Novel Bacillus cereus Strain, ALT1, Enhance Growth and Strengthens the Antioxidant System of Soybean under Cadmium Stress (2021)

Table 1: Growth promoting effect of Bacillus cereus ALT1 on soybean under various cadmium stress. The values with ± show standard deviation (SD). RL: root length; SL: shoot length; FW: fresh weight; DW: dry weight. The superscript letters after the mean values in a column indicate significant differences. Each value represents the mean ± SD (n = 3).

	RL (cm)	**SL (cm)**	**FW (g)**	**DW (g)**
Contro	21 ± 1.2 ^{b}	22.3 ± 0.6 ^{b}	13.3 ± 1.5 ^{b}	3.54 ± 0.01 ^{b}
Isolate ALT1	25 ± 1.1 ^{a}	26.0 ± 1.4 ^{a}	16.9 ± 1.5 ^{a}	5.22 ± 0.25 ^{a}
0.7 mM Cd	15.2 ± 0.9 ^{cd}	14.5 ± 1.3 ^{d}	11.9 ± 0.8 ^{b}	2.84 ± 0.10 ^{d}
1.4 mM Cd	12.1 ± 0.7 ^{e}	11.1 ± 1.2 ^{e}	9.2 ± 0.7 ^{c}	2.25 ± 0.17 ^{ef}
2.1 mM Cd	9 ± 0.8 ^{f}	10.1 ± 1.1 ^{e}	7.4 ± 1.1 ^{c}	1.88 ± 0.40 ^{f}
0.7 mM + ALT1	17.38 ± 1.1 ^{c}	18.3 ± 1.0 ^{c}	12.5 ± 1.5 ^{b}	4.16 ± 0.36 ^{b}
1.4 mM + ALT1	15 ± 0.5 ^{d}	17.2 ± 1.2 ^{c}	12.4 ± 1.4 ^{b}	3.87 ± 0.11 ^{c}
2.1 mM + ALT1	14 ± 0.5 ^{de}	13.4 ± 0.9 ^{d}	9.5 ± 1.0 ^{c}	2.56 ± 0.11 ^{de}

Source: https://www.mdpi.com/2073-4395/11/2/404

Bacillus pumilus induced tolerance of Maize *(Zea mays L.)* against Cadmium (Cd) stress (2021)

Table 1: Preparation of treatment applications.

Treatments	*Bacillus pumilus* inoculation	$CdSO_4$ (mg kg^{-1})
T1	−	0
T2	+	0
T3	+	0.25
T4	+	0.50
T5	+	0.75
T6	−	0.25
T7	−	0.50
T8	−	0.75

Table 2: Accumulation of micro and macro nutrients by maize plants. All treatments sharing common letter are similar otherwise difer signifcantly at $p<0.05$. T1=control, T2=inoculated seed, T3=0.25 mg $CdSO_4$ 100 mL $^{-1}$+uninoculated seed, T4=0.50 mg $CdSO_4$ 100 mL $^{-1}$+uninoculated seed, T5=0.75 mg $CdSO_4$ 100 mL^{-1}+uninoculated seed, T6=0.25 mg $CdSO_4$ 100 mL^{-1},+Inoculated seed, T7=0. $CdSO_4$ 100 mL^{-1}+Inoculated seed, T8=0.75 mg $CdSO_4$ 100 mL^{-1}+Inoculated seed.

Nutrients	**Nutrient concentration**							
	T1	T2	T3	T4	T5	T6	T7	T8
Cu (mg/g)	4.33±0.0.35C	6.84±0.171B	4.33±0.37C	2.66±0.151D	1.98±0.13BD	2.66±0.29CD	2.37±0.28D	2.04±0.26D
Mn (mg/g)	3.28±0.016C	6.40±0.26B	10.47±0.22A	3.33±0.07C	1.78±0.07BD	1.62±0.18D	1.16±0.04D	1.62±0.21D
Na (g/Kg)	1.57±0.03D	5.13±0.18B	6.11±1.21A	2.56±0.19C	2.27±0.17C	0.90±0.04E	0.896±3.03E	0.49±0.5E
K (mg/g)	2.62±0.14A	2.72±0.15A	1.44±0.03B	1.03±0.01BC	0.38±0.01D	0.41±0.02D	0.83±0.22CD	0.29±0.02D
Fe (mg/g)	2.89±0.24A	1.65±0.15BC	1.41±0.15BCD	0.70±0.14BCD	1.15±2.26BCD	2.04±8.23AB	0.54±1.19D	1.29±0.20BCD
Ca (g/Kg)	1.68±0.12D	4.53±0.14B	6.81±0.13A	5.26±0.020B	2.49±0.13C	2.36±0.19DCD	2.47±0.20C	O6.07±0.14E
Mg (g/Kg)	1.18±0.01AB	1.36±0.142A	0.75±0.13BCD	1.11.±0.020ABC	O.62±0.019CD	1.066±0.020ABCD	0,56±0.0135D	0.66±0.54CD

Source: https://www.nature.com/articles/s41598-021-96786-7

Combination of Siderophore-Producing Bacteria and *Piriformospora indica* Provides an Efficient Approach to Improve Cadmium Tolerance in Alfalfa (2021)

Table 1: Multiple PGP activities of Sinorhizobium meliloti isolates (B1 and B2) and Pseudomonas fluorescens (B3).

Bacterial isolates	**Plant growth-promoting traits**					
	P solubilization (mg l^{-1})	Siderophore production	IAA production[1]	HCN production score[2]	ACC deaminase activity	% S.E.[3]
B1	302	-	2.5	+	+	125.6
B2	368	+	2.7	+	+	126.4
B3	373	+	2.9	+	+	-

[1] Halo diameter (HD)/colony diameter (CD); [2] The point given for HCN production was excluded;
[3] Symbiotic efficiency = (nitrogen content in inoculated plants with rhizobium/nitrogen content in treated plants with nitrogen fertilizer) × 100

Table 2: Effect of bacterial and fungal microorganisms with different abilities of siderophore production [B1*: S. meliloti (Sid-)*, B2: *S. meliloti (Sid+)*, B3:*P. fluorescens (Sid+)*, F =*P. indica (Sid+)*] on nitrogen and phosphorus concentrations in the shoot of alfalfa under Cd stress. Values are the mean of three individual replicates. Mean value ± standard deviation with different letters is significantly different ($P \leq 0.05$) according to Tukey's HSD test.

