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Short Research Article

Effect of Cadmium Application Alone or Along with FYM on Spinach Grown on Calcareous and Non-calcareous Soil

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Abstract

Heavy metals such as Cd, Ni, Cr, Cu, Pb and Hg are common environmental pollutants, particularly in areas with anthropogenic pressure. Their presence in the atmosphere, soil and water, even in traces can cause serious problems to all organisms. The mobilization of heavy metals into the biosphere by human activity has become an important aspect in the geochemical cycling of these metals. Hence experiments were conducted to study the cadmium toxicity in calcareous and non-calcareous in spinach crop. Two types of soil were collected in bulk, one from calcareous belt and another from non-calcareous belt with two levels of FYM application i.e. 0 t ha^{-1} and 10 t ha^{-1}. Varying levels ranging from 0 to 120 ppm of Cd were applied with or without FYM in both the soils and replicated thrice in a completely randomized design. Spinach was grown for 45 days for various observations. The biomass yield started to decrease at 5 and 10 ppm levels of Cd. Application of FYM increased the Cd content as well as uptake in crop and soils. The toxic levels of Cd in spinach were 0.58 µg g^{-1} for calcareous soil and 3.73 µg g^{-1} for non-calcareous soil. The toxic level of cadmium in calcareous soil for spinach were 2.3 µg g^{-1}, while in non-calcareous soil it was 3.00 µg g^{-1}.

1. Introduction

Heavy metals such as cadmium, copper lead, chromium and mercury are important environmental pollutants, particularly in areas with anthropogenic pressure. Their presence in the atmosphere, soil and water, even in traces can cause serious problems to all organisms. Heavy metal accumulation in soils is of great concern in agricultural production due to the adverse effects on food quality (safety and marketability), crop growth (due to phytotoxicity) (Ma et al., 1994) and environmental health (Soil flora/fauna and terrestrial animals). The mobilization of heavy metals into the biosphere by human activity has become an important process in the geochemical cycling of these metals. This is evident in urban areas where various stationary and mobile sources release large quantities of heavy metals into the atmosphere and soils, exceeding the natural emission rates (Nriagu, 1989). Heavy metal bioaccumulation in the food chain can be especially highly dangerous to human health.

Vegetables constitute essential diet components by contributing protein, vitamins, iron, calcium and other nutrients, which are usually in short supply (Thompson and Kelly, 1990). They also act as buffering agent for acidic substances produced during the digestion process. Metal accumulation in vegetables may pose a direct threat to human health (Turkdogan et al., 2003). Vegetables take up metals by absorbing them from contaminated soils as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Zurera-cosarno et al., 1989). Food contamination by heavy metals depends both on their mobility in the soil and bio-availability. The bio-availability concentration of heavy metals in surface soils and the corps grown in the low lying agricultural land of Hooghly river basin contaminated sites receiving long-term irrigation through sewage effluent from industries, disposal of waste water sludges, municipals refusals, animal's wastes and heavy traffic-road washing were assessed. Palak (*Beta vulgaris*) is a highly nutritious leafy vegetable that is widely cultivated and consumed in Urban India, particularly by the poor. A field study was conducted at three major sites in the suburban areas of Varanasi, India receiving irrigation water either from treated or untreated waste water (Kumar et al., 2006). Samples of irrigation water, soil and the edible portion of the palak were collected monthly during the summer and winter seasons and were analyzed for Cd, Cu, Zn, Pb, Cr, Mn, and Ni.

Heavy metals in irrigation water were below the internationally recommended (WHO, 1992) maximum permissible limits set for agricultural use for all heavy metals except Cd at all the sites. Similarly, the mean heavy metal concentrations in soil were below the Indian standards for all heavy metals, but the maximum value of Cd recorded during January was higher than the standards. However, in the edible portion of palak, the Cd concentration was higher than the permissible limits of the Indian standard during summer, where as Pb and Ni concentration were higher in both summer and winter seasons. They concluded that the use of treated and untreated waste water for irrigation has increased the contamination of Cd, Pb, and Ni in edible portion of vegetables causing potential health risk in the long term from this practice. However, the toxic level of heavy metals particularly Cd and Ni have not been studied so far. The information on this aspect is very meager.

