weight was also influenced by the cadmium application significantly (P<0.01). Interactions of peat and cadmium significantly affected shoot and root dry weights (P<0.01).

Table 2. F values of the varience analyses for the seedling criterias.

	df	Shoot dry weight	Rhoot dry weight
Peat (Pt)	2	111.175**	44.696 **
Cadmium	2	0.78 ns	27.577 **
Pt x Cd	4	7.467 **	18.728 **

** significant at 0.01 level, *significant at 0.05 level, ns:non significant.

Application of 20% peat ratio significantly increased shoot dry weight compared to control and 10% peat ratio (Table 3). While the highest mean shoot dry weight (1.45 g) was obtained in the application of 20% peat ratio, the highest mean root dry weight (0.51 g) was determined in the growth media including no peat (0% peat ratio). Mean root dryweights decreased with increasing Cd dose application. Considering the interactions between soil:peat ratio and Cd doses (Pt x Cd), the highest shoot (1.57 g) and root (0.64 g) dry weights were determined in the $Pt_{20}Cd_0$ application.

Varience analyses results in Table 4 indicated that the peat applications significantly affected K contents of shoots and roots (P<0.01) and Cd contents in shoots (P<0.01). Cd contents in shoots and roots were also significantly influenced by the Cd application. The interaction between peat ratio and cadmium doses significantly affected K (P<0.01) and Cd (P<0.05) contents of shoots.

Table 3. Effects of peat and cadmium applications on the pepper seedling criterias.

		Pt_0	Pt_{10}	Pt_{20}	Mean
Shoot Dry Weight, g	Cd_0 (0 mg/kg)	1.07 bc	0.60 d	1.57 a	1.08
	Cd_1 (2.5 mg/kg)	1.20 b	0.67 d	1.56 a	1.14
	Cd_2 (5.0 mg/kg)	1.24 b	0.83 cd	1.22 b	1.10
Mean		1.17 B	0.70 C	1.45 A	
LSD (Pt):0.147** LSD(PtxCd):0.255**					
Root Dry Weight, g	Cd_0 (0 mg/kg)	0.57 ab	0.32 d	0.64 a	0.51 A
	Cd_1 (2.5 mg/kg)	0.52 b	0.35 d	0.52 b	0.46 A
	Cd_2 (5.0 mg/kg)	0.45 bc	0.37 cd	0.29 d	0.37 B
Mean		0.51 A	0.35 B	0.48 A	
LSD (Pt, Cd):0.055** LSD(PtxCd):0.094**					

**significant at 0.01, *significant at 0.05 level, Pt_0: soil:0%peat; Pt_{10}: soil:10%peat; Pt_{20}: soil:20%peat.

Table 4. F values of the varience analyses for the cadmium and K contents.

		Shoot		**Root**	
	df	Cd	K	Cd	K
Peat (Pt)	2	9.68 **	98.54 **	1.74 ns	10.96 **
Cadmium	2	14.63 **	1.33 ns	13.20 **	0.46 ns
Pt x Cd	4	4.26 *	36.74 **	0.21 ns	2.49 ns

** significant at 0.01 level, *significant at 0.05 level, ns:non significant.

While the means of Cd contents in shoots were significantly increased by Cd application, they were significantly decreased by the peat treatments (Figure 1). When considering the interaction between Cd and peat ratio, the highest Cd content (2.06 ppm) was in Pt_0Cd_2 and the lowest Cd content (0.70 ppm) was in $Pt_{20}Cd_0$ application (Figure 2).