Cadmium				
Microbe				
	Cd0	Cd2	Cd5	Cd10
C	2.86 ± 0.04 $^{c-g}$	2.56 ± 0.11 $^{g-j}$	2.22 ± 0.09 $^{j-m}$	2.49 ± 0.13 $^{g-k}$
B1	3.54 ± 0.20 ^{ab}	3.03 ± 0.11^{bc}	3.12 ± 0.16 $^{c-f}$	2.82 ± 0.06 $^{c-g}$
B2	3.57 ± 0.25 ^{a}	3.13 ± 0.11^{bc}	2.76 ± 0.29 $^{c-h}$	2.82 ± 0.15 $^{c-g}$
B3	2.97 ± 0.06 ^{bcd}	2.85 ± 0.12 $^{c-g}$	2.65 ± 0.19 $^{h-l}$	2.17 ± 0.09 $^{d-i}$
F	2.88 ± 0.13 $^{c-f}$	3.04 ± 0.06 ^{bc}	2.29 ± 0.04 $^{i-l}$	2.26 ± 0.05 ^{klm}
F + B1	3.14 ± 0.04 ^{bc}	3.04 ± 0.01^{bc}	2.55 ± 0.15 $^{g-j}$	2.11 ± 0.03 ^{lm}
F+ B2	3.07 ± 0.04 ^{bc}	2.94 ± 0.04 $^{b-e}$	2.25 ± 0.15 ^{jkl}	2.11 ± 0.01 ^{lm}
F+ B3	3.31 ± 0.03 ^{bcd}	2.57 ± 0.01 $^{e-j}$	2.11 ± 0.01 ^{lm}	1.85 ± 0.06 ^{m}
Phosphorous (mg g^{-1} DW)				
C	2.81 ± 0.52 $^{f-i}$	2.57 ± 0.50 $^{i-m}$	1.97 ± 0.22^{opq}	1.97 ± 0.04 ^{opq}
B1	3.15 ± 0.71 ^{de}	3.19 ± 0.64 ^{d}	2.81 ± 0.36 $^{f-j}$	2.81 ± 0.41 $^{f-j}$
B2	3.10 ± 0.09 ^{def}	2.64 ± 0.14 $^{h-i}$	2.49 ± 0.32 $^{i-m}$	2.49 ± 0.33 $^{i-m}$
B3	3.67 ± 0.20 ^{c}	2.78 ± 0.04 $^{f-j}$	2.48 ± 0.32 $^{j-m}$	2.51 ± 0.24 $^{j-m}$
F	5.59 ± 0.31 ^{a}	5.27 ± 0.12 ^{a}	3.08 ± 0.58 ^{def}	2.94 ± 0.29 ^{def}
F + B1	4.53 ± 0.45 ^{b}	4.22 ± 0.14 ^{b}	3.18 ± 0.60 ^{d}	3.24 ± 0.18 ^{d}
F+ B2	3.21 ± 0.51 ^{d}	3.02 ± 0.09 $^{d-g}$	2.69 ± 0.23 $^{g-l}$	2.54 ± 0.43 $^{g-l}$
F + B3	2.74 ± 0.08 $^{g-k}$	2.53 ± 0.28 $^{i-m}$	2.14 ± 0.23 ^{nop}	2.02 ± 0.24 ^{nop}

Source: https://link.springer.com/article/10.1007/s00248-020-01629-z

Effects of biochar and crop straws on the bioavailability of cadmium in contaminated soil (2020)

Table 1: Assignment of characteristic absorption bands in infrared spectra.

Absorption band position/cm^{-1}	**Absorption band assignment**
650-520	Stretching vibration of -OH (carbohydrates)
870	Carbonate substance
1020-970	Stretching vibration of C-O or stretching vibration of inorganic SiO (carbohydrates)
1080–1020	Asymmetric stretching vibration of C-O (phenols or alcohols)
1170–1150	Stretching vibrations of C-OH and C-O (aliphatic)
1220–1210	Asymmetric stretching vibration of C-O or deformable vibration of N-H (hydroxyl)
1250–1230	Stretching vibration of C-O or stretching vibration of SiO in organosilicon compounds (phenols)
1460–1400	Symmetric deformable vibrations of $-CH_3$ and $-CH_2$, and asymmetric stretching vibration on hydroxyl group, or stretching vibration of C-OH (aliphatic)
1555–1540	Deformable vibration of -N-H (secondary amide)
1650–1600	Stretching vibration of -C = O, stretching vibration of C = C on aromatic group or antisymmetric vibration of organic carboxylate COO- (aldehyde, ketone)
1720–1690	Stretching vibration of -C = O, stretching vibration of C = O in hydroxyl group (hydrogen bond formed between molecules and within molecules)
2870–2850	Symmetric stretching vibrations of $-CH_3$ and $-CH_2$
2900	Stretching vibration of C-H (aliphatic)
2930	Asymmetric stretching vibration of $-CH_2$ (aliphatic)
2950	Asymmetric stretching vibration of $-CH_3$ (aliphatic)
2060–3030	Stretching vibration of -C-H (aromatic nucleus)
3500–3300	Stretching vibrations of -COOH and -OH or stretching vibration of N-H and hydrogen bond association

According to Huang (2013), etc.

Table 2: Effect of biochar and crop straw addition on the biomass and yield of peanut.

Treatments	**Biomass**				**Yield**	
	Aboveground ($\text{g}\cdot\text{plant}^{-1}$)	**Underground ($\text{g}\cdot\text{plant}^{-1}$)**			**Number of effective pods per plant**	**Number of seeds per plant**
		Roots	**Seeds**	**Shells**		
$\mathbf{T_{CK}}$	9.45 ± 1.54c	1.61 ± 0.29c	6.26 ± 0.46c	3.75 ± 0.34b	15.00 ± 0.58c	19.00 ± 1.15c
$\mathbf{T_{B}}$	17.61 ± 2.33a	4.05 ± 0.09a	11.17 ± 0.55a	5.17 ± 0.32a	21.00 ± 0.57a	30.67 ± 0.58a
$\mathbf{T_{P}}$	14.00 ± 1.38b	2.16 ± 0.09b	9.91 ± 1.62b	4.62 ± 1.14b	15.33 ± 1.53b	21.00 ± 1.53b
$\mathbf{T_{R}}$	14.97 ± 1.25b	2.37 ± 0.24b	10.50 ± 0.82b	4.85 ± 0.77b	16.33 ± 0.57b	22.00 ± 1.15b

Treatments: TCK: control, TB: biochar addition, TP: peanut straw addition, TR: rice straw addition.
All values are presented as mean ± standard error ($n = 3$), different letters in the same row indicate significant differences between treatments ($P < 0.05$).

Source: https://www.nature.com/articles/s41598-020-65631-8

Bioremediation of cadmium-contaminated paddy soil using an autotrophic and heterotrophic mixture (2020)

Table 1: Physiochemical properties of experimental soils, mean ± standard deviation (n = 3)

Characteristics	Soil 1	Soil 2	Soil 3
Soil pH	5.96 ± 0.23	5.89 ± 1.05	6.05 ± 0.27
Soil ORP	290.30 ± 21.40	322.30 ± 20.60	250.80 ± 18.10
Available N (mg kg^{-1})	234.67 ± 60.48	214.33 ± 54.05	223.67 ± 36.75
Available P (mg kg^{-1})	0.64 ± 0.35	4.25 ± 3.15	1.32 ± 1.38
Available K (mg kg^{-1})	108.33 ± 17.90	101.67 ± 9.24	119.67 ± 19.22
Total N (g kg^{-1})	2.38 ± 0.33	2.12 ± 0.31	2.28 ± 0.14
Total P (g kg^{-1})	0.48 ± 0.02	0.66 ± 0.18	0.54 ± 0.02
Total K (g kg^{-1})	13.7 ± 0.20	14.7 ± 0.78	13.77 ± 0.71
OM (%)	4.66 ± 0.90	3.79 ± 0.39	4.26 ± 0.49
Total Cd (mg kg^{-1})	9.09 ± 0.44	10.03 ± 0.45	9.73 ± 1.62

Table 2: Mantel test of different environmental factors and the change of microbial community structure. The r value represents the correlation between different factors, and the p value indicates the correlation is significant.

	r	p
Total factors	0.366	0.001
pH	0.447	0.001
ORP	0.163	0.006
Total Cd	0.357	0.001

Source: https://pubs.rsc.org/en/Content/ArticleLanding/2020/RA/D0RA03935G#!divAbstract

Mechanism of Remediation of Cadmium-Contaminated Soil with Low-Energy Plant Snapdragon (2020)

Table 1: Enrichment Factor (EF) and Translocation Factor (TF) in snapdragons under different cadmium concentrations.

	TF	EF
Control	0.60	
1.0 mg/kg Cd	0.71	0.17
2.5 mg/kg Cd	0.81	0.10

Table 2: Effects of Cd on mineral nutrient accumulation in snapdragon tissues (mg/kg, DW).