2. Materials and Methods

The main purpose of this study was to investigate the effect of Cadmium toxicity in calcareous and non-calcareous soils especially in spinach plant. In the present investigation, laboratory and pot culture experiments were conducted to know the response, uptake and phytotoxic limit of Cadmium in calcareous and non-calcareous soils in spinach plant. The experiment was conducted in 2010 in a greenhouse (pots experiments) of Rajendra Agricultural University, Pusa, Samastipur, Bihar, India for the purpose to know the phytotoxic limit of Cadmium in soil and spinach crop.

Two surface soil samples, one calcareous soil (young alluvium) from Pusa, Samastipur District and another non-calcareous soil (old alluvium) from Patna district were collected in bulk from 0–15 cm depth for the pot experiment. The experimental soil was sandy clay loam in texture in non calcareous soil (58.36% sand, 16.95% silt, 23.05% clay) and for calcareous soil i.e., sandy loam in texture (37.24% sand, 30.04% silt, and 13.38% clay). Bulk density, percentage pore space and water holding capacity was 1.95 g cm^{-3}, 26.40, 31.02% respectively for non-calcareous soil and 1.76 g cm^{-3}, 33.58, 19.58% for calcareous soil respectively. The soil pH 7.83, EC 0.40 dS m^{-1}, organic carbon 0.54%, CEC 20.03 (cm [p+] kg^{-1}), DTPA extractable Cd, Fe, Cu, Zn, Mn was 0.15, 0.43, 33.30, 5.66, 1.98, 5.92 mg kg^{-1} respectively. Available N 198.80 kg ha^{-1}, Available P_2O_5 37.33 kg ha^{-1}, Available K_2O 224.83 kg ha^{-1} for non-calcareous soil and for calcareous soil. The soil pH 8.51, EC 0.84 dS m^{-1}, organic carbon 0.46%, CEC 8.07 cm [p+] kg^{-1}, Free $CaCO_3$ 34.38%, DTPA extractable Cd, Fe, Cu, Zn, Mn was 0.07, 0.25, 21.40, 2.19, 0.51, 3.62 mg kg^{-1} respectively. Available N 183.40 kg ha^{-1} Available P_2O_5 28.00 kg ha^{-1}, Available K_2O 133.25 kg ha^{-1} the plastic pots were arranged as per lay out plan which was filled with 4 kg of respective soil separately. Two levels of organic matter (FYM) has been taken i.e., Alone FYM (Mo) and Along with FYM ($M_{1)}$ @ 20 g FYM Pot^{-1}. Eight treatments of Cadmium (0, 2.5, 5.0, 10.0, 20.0, 40.0, 80.0, and 120.0 mg kg^{-1}) were laid at in a randomized design with 3 replication. Each of the pot was treated with a 0.348 g urea, 0.15 g potassium dihydrogen orthophosphate (KH_2PO_4) and 0.052 g potassium chloride (KCL) in form of solution by dissolving above fertilizers in 50 ml volume with distilled water. The treatments were also given as per lay out plan and treatments. The experiment was conducted during November-December (2008–09) with spinach test crop. Ten seeds were sown in each pot and the stand was thinned to 5 after germination. The pots were irrigated with deionizer water as and when required. Plants were harvested after 45 days of sowing and after harvesting soil were used for analysis of organic matter and DTPA Cd of Post harvest soil.

3. Results and Discussion

3.1. Dry matter yield of spinach

Corps was grown; the germination was good which was thinned. The crop stand was good. The response/toxicity of Cd with or without FYM was noticed. The Cd toxicity symptoms were also observed on older leaves of spinach. The toxicity started at early stage which was characterized by yellowing of leaves then at latter stage marginal scorching of older leaves was noticed at higher level of Cd.