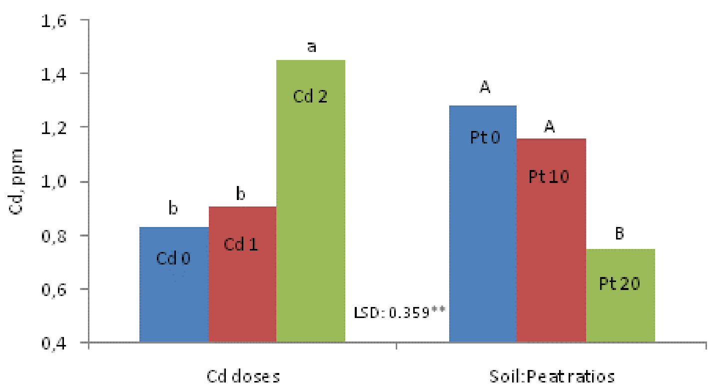

Figure 1. Cadmium contents in shoots of pepper seedlings

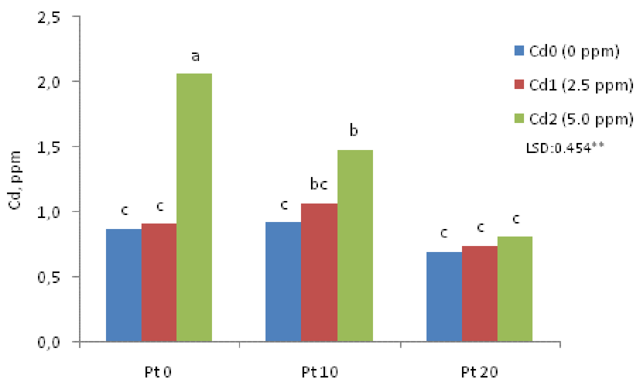

Figure 2. Effects of Cd x peat interactions on Cd contents in shoots

Application of 20% soil:peat ratio (Pt_{20}) significantly incresaed mean K (5.96%) content of shoots when compared with the mixtures of no peat and 10% soil:peat ratios (Figure 3). Mean K contents in shoots were not significantly influenced by the Cd application. When considering the interaction between Cd and peat ratio, the highest K content (7.00 %) was in $Pt_{20}Cd_2$ and the lowest K content (4.10%) was in Pt_0Cd_2 application (Figure 4). While the K content was generally decreased in Pt_0 and Pt_{10} ratios with Cd application, it was increased in Pt_{20} ratio with increasing Cd doses.

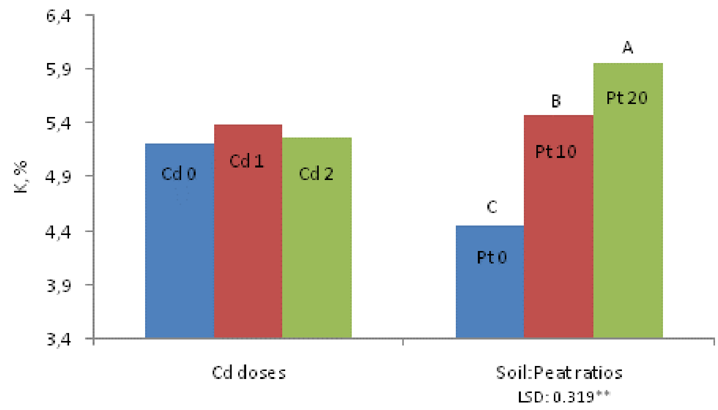

Figure 3. Potassium contents in shoots of pepper seedlings

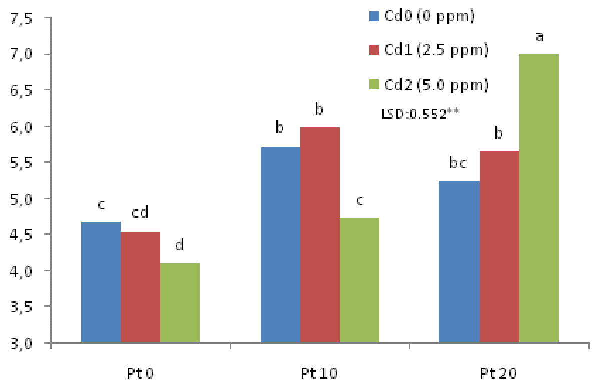

Figure 4. Effects of Cd x peat interactions on K contents in shoots

While the means of Cd contents in roots were significantly increased by Cd application, they were decreased by the increasing soil:peat ratios (Figure 5). When considering the interaction between Cd and peat ratio, the highest Cd content (2.40 ppm) was in Pt_0Cd_2 and the lowest Cd content (0.96 ppm) was in $Pt_{20}Cd_0$ application (Figure 6).