	Zn	B	P	Fe	Mn	Ca	Cu	Mo	Mg
Root									
Control	386^{a}	85^{a}	211^{a}	510^{a}	168^{a}	622^{a}	25^{a}	119^{a}	$6,593^{a}$
1.0 mg/kg	355^{ab}	59^{ab}	190^{b}	263^{ab}	134^{ab}	621^{a}	12^{a}	110^{b}	$5,197^{b}$
2.5 mg/kg	560^{b}	47^{b}	152^{b}	211^{b}	115^{b}	617^{b}	11^{a}	112^{b}	$3,341^{c}$
***p*-value**	0.021	0.03	0.009	0.041	0.004	0	0.071	0.001	0.033
Shoot									
Control	17^{a}	58^{a}	145^{a}	28^{a}	32^{a}	379^{a}	11^{a}	39^{a}	$1,341^{a}$
1.0 mg/kg	13^{ab}	36^{b}	129^{b}	16^{b}	20^{ab}	314^{ab}	7^{b}	27^{b}	689^{a}
2.5 mg/kg	28^{b}	35^{b}	118^{b}	12^{b}	28^{b}	192^{b}	5^{b}	28^{b}	341^{a}
***p*-value**	0.047	0.029	0.001	0.031	0.017	0.033	0.049	0.015	0.114

Different letters stand for statistical differences at $p \leq 0.05$.

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7158863/#!po=45.6522

Table 1: Cd concentration in wheat and soil globally.

Cd (mg/Kg) in Wheat; Average or Range	Cd (mg/Kg) in Soil; Average or Range	Soil Characteristics	Remarks	Area
0.14 (grain)	0.38	pH = 5.9 CEC (cmol/Kg) = 21.3 OM (%) = NR ** Clay (%) = 15.8	Yangmai16 *	The north of Zhejiang Province, China
0.12 (grain)	0.36	pH = 4.9 CEC (cmol/Kg) = 34.6 OM (%) = NR Clay (%) = 117.5	Yangmai16	The east of Zhejiang Province, China
3.17 (root) **1.11 (stem)** **0.25 (grain)**	2.06	pH = 7.5 CEC (cmol/Kg) = 7.6 OM (%) = NR Clay (%) = NR	Zhengmai7698	Henan Province, China
0.006 to 0.17 (grain)	0.09 to 1.0	pH = 6.6 CEC (cmol/Kg) = 18.2 OM (%) = 3.0 Clay (%) = NR	NR	Kunshan, China
0.247 (grain)	0.10	pH = 7.5 CEC (cmol/Kg) = NR OM (%) = NR Clay (%) = NR	-	Brandon, Manitoba, Canada
0.01 to 0.08 (grain)	0.21	pH = 5.3 CEC (cmol/Kg) = 31 OM = NR Clay (%) = NR	-	São Gotardo (MG), Brazil
0.95 (root) **0.60 (stem)**	0.27	pH = 7.8 CEC (cmol/Kg) = NR OM (%) = 0.7 Clay (%) = NR	-	Khuzestan Province, Iran
0.01 to 0.02 (grain) **0.01 to 0.03 (grain)**	3.2	pH = 7.6 CEC (cmol/Kg) = NR OM = 0.14 Clay (%) = 46	Rushan Falat	Qom, Iran
0.93 (grain) **0.16 (stem)** **0.67 (root)**	NR	pH = NR CEC (cmol/Kg) = NR OM = NR Clay (%) = NR	-	Lahore, Pakistan
0.003 to 0.03 (grain)	NR	pH = NR CEC (cmol/Kg) = NR OM = NR Clay (%) = NR	-	Sydney, Australia

* Local names; ** not reported.

Table 2: Gene families and channels involved in the Cd uptake, transport, and metabolism in wheat.

Name	Remarks
AtIRT1	A plasma membrane transporter. Involved in entrance of Cd into root.
TcZNT1	Involved in entrance of Cd to root.
OsNRAMP1	Cd-influx transporter in the plasma membrane. Involved in entrance of Cd into root.
OsNRAMP5	Cd-influx transporter in the plasma membrane. Involved in entrance of Cd into root.
AtNRAMP6	An intracellular metal transporter. Involved in entrance of Cd into root.
TaLCT1	An influx transporter in wheat. Involved in entrance of Cd into root.
YSL	A kind of oligopeptide transporter. Involved in entrance of Cd into root over Cd-chelates across plant cell membranes.
P_{1B}-ATPases	A group of ubiquitous membranes. Transporting Cd from root to shoot.
CNGC gene family	Ca^{2+} channels in root protoplast plasma membrane. Indirectly involved in entrance of Cd into root. Responsible for coding of HACCs, VICCs, and DACCs *.
DACCs	Ca^{2+} channels. Involved in entrance of Cd into root.
HACCs	Ca^{2+} channels. Involved in entrance of Cd into root.
VICCs	Ca^{2+} channels. Involved in entrance of Cd into root.

* Depolarization-activated calcium channels (DACCs), hyper polarization-activated calcium channels (HACCs) and voltage-insensitive cation channels (VICCs).

Table 3: Reported methods for decreasing the uptake of Cd by wheat plants.

Decreasing of Cd Accumulation in Root/Stem or Straw/Grains	Cd Concentration in Wheat after Treating (mg/Kg)	Method	Remarks
48.3% (in straw) **97.8% (in grain)**	0.80 (in shoot) 0.01 (in grain)	Using rice husk biochar	Mixing silicon-rich biochar with soil
54% (in root) **50% (in shoot)** **65% (in grains)**	2.0 (in root) 1.1 (in shoot) 0.2 (in grain)	Using co-composted farm manure and biochar	Mixing organic amendments with soil
69% (in root) **67% (in shoot)** **62.5% (in grains)**	12 (in root) 2.7 (in shoot) 0.15 (in grain)	Using rice husk biochar	Mixing biochar with soil
55% (in root) **51% (in shoot)**	1.2 (in root) 0.7 (in shoot)	Using biochar	Mixing biochar with soil under stress conditions
57% (in grains)	0.2 (in grain)	Using biochar	Mixing biochar (5%) with soil
97% (in straw)	>0.2 (in straw)	Using limestone + biochar	Mixing limestone + biochar with soil
77% (in grains)	1.1–0.2 (in grain)	Using zinc oxide nanoparticles	Foliar application
55% to 69% (in root)	1–0.6 (in root)	Using zinc	Using $ZnSO_4$ in nutrient solution
7%–24% (in root) **13%–37% (in stem)** **13%–50% (in grains)**	4–3 (in root) 3.8–2.2 (in stem) 0.2–0.9 (in grain)	Using zinc	Foliar application
10%–31% (in root) **27%–52% (in shoot)** **33%–70% (in grains)**	2.7–2.0 (in root) 1.6–0.9 (in shoot) 0.5–0.2 (in grain)	Using zinc–lysine	Foliar application
19%–64% (in root) **11%–53% (in shoot)** **20%–82% (in grains)**	12–5 (in root) 6–2 (in shoot) 1.1–0.3 (in grains)	Using silicon nanoparticles	Foliar application
30% (in shoot)	1.2 (in shoot)	Using inorganic silicon fertilizer	Mixing the fertilizer with soil
24% (in grains)	0.35 (in grain)	Using sodium sulfate	Mixing with soil
40% (in root)	NR	Using bacteria	Using *Ralstonia eutropha* Q2-8

* NR = Not reported.