3.1.1. Shoot dry weight

The dry matter yield of shoot and root of spinach grown on two soils with different organic matter and Cd levels are given in Table 1. The overall dry weight of spinach shoot and root varied from 1.60 to 5.53 and 0.28 to 0.94 g pot^{-1}, respectively. The dry weight of spinach shoot in non-Calcareous soil was recorded 3.52 g pot^{-1} which was significantly superior to calcareous soil (2.70 g pot^{-1}). Due to application of organic matter dry weight shoot of spinach in both calcareous and non-calcareous soil increased significantly. This may be attributed to variation in soil properties like organic carbon content, clay content and nutrient status. Organic matter has increased the dry weight of shoot which varied from 2.43 to 2.96 and 3.17 to 3.85 g Pot^{-1} in calcareous and non calcareous soils, respectively. Increasing level of Cd significantly decreases dry weight of spinach shoot after T_3 treatment (5 ppm Cd) which was at par with T_2 treatment (2.5 ppm Cd). Similar results were found by Sameni et al. (1987), they reported that highest Cd level markedly decreased shoot and root dry weight with increasing Cd levels. Similar, results were also found by MNS (Department of Soil Science, RAU, Pusa, Bihar (2002–03), India. So the highest dry weight of spinach shoot was recorded at 2.5 mg kg^{-1} Cd i.e. 4.09 g Pot^{-1} and lowest at 120 ppm Cd i.e. 1.92 g Pot^{-1}. Although interaction with soil×organic matter and soil×Cd levels were found non-significant but interaction with organic matter and Cd levels were found significant. Increasing level of Cd in FYM applied soil decreases the dry weight of spinach shoot in both the soil. The effect of soil, organic matter and levels of Cd and their interaction on dry weight of spinach shoot were found non-significant.

Table 1: Effect of cadmium application alone or along with FYM on dry weight of spinach shoot and root grown on calcareous and non-calcareous soil

Cd levels mg kg^{-1}	Calcareous soil			Non-calcareous soil			Mean
	M_0	M_1	Mean	M_0	M_1	Mean	
Shoot dry weight (g pot^{-1})							
0	2.58	3.67	3.13	3.57	4.09	3.83	3.48
2.5	3.20	3.81	3.51	4.33	5.01	4.67	4.09
5	2.77	3.16	2.97	4.78	5.53	5.16	4.06
10	2.54	3.03	2.79	3.93	4.67	4.30	3.54
20	2.33	2.93	2.63	2.77	3.48	3.13	2.88
40	2.19	2.66	2.43	2.46	3.15	2.81	2.62
80	1.98	2.26	2.12	1.94	2.76	2.35	2.23
120	1.85	2.13	1.99	1.60	2.11	1.86	1.92
Mean	2.43	2.96	2.70	3.17	3.85	3.52	
Sources	SEm±		CD (p=0.05)		CV		
Soil (A)	0.04		0.12		10.09		
OM(B)	0.04		0.12				
Cd level (C)	0.09		0.25				
A×B	0.06		NS				
A×C	0.12		NS				
B×C	0.12		0.35				
A×B×C	0.18		NS				
Root dry weight (g pot^{-1})							
0	0.63	0.85	0.74	0.48	0.59	0.54	0.64
2.5	0.68	0.94	0.81	0.80	0.93	0.87	0.84
5	0.57	0.87	0.72	0.91	0.87	0.89	0.80
10	0.51	0.77	0.64	0.94	0.83	0.89	0.76
20	0.47	0.63	0.55	0.75	0.84	0.80	0.67
40	0.40	0.53	0.47	0.51	0.66	0.59	0.53
80	0.34	0.40	0.37	0.40	0.41	0.41	0.39
120	0.30	0.34	0.32	0.31	0.28	0.30	0.31
Mean	0.49	0.67	0.58	0.64	0.67	0.66	
Sources	SEm±		CD (p=0.05)	CV			
Soil (A)	0.01		0.04	14.65			
OM (B)	0.01		0.04				
Cd level (C)	0.03		0.07				
A×B	0.02		0.05				
A×C	0.04		0.10				
B×C	0.04		0.10				
A×B×C	0.05		0.14				