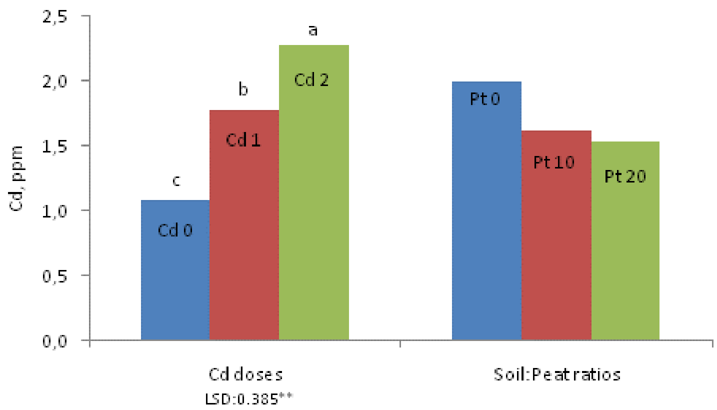

Figure 5. Cadmium contents in roots of pepper seedlings

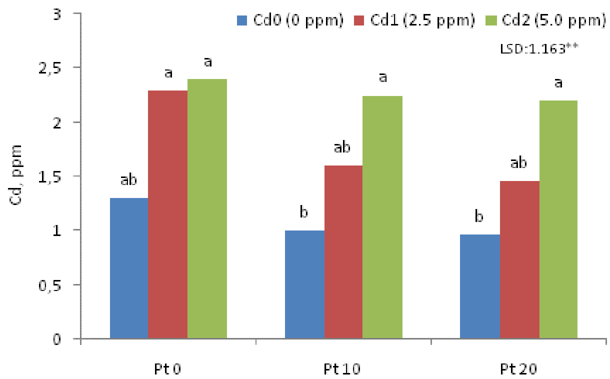

Figure 6. Effects of Cd x peat interactions on Cd contents in roots

The highest mean K (3.11%) content of roots was in the mixture of 0% soil:peat ratio (Figure 7). Mean K contents in roots decreaseed when adding the peat into soil and not significantly influenced by the Cd application. When considering the interaction between Cd and peat ratio, the highest K content (3.27%) was in Pt_0Cd_2 and the lowest K content (2.12%) in root was in $Pt_{20}Cd_0$ application (Figure 8). While the K content in roots was generally decreased in Pt_{10} ratio with Cd application, it was increased in Pt_0 and Pt_{20} ratios with increasing Cd doses.

Discussion

According to the results, it can be concluded that increasing peat concentrations in ratio of soil:peat mixtures had positive effects on shoot dry weight. Root dry weight significantly deceased by the cadmium application. Torun et al. (2009) determined that amount of dry matter in cherry plants decreased depending of application of Cd at increasing rates. Ameliorative effects of peat on seedling criteria were reported by the most researchers (Gülser et al. 1998; Özman and Ocak, 2002; Çinkılıç, 2008).

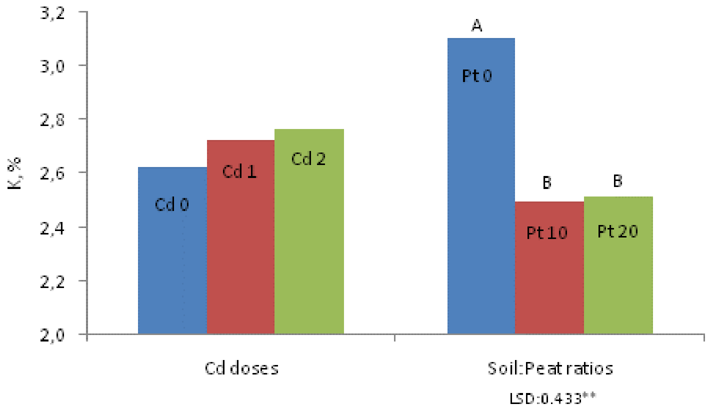

Figure 7. Potassium contents in roots of pepper seedlings

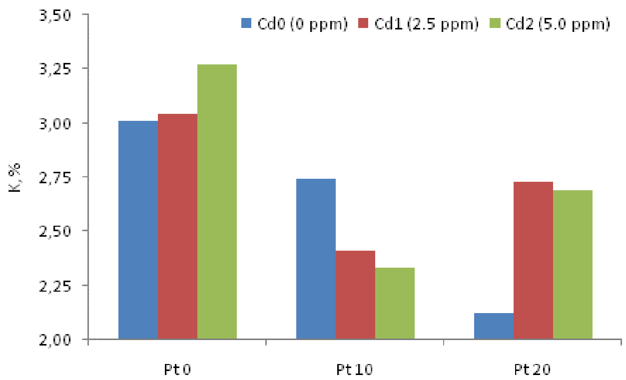

Figure 8. Effects of Cd x peat interactions on K contents in roots

Increasing Cd doses increased Cd contents in both shoots and roots. Cadmium was concentrated mainly in the roots, and its small amount was transferred to the shoots. The results of the present investigation are similar to those of Kumar et al., (1995), Jiang et al., (2001), Liu et al., (2006) and Wang et al., (2007) for the use of plants to remove heavy metals from soils. Cadmium contents in shoots and roots were decreased by the increasing rates of soil:peat mixtures. Krogstad (1983) reported that organic matter makes strong complexes with heavy metals. Soil organic matter may retain metals in the solid phase of the soil; on the contrary dissolved organic matter may increase mobility of the metals (Japenga et al., 1992; Lo et al., 1992). The decrease in the cadmium contents with peat application is similar to the results reported by Eriksson (1988), He and Singh (1993), Arnesen and Singh (1998). Mean Cd contentents in shoots were decreased with increasing K contents in shoots and growing media from soil:no peat (176 ppm K) to 20% soil:peat ratio (287 ppm K). Chen et al. (2007) reported that the application of K_2SO_4 significantly reduced the uptake of Cd in different parts of wheat. As a result, while increasing peat mixture ratio into soil increased K content and pepper seedling growth, they decrased Cd content in the plants.

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