Source: https://www.mdpi.com/2223-7747/9/4/500/htm

Toxicity of cadmium and its competition with mineral nutrients for uptake by plants: A review (2020)

Table 1: Cadmium contents in primary pollution sources regarding farmland soils[a])

Pollution source	mg kg^{-1}/mg L^{-1}/ng L^{-1}/μg L^{-1} product[b])	mg kg^{-1} P
Fertilizer		
Complete fertilizer	23–29	**418–527**
Single superphosphate	16–26	**186–302**
Superphosphate	13–34	**151–395**
Rock phosphate	7.2–47	**54–303**
High-analysis fertilizer	< 0.6–5.6	**15–118**
Double superphosphate	< 0.6–12	**< 3.6–72**
Triple superphosphate	0.8–7.0	**24–35**
Mono-ammonium phosphate	1.8–8.1	**12–37**
Di-ammonium phosphate	4.3–6.6	**22–28**
Sewage Suldge	5.0-3.32	**–c)**
Organic manures	0.1–11	**-**
Irrigation waste water	0.05-0.35	**-**
Atmospheric deposition		
Dry deposition	0.03–8	**-**
Wet deposition	**0.01–52**	**-**

a)Data adapted from Kidd et al. (2007), Connan et al. (2013), Jiang et al. (2014), Nookabkaew et al. (2016), and Kumarpandit et al. (2017).

b)Unit for Cd content is mg kg^{-1} except that in irrigation waste water, dry deposition, and wet deposition which is mg L^{-1} , ng m^{-3} , μg L^{-1} , respectively.

c)Not applicable.

Table 2: Summary of transporters related to Cd uptake and transport.

Transporter	Metal	Plant species	Tissue expression/subcellular localization	References
AtCAX2	Cd/Mn/Ca	Arabidopsis	Vacuolar membrane	**Hirschi *et al.*, 2000; Shigaki and Hirschi, 2006**
AtCAX4	Cd/Ca	Arabidopsis	Vacuolar membrane	**Cheng *et al.*, 2002**
AtHMA2	Cd/Zn	Arabidopsis	Plasma membrane	**Hussain *et al.*, 2004; Verret *et al.*, 2004**
AtHMA3	Cd/Zn/Co/Pb	Arabidopsis	Vacuolar membrane	**Morel *et al.*, 2009**
AtHMA4	Cd/Zn/Pb/Co	Arabidopsis	Plasma membrane	**Verret *et al.*, 2004; Mills *et al.*, 2005**
AtATM3	Cd/Pb	Arabidopsis	Mitochondrial membrane	**Kim *et al.*, 2006**
AtNRAMP6	Cd	Arabidopsis	Leaves and flowers	**Cailliatte *et al.*, 2009**
AtPDR8	Cd/Pb	Arabidopsis	Root hairs/epidermal cells	**Kim *et al.*, 2006**
OsNRAMP5	Cd/Mn	Rice	Roots/plasma membrane	**Sasaki *et al.*, 2012**
OsHMA2	Cd/Zn	Rice	Roots/plasma membrane	**Satoh-Nagasawa *et al.*, 2011; Takahashi *et al.*, *2012; yamaji et al.,2013***
OsHMA3	Cd	Rice	Root/Tonoplast	**Ueno et al., 2010; Miyadate et al., 2011**
OsIRT1	Cd/Fe	Rice	Roots	**Nakanishi *et al.*, 2006**
OsIRT2	Cd/Fe	Rice	Roots	**Nakanishi *et al.*, 2006**
OsLCT1	Cd	Rice	Leaf nodes/plasma membrane	**Uraguchi et al., 2011**
OsLCD	Cd	Rice	Vascular tissues in roots and phloem companion celles in leaves	**Shimo et al., 2011**
OsNRAMP1	Cd/Fe	Rice	Plasma membrane	**Takahashi et al., 2011**
OsNMP5	Cd/Mn/Fe	Rice	Plasma membrane	**Ishimaru *et al.*, 2012**
OsZIP1	Cd/Zn	Rice	Roots	**Ramesh *et al.*, 2003**
ZNT1	**Cd/Zn**	***Thlaspi caerulescens***	**Roots and shoot**	**Pence *et al.*, 2000**

Source: https://www.sciencedirect.com/science/article/abs/pii/S1002016020600029

Table 1: Some selected references of Cd contamination world-wide exceeding permissible limits.

Country (City)	Cd (mg kg^{-1})	Allowable limit (country)	Soil pH	References
Spain (Barakaldo)	4.5	1 (mg kg^{-1})	8.74	Galdames et al. 2017
Spain (Azkoitia)	0.40	1 (mg kg^{-1})	7.5	Galdames et al. 2017
China (Tianjin)	2.1	≤0.60 (mg kg^{-1})	7.4	Wang et al. 2017
China (Yixing)	5	≤0.30 (mg kg^{-1})	5.36	Bian et al. 2014
China (Xinxiang)	0.88	≤0.60 (mg kg^{-1})	8.3	Li et al. 2016
China (Xiangtan)	1.42	≤0.30 (mg kg^{-1})	5.01	Shi et al. 2019
China (Youxi)	15.44	≤0.30 (mg kg^{-1})	5.70	Chen et al. 2016
Belgium (Sclaigneaux)	24	≤10 (mg kg^{-1})	6.57	Houben et al. 2013
Austria (Arnoldstein)	12.5	≤10 (mg kg^{-1})	5.97	Karer et al. 2015
Czech Republic (Trhové Dušníky)	42.7	≤10 (mg kg^{-1})	6.6	Břendová et al. 2015
Nigeria	0.00 to 1.02	3 (μg g^{-1})	5.14–6.73	Diagboya et al. 2015
New Zealand	0.79	3 (mg kg^{-1})	6.3	Stafford et al. 2018
New Zealand	0.61	3 (mg kg^{-1})	5.6	Stafford et al. 2018
Pakistan (Multan)	7.35	0.6 (mg kg^{-1})	7.23	Rehman et al. 2017
Pakistan (Multan)	3.02	0.6 (mg kg^{-1})	7.25	Qayyum et al. 2017
Korea (Seosan)	17	b4 (mg kg^{-1})	6.3	Ok et al. 2011
Malaysia (Kuala Lumpur)	5.20	0.80 (mg kg^{-1})	7.83	Ashrafi et al. 2015
Egypt (Gharbia)	122	≤10 (mg kg^{-1})	7.89	Mahmoud and Nasser, 2016
Iran (Zanjan)	41.2	0.80 (mg kg^{-1})	7.19	Abbaspour and Ahmad, 2011
United Kingdom (Staffordshire)	**119**	**1.8 (mg kg^{-1})**	**6.2**	Beesley and Marmiroli, 2011

Table 2: Biochar as an adsorbent of cadmium.

Biochar type	Pyrolysis temperature and time	Chemical composition of biochar	Instruments used	Adsorbed compound and extraction method	Efficiency	Mechanisms involved	References
Rice straw biochar	500 °C (2 h)	C 54% and N 1.6%, PO4–3 8.02 mg g^{-1}, CO3^{-2} 10.3 mg g^{-1}, Ca^{2+} 9.69 mg g^{-1}, Mg^{2+} 2.32 mg g^{-1}	Atomic absorption spectrophotometer	Cd, Pb (BCR fraction, TCLP and $CaCl_2$)	Acid-soluble Cd reduced by (27.5–34.8%), TCLP extract (14.7–16.9%), $CaCl_2$ (28–32%)	Surface functional groups (hydroxyl, carboxylic, phenolic), adsorption	**Bashir et al. 2018a**
Sugarcane bagasse feedstock biochar	500 °C (2 h)	C% 640, Total N 11.40 g kg^{-1}, Total P 16.21 g kg^{-1}, Total P 23.92 g kg^{-1},	AAS, spectrophotometer	Cd, Cr (DTPA-extracted)	Cd concentration decreased in mash beans tissues by 28.74 and 32% in Cd- and Cr–Cd-contaminated	Insoluble mineral formation through complexation and precipitation	**Bashir et al. 2018b**