3.1.2. *Root dry weight*

The dry weight of spinach roots in non calcareous soil were found 0.66 g Pot^{-1} which was significantly higher than calcareous soil i.e. 0.58 g Pot^{-1} Application of organic matter significantly increased the dry weight of spinach roots in calcareous soil from 0.49 to 0.67 g Pot^{-1} while in non-calcareous soil the increase was less i.e. 0.64 to 0.67 g Pot^{-1}. Increasing levels of Cd decreases the dry weight of spinach roots after T_2 treatment (2.5 ppm Cd). Application of organic matter significantly increased the dry weight yield of spinach root in both calcareous and Non-calcareous soil. The dry weight of spinach root in Cd treated soil along with FYM significantly increases in comparison to alone FYM treated soil. Increasing level of Cd significantly decreased the dry weight of spinach root after T_3 treatment (5 ppm Cd) which was found at par with T_2 treatment (2.5 ppm Cd) in calcareous soil while in non-calcareous soil the dry weight of spinach root decrease after T_4 treatment (10 ppm Cd) which was found at par with T_3 treatment (5 ppm Cd). Increasing level of Cd in both soil alone and alongwith FYM significantly, decreases the dry weight yield of spinach root over control. The effect of soil, organic matter and levels of Cd and their interaction on root dry weight were found significant.

3.2. *Cadmium concentration in spinach*

3.2.1. *Cadmium concentration in shoot*

The concentration of Cd in shoot and root of spinach grown on two soils with different organic matter and Cd levels are given in Table 2. The overall Cd concentration in shoot and root of spinach varied from 0.15 to 58.15 and 0.50 to 102.70 µg g^{-1}, respectively. Cadmium concentration in shoots and roots varied both with different cadmium levels and type of vegetables. Generally cadmium accumulations in various plant parts in vegetables crops increased with increasing cadmium concentration in the growth medium (Ni et al., 2002). The concentration of Cd in shoots of spinach in non-calcareous soil was observed 17.25 µg g^{-1} which was significantly higher to calcareous soil (6.18 µg g^{-1}). Due to application of organic matter Cd concentration in both calcareous and non-calcareous soil increased significantly. Organic matter has increased the Cd concentration in shoot from 2.36 to 10.01 and 11.94 to 22.56 µg g^{-1} in calcareous and non-calcareous soils, respectively. Increasing level of Cd significantly increased Cd concentration in shoot of spinach over control except for T_2 treatment (2.5

Table 2: Effect of cadmium application alone or alongwith FYM on cadmium concentration of spinach shoot and root grown on calcareous and non-calcareous soil

Cd levels mg kg^{-1}	Calcareous soil			Non-calcareous soil			Mean
	M_0	M_1	Mean	M_0	M_1	Mean	
Cadmium concentration in shoot (µg g^{-1})							
0	0.15	0.50	0.33	0.77	1.03	0.90	0.61
2.5	0.58	1.06	0.82	1.17	1.67	1.42	1.12
5	0.87	3.36	2.12	3.73	6.35	5.04	3.58
10	1.31	5.53	3.42	6.13	11.13	8.63	6.02
20	2.18	9.20	5.69	10.72	17.70	14.21	9.95
40	3.13	12.70	7.92	17.37	35.15	26.26	17.09
80	4.66	21.33	13.00	25.45	49.32	37.39	25.19
120	6.01	26.36	16.19	30.17	58.15	44.16	30.17
Mean	2.36	10.01	6.18	11.94	22.56	17.25	
Sources	SEm±	CD (p=0.05)		CV			
Soil (A)	0.19	0.53		11.32			
OM(B)	0.19	0.53					
Cd level (C)	0.38	1.06					
A×B	0.27	0.75					
A×C	0.54	1.50					
B×C	0.54	1.50					
A×B×C	0.77	2.12					
Cadmium concentration in root (µg g^{-1})							
0	0.50	2.56	1.53	1.32	1.55	1.44	1.48
2.5	1.00	4.00	2.50	5.88	8.88	7.38	4.94
5	1.57	5.83	3.70	12.33	20.00	16.17	9.93
10	4.47	10.70	7.59	19.90	27.77	23.84	15.71
20	6.63	22.96	14.80	24.08	33.50	28.79	21.79
40	10.50	37.96	24.23	42.30	55.62	48.96	36.59
80	19.77	47.60	33.69	48.13	68.83	58.48	46.08
120	23.87	67.63	45.75	58.13	102.70	80.42	63.08
Mean	8.54	24.91	16.72	26.51	39.86	33.18	
Sources	SEm±	CD (p=0.05)		CV			
Soil (A)	0.34	0.97		9.69			
OM (B)	0.34	0.97					
Cd level (C)	0.70	1.93					
A×B	0.49	1.37					
A×C	0.99	2.73					
B×C	0.99	2.73					
A×B×C	1.40	3.87					

ppm Cd) which was at par with control. The increase in Cd concentration in spinach shoot was more in non-calcareous soils as compared to calcareous soil. Increasing levels of Cd significantly increased the Cd concentration in shoot of spinach over control after T_4 Treatment (10 ppm Cd) which was found at par with T_3 treatment (5 ppm Cd) in calcareous soil while in non-calcareous soil the Cd concentration in shoot of spinach after T_2 treatment (2.5 ppm Cd) which was found at par with control. Adhikari et al. (1998) reported that above 80 mg kg^{-1} there was very slow growth of spinach after germination. Increasing levels of Cd in FYM applied soil significantly increased the Cd concentration in both soil. However, Alone FYM soil Cd Concentration increased in shoot of spinach over control after T_4 treatment (10 ppm Cd) which was at par with T_3 treatment (5 ppm Cd) while in case of alongwith FYM applied soil Cd concentration increased in shoot of spinach after T_3 treatment (5 ppm) which was found at par with T_2 treatment (2.5 ppm Cd). The effect of soil, Organic matter and levels of Cd and their interaction on Cd concentration in shoot of spinach were found significant.

3.2.2. *Cadmium concentration in root*

The concentration of Cd in roots of spinach in non calcareous soil was observed 33.18 µg g^{-1} which was significantly superior than calcareous soil (16.72 µg g^{-1}). Due to application of organic matter Cd concentration in both calcareous and non-calcareous soil increased significantly. Organic matter has increased the Cd concentration in roots from 8.54 to 24.91 and 26.51 to 39.86 µg g^{-1} in calcareous and non calcareous soil respectively non-calcareous soils respectively. Increasing level of Cd increased Cd concentration in root of spinach over control. Yargholi et al. (2008) has been reported the objective of analyzing the impact of various levels of Cd concentration in the root region on the quantity of its absorption and accumulation in various parts of vegetables. Application of organic matter significantly increased the Cd concentration in spinach root in both calcareous and non-calcareous soil. The increase in Cd concentration in spinach root was found more in non-calcareous soil as compared to calcareous soil. Increasing levels of Cd significantly increased the Cd concentration in root of spinach after T_3 treatment (5 ppm Cd) which was found at par with T_2 treatment (2.5 ppm Cd) in calcareous soil. While in non-calcareous soil the Cd concentration in root of spinach over control increase with increasing levels of Cd. Wichmann et al. (1983) reported that carrot root growth were stimulated at less than 6.0 ppm and inhibited at more than 100.0 ppm. Increasing levels of Cd in FYM applied soil significantly increased the Cd concentration in both the soils. However, alone FYM soil Cd concentration increased in root of spinach after T_3 treatment (5 ppm Cd) which was found at par with T_2 treatment (2.5 ppm Cd) while in case of FYM applied soil Cd concentration increased in root of spinach over control at all levels of Cd. The effects of soil, organic matter and levels of Cd and their interaction on Cd concentration in roots of spinach were found significant.

3.3. Cadmium uptake by spinach

3.3.1. Cadmium uptake by shoot

The cadmium uptake by spinach shoot and root grown on two soils with different organic matter and Cd levels are given in Table 3. The overall cadmium uptake by spinach shoot and root varied from 0.40 to 123.71 and 0.32 to 29.05 μg pot^{-1}, respectively. The Cd uptake by spinach shoot in non-calcareous was observed 47.01 μg pot^{-1} which was significantly higher to calcareous soil i.e. 14.90 μg pot^{-1}. Due to application of organic matter Cd uptake by spinach shoot in both soils increased significantly and it varied from 5.05 to 24.75 and 27.48 to 66.54 μg pot^{-1}, respectively. Increasing levels of Cd significantly increased the Cd uptake by spinach shoot after T_2 treatment (2.5 ppm Cd) which was at par with control. The Cd uptake increased from 2.31 to 60.80 μg pot^{-1} by shoot of spinach with increasing level of Cd except T_8 treatment (120 ppm Cd). The application of organic matter in respect of soil increased the uptake significantly in both calcareous and non-calcareous soil. Due to organic matter, the increase in Cd uptake by spinach shoot was observed more in non-calcareous soil as compared to calcareous soil.