					soil		
Oil palm fibers biochar	700 °C (4 h)	C% 86.7, O% 3.2, H% 1.8, K% 1.3,	ICP-AES, hydrogen generation-atomic fluorescence spectrometer, graphite furnace atomic absorption	Cd, As (Metals fractionation), DCB solution	Cd and As in rice grains were decreased by 93% and 61%	Biochar's liming effect leads to the raise in soil pH, which can greatly reduce the mobility and bioavailability of Cd	**Qiao et al. 2018**
Wheat straw biochar	485 °C	Total N 5.9 g kg^{-1}, Total P 14.4 g kg^{-1}	spectrometer. Atomic absorption spectrometry using a graphite furnace (GFAAS)	Cd, Pb ($CaCl_2$),	Biochar addition reduced Cd by 30 and 5% and Pb by 50 and 19%	An increase in soil pH contributed to the decrease in Cd and Pb mobility	**Sui et al. 2018**
Chicken manure biochar	550 °C	pH 7.5, Cd 1.3 mg kg^{-1}	ICP-OES, ICP-MS	AS, Cd (1 M NH4NO3 extraction)	higher amounts of Cd are extracted by NH4NO3	Processes involved (the decline in pH, Cd desorption by NH4+ and the formation of soluble metal-complexes)	**Rocco et al. 2018**
Rice straw biochar	400 °C (2 h)	Organic carbon 62.5%, Total N 1.38%, Total P 0.65%, Total K 1.18%	X-ray diffraction, FTIR, scanning electron microscopy, (atomic absorption)	Cd, Pb	76.8% and 74.2%, reduction in Cd and Pb accumulation by canola shoots	Presence of functional groups (C=H, C–C–C, Al–OH–Fe, i-O-Si, O-P-O, C–OH and C=C)	**Mahmoud et al. 2018**
Malaysian Palm Oil Board biochar	250 °C	pH 9.33, Total C (%) 61.87, N (%) 1.096	ICP-OES, Atomic adsorption spectrometry, ICP-OES	Cd, Pb (SRW-extractable)	Cd and Pb significantly decreased with the increasing incubation time	Oxygen-containing functional groups, which are expected to be more effective in retaining heavy metals	**Fahmi et al. 2018**
Rice straw biochar	450 °C and 550 °C	pH 10.0, C 42.3%, N 1.5%, P 0.3%, K 2.54%	Atomic absorption spectrophotometer	Cd (AB-DTPA extractable)	Cd was lowered by 46%, 45%, and 55% in roots, shoots and grains and BC application reduced	The decreased Cd contents may be attributed to increased concentration of organic matter. While,	**Abbas et al. 2018**

					bioavailable Cd in soil	abridged seed Cd may be due to plant high which can hold Cd in shoots and roots.	
Scot pine and silver birch biochar	450 °C (2 h and 45 min) 700 °C (2 h and 45 min)	pH 8.56, TC (%) 96.3 pH 8.69, TC (%) 95	Atomic absorption spectrophotometer, flame atomic absorption spectrophotometer (FAAS), SEM	Cd, Cu, Pb, Zn	Increase in metals concentration resulted occupying available adsorption sites	Higher cation exchange capacity and increase of specific surface area	**Komkiene and Baltrenaite , 2016**
Wheat straw biochar	450 °C	Organic Matter (g kg^{-1}) 467.2, CEC (cmol kg^{-1}) 21.70, Total N (g kg^{-1})	SEM, X-ray spectroscopy, FTIR spectra	Cd, Pb (BCR)	Exchangeable fractions of Cd and Pb were significantly decreased	Decreased content may be attributed to the dilution effect of the amendment	**Cui et al. 2016**
Bamboo biochar	750 °C (3 h)	5.90 Nitrogen (g kg^{-1}) 4.5, cation exchange capacity (cmol kg^{-1}) 15	XRD and FTIR spectroscopy ,	Cd, Cu, Pb and Zn ($CaCl_2$ and DTPA extraction), Sequential extraction	5% rice straw biochar was more effective in reducing $CaCl_2$ and DTPA extractable metals	Possible mechanism (the formation of precipitates, increases in the specific adsorption of metals, increases in electrostatic interactions).	**Lu et al. 2017**
Peanut shell biochar	350–500 °C	pH (H_2O) 9.95, Total C (g kg^{-1}) 133.7, Total Cd (mg kg^{-1}) 0.123	FAAS	Cd, Pb (sequential extraction)	Cd and Pb concentrations in rice roots were lower by 50.8 and 22.6% using PBC	Biochar enhanced soil pH, which led to the precipitation of Cd and Pb as $CdCO_3$ and$Pb_5(PO_4)_3OH$	**Xu et al. 2018**
Rice straw biochar	**500 °C (3 h)**	**pH 9.5, total organic C 29.3 g kg^{-1},N 1.83%, P 1.43%, K 18.9%**	**ICP-MS**	**Cd (EDTA extraction, sequential extraction)**	**Bioavailable Cd decreased from 0.45 and 0.85 mg kg^{-1} to 0.05 and 0.39 mg kg^{-1}**	**Biochar transforms soluble Cd to stable form, especially formation of metal (hydr)oxide, carbonate**	**Run-Hua et al. 2017**

Source: https://www.sciencedirect.com/science/article/abs/pii/S0048969719361170

Table 1: Mass of barley plants and Cd content in the plants in the earing phase (experiment 1)

Variant	**Plant weight (dry matter), g/pot**	**Cd content in plants, mg/kg dry mass**
Vegetative mass		
Control – NPK	2.16 ± 0.05a	Traces
Cd + NPK	2.21 ± 0.03a	7b
Cd + *P. fluorescens* 21 + NPK	2.14 ± 0.04a	3a
Roots		
Control – NPK	0.52 ± 0.06a	Traces
Cd + NPK	0.54 ± 0.05a	81
Cd + *P. fluorescens* 21+ NPK	0.62 ± 0.07b	71

Mean data on four replicates of the experiment ± confidence interval are reported. Errors in determining the Cd content in plants did not exceed 15%. The values indicated by different letters differed at a significance level of 5%.

Table 2: Mass of barley plants and Cd content in the plants in the full ripeness phase (experiment 2)

Variant	**Plant weight (dry matter), g/pot**				**Cd content in plants, mg/kg dry mass**		
	grain	**straw**	**roots**	**total**	**grain**	**straw**	**roots**
Control – NPK	33.6	33.4	3.7	70.7	Not detected		
Cd + NPK	25.9	29.9	3.7	59.5	2	18	143
Cd + *P. fluorescens* 21 + NPK	32.4	37.3	4.4	74.0	2	17	88
Cd + *P. putida* 23 + NPK	33.7	36.5	5.4	75.6	2	19	90
Cd + zeolite + NPK	32.9	33.7	4.8	71.5	2	16	120
Cd + *P. fluorescens* 21 + zeolite + NPK	35.3	37.4	5.6	78.3	2	15	100
LSD$_{05}$	3.0	3.7	1.5	10.0	1.0	3.0	11.1

Table 3: Removal of Cd by barley plants in the phase of full ripeness (experiment 2)

Variant	**Cd removal by plants**				
	grain	**straw**	**roots**	**total**	
	µg/pot			**mg/pot**	**% of added Cd**
Control – NPK	Not det.	Not det.	Tr.	Tr.	Tr.
Cd + NPK	52	538	529	1.1	2.2
Cd + *P. fluorescens* 21 + NPK	65	634	387	1.1	2.2
Cd + *P. putida* 23 + NPK	68	694	486	1.2	2.5

Cd + zeolite + NPK	66	539	576	1.2	2.4
Cd + *P. fluorescens* 21 + zeolite + NPK	71	561	560	1.2	2.4
LSD$_{05}$	8	75	69	0.2	

Table 4: Reaction of the soil medium after barley growing

Variant	**N**	**P**	**K**	**Ca**	**Mg**	**Fe**	**Zn**	**Mn**	**Cu**
	%				**mg/kg plant matter**				
	Grain								
Control – NPK	1.59	0.41	0.56	0.05	0.02	66	56	22	8
Cd + NPK	1.68	0.44	0.58	0.04	0.02	85	52	18	8
Cd + *P. fluorescens* 21 + NPK	1.42	0.47	0.59	0.03	0.02	95	51	18	8
Cd + *P. putida* 23 + NPK	1.51	0.47	0.57	0.04	0.02	87	52	21	9
Cd + zeolite + NPK	1.42	0.45	0.58	0.03	0.02	100	53	20	8
Cd + *P. fluorescens* 21 + zeolite + NPK	1.50	0.50	0.58	0.04	0.02	101	52	18	9
	Straw								
Control – NPK	0.37	0.04	2.5	0.07	0.01	100	20	98	8
Cd + NPK	0.41	0.06	2.1	0.09	0.01	100	26	78	8
Cd + *P. fluorescens* 21 + NPK	0.37	0.07	2.1	0.08	0.01	110	32	87	8
Cd + *P. putida* 23 + NPK	0.42	0.07	2.4	0.06	0.01	110	51	108	9
Cd + zeolite + NPK	0.43	0.05	1.9	0.07	0.01	123	36	94	8
Cd + *P. fluorescens* 21 + zeolite + NPK	0.35	0.06	2.0	0.06	0.01	125	38	89	8
	Roots								
Control – NPK	1.30	0.17	0.19	0.32	0.05	1900	203	151	23
Cd + NPK	0.97	0.18	0.40	0.32	0.05	1700	240	110	33
Cd + *P. fluorescens* 21 + NPK	1.03	0.15	0.25	0.33	0.07	1600	185	126	27
Cd + *P. putida* 23 + NPK	1.15	0.16	0.24	0.34	0.06	1800	210	124	28
Cd + zeolite + NPK	1.17	0.16	0.36	0.33	0.06	1600	230	108	27
Cd + *P. fluorescens* 21 + zeolite + NPK	1.00	0.15	0.36	0.33	0.06	1800	257	127	29

Table 5: The contents of biophilous elements in barley plants in the phase of full ripeness (experiment 2)

Experiment no.	**Phase of plant development**	**Variant**	**$\mathrm{pH_{KCl}}$**
1	Earing	Control – NPK	5.13 ± 0.09a
		Cd + NPK	5.23 ± 0.07b
		Cd + *P. fluorescens* 21 + NPK	5.23 ± 0.08b
2	Full ripeness	Control – NPK	5.31 ± 0.07a
		Cd + NPK	5.47 ± 0.08b
		Cd + *P. fluorescens* 21 + NPK	5.42 ± 0.09b
		Cd + *P. pitida* 23 + NPK	5.31 ± 0.06a
		Cd + zeolite + NPK	5.27 ± 0.05a
		Cd + *P. fluorescens* 21 + zeolite + NPK	5.32 ± 0.05a

The mean of four replicated. Errors in the determination of macro- and microelements for the variants did not exceed 5 and 15%, respectively.

Table 6: Removal of biophilous elements by barley plants in the full ripeness phase (experiment 2)

	N	**P**	**K**	**Ca**	**Mg**	**Fe**	**Zn**	**Mn**	**Cu**
Variant	Grain								
	mg/pot							µg/pot	
Control – NPK	**534**	**138**	188	**17**	**6.7**	2.2	1.9	**739**	**269**
Cd + NPK	435	114	195	10	5.2	2.2	1.4	518	207
Cd + *P. fluorescens* 21 + NPK	460	**152**	191	10	**6.5**	**3.1**	**1.7**	**583**	**201**
Cd + *P. putida* 23 + NPK	**509**	**159**	192	**14**	**6.7**	**3.0**	**1.8**	**708**	**291**
Cd + zeolite + NPK	467	**148**	191	10	**6.5**	**3.2**	**1.7**	**592**	**263**
Cd + *P. fluorescens* 21 + zeolite + NPK	**530**	**177**	205	**14**	**7.0**	**3.6**	**1.8**	**638**	**318**
	Entire plant								
	mg/pot								µg/pot
Control – NPK	**707**	**157**	**1030**	52	**11.9**	12.6	3.2	**4.6**	**622**
Cd + NPK	594	139	838	49	10.0	11.4	3.1	3.3	567
Cd + *P. fluorescens* 21 + NPK	643	**185**	**985**	55	**13.3**	**14.4**	**3.7**	**4.3**	**708**
Cd + *P. putida* 23 + NPK	**724**	**194**	**1080**	54	**13.6**	**18.6**	**4.8**	**5.3**	**777**
Cd + zeolite + NPK	**668**	**173**	848	50	**12.8**	**15.6**	**4.0**	**4.3**	**663**
Cd + *P. fluorescens* 21 + zeolite + NPK	**717**	**208**	**953**	54	**14.0**	**18.2**	**4.6**	**4.7**	**778**

The values exceeding those for the Cd-contaminated soil without application of bacteria and zeolite at the significance level of 5% are shown in bold.

Source: https://link.springer.com/article/10.1134/S1064229320060113

Table 1: Effects of intercropping with accumulator plants and application of their straw on the biomass of *B. chinensis* in Cd-contaminated soil.

Treatments	**Roots (g/plant DW)**	**Shoots (g/plant DW)**	**Root/shoot ratio**
Experiment 1			
Monoculture	0.36 ± 0.01a	1.70 ± 0.07a	0.21 ± 0.01b
Intercropping with *S. media*	0.25 ± 0.01c	1.23 ± 0.01d	0.20 ± 0.01b
Intercropping with *C. hirsute*	0.24 ± 0.01c	1.06 ± 0.03e	0.22 ± 0.02a
Intercropping with *C. glomeratum*	0.29 ± 0.01b	1.43 ± 0.05b	0.20 ± 0.01b
Intercropping with *G. aparine*	0.28 ± 0.01b	1.34 ± 0.03c	0.21 ± 0.01b
Experiment 2			
Control	0.33 ± 0.02a	1.81 ± 0.01a	0.18 ± 0.01b
Application of *S. media*	0.28 ± 0.01d	0.92 ± 0.01e	0.30 ± 0.02a
Application of *C. hirsute*	0.31 ± 0.01b	1.68 ± 0.01b	0.18 ± 0.01b
Application of *C. glomeratum*	0.28 ± 0.01c	1.00 ± 0.01d	0.28 ± 0.02a
Application of *G. aparine*	0.30 ± 0.01b	1.52 ± 0.01c	0.20 ± 0.01b

Table 2: Effects of intercropping with accumulator plants and application of their straw on the water content of *B. chinensis* in Cd-contaminated soil

Treatments	**Roots (%)**	**Shoots (%)**
Experiment 1		
Monoculture	83.16 ± 0.05a	90.21 ± 0.12b
Intercropping with *S. media*	76.76 ± 0.09d	88.00 ± 0.14c
Intercropping with *C. hirsute*	69.99 ± 0.07e	88.12 ± 0.16c
Intercropping with *C. glomeratum*	80.88 ± 0.02b	90.48 ± 0.13a
Intercropping with *G. aparine*	78.88 ± 0.03c	89.99 ± 0.17b
Experiment 2		
Control	79.56 ± 0.16a	90.38 ± 0.07a
Application of *S. media*	78.82 ± 0.03b	87.53 ± 0.07e
Application of *C. hirsute*	78.28 ± 0.11c	88.34 ± 0.04c
Application of *C. glomeratum*	78.93 ± 0.20b	87.98 ± 0.16d
Application of *G. aparine*	78.88 ± 0.17b	89.21 ± 0.12b