Increasing levels of Cd significantly increased the uptake of spinach shoot after T_2 treatment (2.5 ppm Cd) which was at par with control in Non-calcareous soil. Increasing levels of Cd in FYM applied soil significantly increased the Cd uptake in both soil. However, Along with FYM soil Cd uptake in spinach shoot increased over control after T_3 treatment (5 ppm Cd) which was at par with T_2 treatment (2.5 ppm Cd). While in case of alone FYM soil Cd uptake in spinach shoot increased at 10 ppm Cd which was at par with T_3 treatment (5 ppm Cd). Over all Cd uptake in non-calcareous is more significant than calcareous soil and this was due to presence of organic matter in soil which enhance the biomass and old root decomposition which increase Cd concentration in soil. The effect of soil, organic matter and levels of Cd and their interaction on Cd uptake in spinach shoot were found significant.

3.3.2. Cadmium uptake by root

The Cd uptake in roots of spinach in non-calcareous soil was observed 17.85 μg pot^{-1} which was significantly superior to calcareous soil i.e., 7.58 μg pot^{-1}. Due to application of organic matter Cd uptake in both calcareous and non calcareous soil increased significantly. Organic matter has increased the Cd uptake in roots varying from 3.14 to 12.03 and 14.14 to 21.55 μg pot^{-1}, in calcareous and non-calcareous soil, respectively. Increasing level of Cd significantly increased the uptake of Cd in root of spinach in non-calcareous soil over control while

Table 3: Effect of cadmium application alone or along with FYM on cadmium uptake by spinach shoot and root grown on calcareous and non-calcareous soil

Cd levels mg kg^{-1}	Calcareous soil			Non-calcareous soil			Mean
	M_0	M_1	Mean	M_0	M_1	Mean	
Cadmium uptake by shoot (μg pot^{-1})							
0	0.40	1.86	1.13	2.71	4.25	3.48	2.30
2.5	1.91	4.00	2.96	5.09	8.36	6.73	4.84
5	2.39	10.61	6.50	17.94	35.10	26.52	16.51
10	3.37	16.78	10.08	24.30	51.86	38.08	24.08
20	5.08	27.05	16.07	29.65	61.59	45.62	30.84
40	6.88	33.44	20.16	42.68	110.94	76.81	48.48
80	9.26	48.06	28.66	49.39	136.48	92.94	60.80
120	11.14	56.17	33.66	48.08	123.71	85.90	59.78
Mean	5.05	24.75	14.90	27.48	66.54	47.01	
Sources	SEm±		CD (p=0.05)		CV		
Soil (A)	0.85		2.35		19.04		
OM (B)	0.85		2.35				
Cd level (C)	1.70		4.71				
A×B	1.20		3.33				
A×C	2.40		6.67				
B×C	2.40		6.67				
A×B×C	3.40		9.43				
Cadmium uptake by root (μg pot^{-1})							
0	0.32	2.19	1.26	0.64	0.92	0.78	1.02
2.5	0.66	3.76	2.21	4.77	8.21	6.49	4.35
5	0.89	5.07	2.90	11.25	16.58	13.92	8.41
10	2.28	8.23	5.26	18.79	24.21	21.50	13.38
20	3.10	14.46	8.78	18.07	28.22	23.15	15.96
40	4.15	20.16	12.16	21.82	36.65	29.24	20.70
80	6.70	19.09	12.90	19.60	28.55	24.08	18.49
120	7.15	23.25	15.20	18.20	29.05	23.63	19.41
Mean	3.14	12.03	7.58	14.14	21.55	17.85	
Sources	SEm±		CD (p=0.05)		CV		
Soil (A)	0.29		0.81		16.02		
OM (B)	0.29		0.81				
Cd level (C)	0.56		1.62				
A×B	0.41		NS				
A×C	0.83		2.30				
B×C	0.83		2.30				
A×B×C	1.17		NS				

in calcareous soil, Cd uptake in root of spinach increases at 10 ppm Cd which was at par with T_3 treatment (5 ppm Cd). Increasing level of Cd in FYM applied soil significantly increased the Cd uptake in both the soil over control. This is due to increasing the biomass of root and high decomposition rate of organic matter which enhance the Cd concentration in soil and increasing Cd uptake by spinach roots. Effect of soil, organic matter and levels of Cd and their interaction on Cd uptake in roots of spinach were found non-significant.