Table 3: Effects of intercropping with accumulator plant and application of their straw on the photosynthetic pigment of *B. chinensis* in Cd-contaminated soil

Treatment	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)	Chlorophyll a/b	Carotenoid (mg/g)
Experiment 1					
Monoculture	0.648 ± 0.002a	0.131 ± 0.004a	0.779 ± 0.006a	4.960 ± 0.036d	0.247 ± 0.002a
Intercropping with *S. media*	0.499 ± 0.009d	0.083 ± 0.003c	0.582 ± 0.011d	6.014 ± 0.011a	0.184 ± 0.003c
Intercropping with *C. hirsute*	0.479 ± 0.006d	0.091 ± 0.007c	0.570 ± 0.001d	5.312 ± 0.040b	0.179 ± 0.005c
Intercropping with *C. glomeratum*	0.578 ± 0.014b	0.111 ± 0.004b	0.689 ± 0.017b	5.232 ± 0.043c	0.207 ± 0.005b
Intercropping with *G. aparine*	0.544 ± 0.003c	0.117 ± 0.003b	0.661 ± 0.006c	4.662 ± 0.036e	0.201 ± 0.002b
Experiment 2					
Control	0.675 ± 0.016a	0.132 ± 0.008a	0.807 ± 0.008a	5.111 ± 0.011c	0.246 ± 0.007a
Application of *S. media*	0.426 ± 0.019d	0.068 ± 0.006c	0.494 ± 0.012d	6.273 ± 0.022a	0.163 ± 0.009c
Application of *C. hirsute*	0.631 ± 0.001b	0.125 ± 0.007a	0.756 ± 0.009b	5.044 ± 0.026d	0.232 ± 0.007a
Application of *C. glomeratum*	0.544 ± 0.004c	0.102 ± 0.005b	0.646 ± 0.009c	5.344 ± 0.040b	0.201 ± 0.008b
Application of *G. aparine*	0.547 ± 0.010c	0.109 ± 0.002b	0.656 ± 0.007c	5.030 ± 0.023d	0.201 ± 0.003b

Table 4: Effects of intercropping with accumulator plant and application of their straw on Cd content of *B. chinensis* in Cd-contaminated soil.

Treatment	Roots (mg/kg)	Shoots (mg/kg)	Translocation factor (TF)	Root bioconcentration factor (root BCF)	Shoot bioconcentration factor (shoot BCF)
Experiment 1					
Monoculture	3.54 ± 0.22d	1.75 ± 0.02c	0.49 ± 0.03ab	0.51 ± 0.03d	0.25 ± 0.00c
Intercropping with *S. media*	3.86 ± 0.08c	1.77 ± 0.04c	0.46 ± 0.00bc	0.55 ± 0.01c	0.25 ± 0.01c
Intercropping with *C. hirsute*	4.43 ± 0.20b	2.24 ± 0.05a	0.51 ± 0.01a	0.63 ± 0.03b	0.32 ± 0.01a
Intercropping with *C. glomeratum*	4.05 ± 0.07c	2.08 ± 0.13b	0.51 ± 0.02a	0.58 ± 0.01c	0.30 ± 0.02b
Intercropping with *G. aparine*	4.81 ± 0.12a	2.29 ± 0.03a	0.48 ± 0.01 b	0.69 ± 0.02a	0.33 ± 0.00a
Experiment 2					
Control	3.74 ± 0.18b	1.90 ± 0.12b	0.51 ± 0.01b	0.53 ± 0.03b	0.27 ± 0.02b
Application of *S. media*	3.88 ± 0.09b	1.93 ± 0.07b	0.50 ± 0.02b	0.55 ± 0.01b	0.28 ± 0.01b
Application of *C. hirsute*	4.30 ± 0.08a	2.46 ± 0.07 a	0.57 ± 0.02a	0.61 ± 0.01a	0.35 ± 0.01a
Application of *C. glomeratum*	2.64 ± 0.03c	1.10 ± 0.05d	0.42 ± 0.02c	0.38 ± 0.00c	0.16 ± 0.01c
Application of *G. aparine*	2.83 ± 0.14c	1.25 ± 0.04c	0.44 ± 0.01c	0.40 ± 0.02c	0.18 ± 0.01c

Source: https://link.springer.com/article/10.1007/s11356-020-09148-7

Cadmium-induced changes in the growth and oxidative metabolism of pea plants (2019)

Table : Effect of Cd treatment on photosynthesis, water use efficiency and transpiration of pea plants

Cd (mM)	**Photosynthesis rate**	**Water use**	**Transpiration rate**
	(mM H_2O $m^{—2}$ $s^{—1}$)	efficiency (nmol CO_2 $mM^{—1}$ H_2O)	(mM $H_2Om^{—2}$ $s^{—1}$)
0	12.20 a	4872 a	2.52 a
10	8.48 b	3970 b	2.14 b
20	6.46 c	3625 c	1.79 c
30	5.03 d	3052 d	1.65 d
40	4.14 e	2492 e	1.66 d
50	1.84 f	1318 f	1.42 e

Values are means of 12 replicates. Values followed by the same letter are not significantly different (P-0.05) as determined by Duncan's multiple range test.

The growth inhibition of pea plants was accompanied by a significant decrease in the photosynthesis rate, which was about six times reduced at the highest Cd concentration in comparison with control plants. The transpiration rate and water use efficiency were also affected by Cd treatment, undergoing a significant and progressive decrease with increasing Cd concentrations in the nutrient solution. The transpiration rate and water use efficiency were also affected by Cd treatment, undergoing a significant and progressive decrease with increasing Cd concentrations in the nutrient solution.

Source: http://sci-hub.tw/10.1093/jexbot/52.364.2115

Cadmium-induced changes in the growth and oxidative metabolism of pea plants (2019)

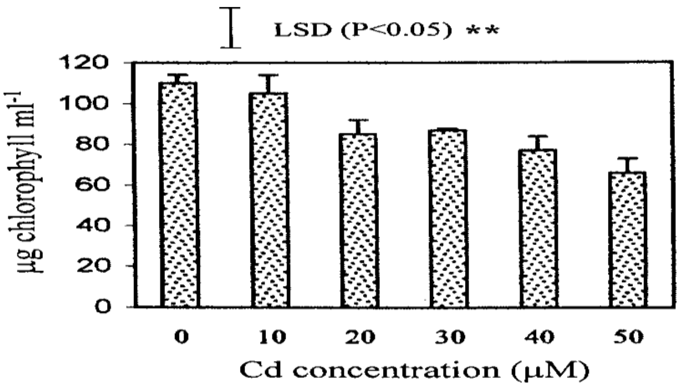
Table: Effect of Cd treatment on growth of pea plants

Cd (mM)	Leaves (g DW)	Roots (g DW)	Leaf area (cm^2)
0	9.95 a	5.98 ab	**4340 a**
10	8.69 a	6.14 ab	**3861 a**
20	6.98 b	6.76 a	**3013 b**
30	6.23 bc	6.70 a	**2633 b**
40	5.36 c	5.80 ab	**2410 b**
50	**3.89 d**	**4.39 c**	**1595 c**

Increasing concentrations of Cd in the nutrient solution produced a significant growth inhibition of pea plants, measured as dry weight (Table), the greatest adverse effect being on leaves while root growth was only significantly affected by 50 mM $CdCl_2$ (Table). The decrease in dry weight of leaves was parallel to a reduction in the leaf area (Table) but no visible symptoms of toxicity, except growth reduction, were observed.