3.4. *Total cadmium uptake*

The total Cd uptake by spinach plant grown on two soils with different organic matter and Cd levels are given in Table 4. The overall Cd uptake by spinach plant varied from 0.72 to 165.02 μg pot^{-1}. The total Cd uptake by spinach plant in non-calcareous soil was observed 64.85 μg pot^{-1} which was significantly superior than calcareous soil i.e. 22.48 μg pot^{-1}. Due to application of organic matter Cd uptake by spinach plant in both calcareous and non-calcareous soil increased significantly. Organic matter has increased the Cd uptake in spinach plant from 8.21 to 36.77 and 41.62 to 88.08 μg pot^{-1} in calcareous and non-calcareous soils, respectively. Increasing level of Cd Significantly increased Cd uptake in spinach plant at all levels of Cd. The threshold levels of Cd toxicity in plant tops of spinach were 13.0 mg kg^{-1}. An increase in Cd uptake by various crops due to application of $CdCl_2$ has been reported by John (1973). The result was supported by Jone et al. (1973) who showed that Cd either in salt form or sludge born was readily available to plants. Application of organic matter significantly increased the Cd uptake in spinach plant in both calcareous and non-calcareous soils. Increasing levels of Cd significantly increased the Cd uptake in spinach plant in non-calcareous soil while in calcareous soil it increases at T_3 treatment (5 ppm Cd) which was at par with T_2 treatment (2.5 ppm Cd) over control in calcareous soil. Increasing level of Cd in FYM applied soil and alone FYM applied soil significantly increased the Cd uptake by spinach plant in both the soil. However, both soil alone or alongwith FYM, the uptake of Cd by spinach plant increased after T_2 treatment (2.5 ppm Cd) over controls which are increases with increasing Cd levels. The effect of soil, organic matter and levels of Cd and their interaction on Cd uptake by spinach plant were found significant.

Table 4: Effect of cadmium application alone or along with FYM on total cadmium uptake by spinach plant grown on calcareous and non-calcareous soil

Cd levels mg kg^{-1}	Calcareous soil			Non-calcareous soil			Mean
	M_0	M_1	Mean	M_0	M_1	Mean	
Total Cadmium uptake by spinach (μg pot^{-1})							
0	0.72	4.05	2.39	3.35	5.17	4.26	3.32
2.5	2.58	7.76	5.17	9.86	16.57	13.22	9.19
5	3.28	15.68	9.40	29.20	51.67	40.44	24.96
10	5.65	25.01	15.33	43.09	76.07	59.58	37.45
20	8.18	41.51	24.85	47.71	89.80	68.76	46.80
40	11.03	53.60	32.32	64.50	147.60	106.05	69.18
80	15.95	67.16	41.56	68.98	165.02	117.00	79.28
120	18.29	79.42	48.86	66.28	152.75	109.52	79.19
Mean	8.21	36.77	22.48	41.62	88.08	64.85	

Sources	SEm±	CD (p=0.05)	CV
Soil (A)	1.00	2.77	16.00
OM (B)	1.00	2.77	
Cd level (C)	2.00	5.55	
A×B	1.41	3.92	
A×C	2.83	7.85	
B×C	2.83	7.85	
A×B×C	4.00	11.10	

4. Conclusion

The biomass yield started to decrease at 5 and 10 ppm levels of Cd. Application of FYM increased the Cd content as well as uptake in crop and soils. The toxic levels of Cd in spinach were 0.58 μg g^{-1} for calcareous soil and 3.73 μg g^{-1} for non-calcareous soil. The toxic level of cadmium in calcareous soil for spinach were 2.3 μg g^{-1}, while in non-calcareous soil it was 3.00 μg g^{-1}. the periodical monitoring of heavy metal concentration in soil and plant should be done.

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