Source: https://www.ncbi.nlm.nih.gov/pubmed/11604450

Effect of Cd treatment on the chlorophyll content of pea leaf extracts.(2019)



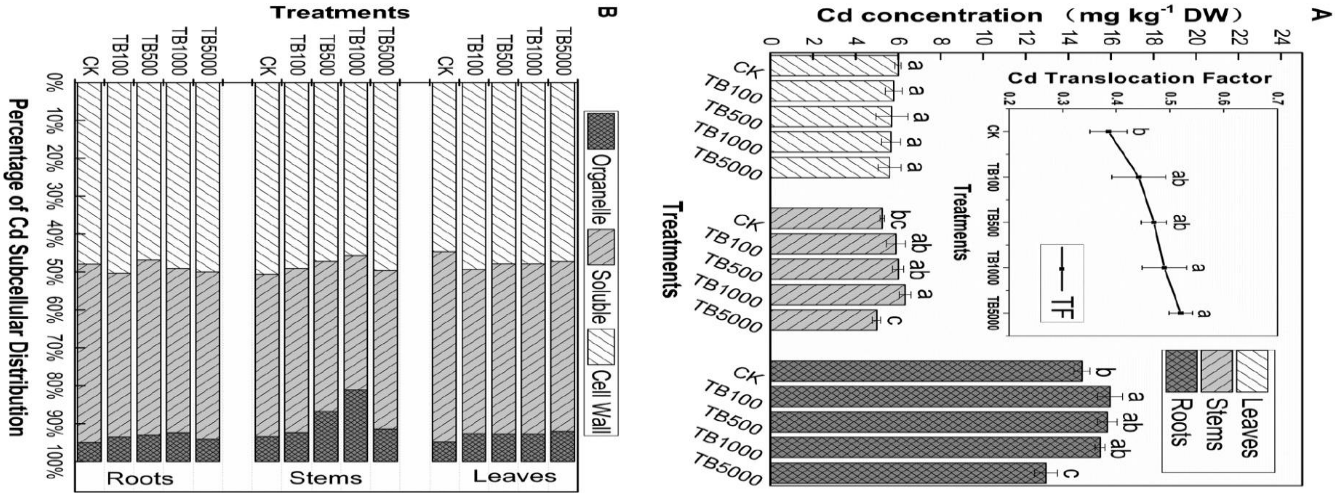
Pea plants were grown with different Cd concentrations (0–50 mM) as described in Materials and methods. Each rectangle represents the mean"SEM of three replicates. Vertical bars indicate LSD (P-0.05) as determined by the Duncan's multiple-range test.

The chlorophyll content was also affected by Cd, showing a reduction which was proportional to the Cd concentration in the nutrient solution.

Source: https://www.ncbi.nlm.nih.gov/pubmed/11604450

Biochar facilitated the phytoremediation of cadmium contaminated sediments: Metal behavior, plant toxicity, and microbial activity(2019)

Cd behaviour in the plants changed by (tea waste derived biochar) TB : Metal behavior in the plants influenced by biochar



The influence of TB on the bio-accumulation and translocation of Cd in ramie seedlings was shown in Fig A. The application of TB increased Cd concentration in ramie roots compared with control, with the exception of the TB5000 treatments, in which the concentration of Cd de- creased significantly. Similar to what was observed in roots, TB at 100, 500 and 1000 mg kg−1 increased Cd concentration in ramie stems by 12-20%, whereas the 5000 mg kg−1 TB reduced Cd concentration by 5% relative to the control. However, no statistical difference in Cd concentration was observed in ramie leaves whether the seedlings were treated with TB or not. The TF value of Cd in ramie seedlings increased with increasing the concentration of TB (Fig.A) whereas, the sub cellular distribution of Cd in ramie seedlings was influenced by the application of TB (Fig.B).

Source: http://sci-hub.tw/https://doi.org/10.1016/j.scitotenv.2019.02.215

Table 1: Effects of various levels of Cd and salinity on growth parameters (plant height, stem diameter, number of branches per plant, root length, shoot dry weight, root dry weight) of A. nilotica in a pot experiment.

Cd and salinity levels	**Plant height (cm)**	**Stem diameter (cm)**	**Branches (plant^{-1})**	**Root length (cm)**	**Shoot dry weight (g plant^{-1})**	**Root dry weight (g plant^{-1})**
Control	81 § 4.04 a	1.2 § 0.04 a	16 § 0.57 a	80 § 3.0 a	37 § 2.0 a	15.7 § 0.66 a
Cd-0-NaCl-0.5	74 § 2.30 b	1.12 § 0.02 b	15 § 0.57 ab	72 § 1.15 bc	32 § 1.0 bc	13.3 § 0.57 bc
Cd-0-NaCl-1.0	59 § 3.71 d	1 § 0.04 c	13 § 0.67 cd	65 § 1.66 d	23 § 1.45 e	11 § 0.88 e
Cd-5-NaCl-0	76.8 § 1.92 ab	1.17 § 0.05 ab	15 § 0.57 ab	77.2 § 3.28 ab	36 § 0.57 a	15 § 0.66 a
Cd-5-NaCl-0.5	72.3 § 1.76 bc	1.02 § 0.04 c	13.3 § 0.57 c	67.3 § 2.84 cd	30 § 0.57 cd	12.5 § 0.57 cd
Cd-5-NaCl-1.0	57 § 1.85 d	0.9 § 0.02 d	12.5 § 0.3 cd	56.2 § 1.15 e	20 § 0.88 f	9.6 § 0.66 f
Cd-10-NaCl-0	74.3 § 1.45 b	1.11 § 0.03 b	13.7 § 0.7 b	74.2 § 2.72 b	34 § 1.52 ab	14 § 0.33 ab
Cd-10-NaCl-0.5	65 § 3.48 cd	0.89 § 0.04 d	12.7 § 0.66 cd	62.2 § 2.88 de	28 § 0.57 d	11 § 0.33 e
Cd-10-NaCl-1.0	50 § 3.2 e	0.8 § 0.03 e	12 § 0.2 d	48.9 § 3.92 f	16 § 1.45 g	8 § 0.33 g
Cd-15-NaCl-0	69 § 3.60 c	1.05 § 0.05 bc	13.2 § 0.66 bc	70.5 § 1.85 c	31.3 § 2.02 bc	13 § 57 bc
Cd-15-NaCl-0.5	60 § 3.06 d	0.85 § 0.05 de	12 § 0.57 d	57.9 § 2.40 e	23.1 § 1.52 e	9.4 § 0.57 f
Cd-15-NaCl-1.0	44 § 2.8 f	0.7 § 0.03 f	10.5 § 0.57 e	41.2 § 2.90 g	12.5 § 1.45 h	6.5 § 0.33 h

For each parameter, the values (mean § standard error of three replicates) sharing the same letter are not significantly different (LSD test, P D 0.05).

Table 2: Effects of various levels of Cd and salinity on root and shoot ionic (Na, K, Cl) concentrations (mmol g-1 dry weight) of A. nilotica in a pot experiment.

Cd and salinity levels	**Root Na**	**Shoot Na**	**Root K**	**Shoot K**	**Root Cl**	**Shoot Cl**
Control	0.12 § 0.02 c	0.14 § 0.01 c	0.90 § 0.07 a	1.25 § 0.02 a	0.16 § 0.04 ij	0.18 § 0.01 hi
Cd-0-NaCl-0.5	0.50 § 0.01 b	0.66 § 0.02 b	0.71 § 0.05 c	0.80 § 0.01 e	0.85 § 0.03 gh	0.90 § 0.03 fg
Cd-0-NaCl-1.0	0.90 § 0.03 a	1.10 § 0.03 a	0.35 § 0.03 ef	0.50 § 0.02 h	1.45 § 0.04 d	1.57 § 0.03 d
Cd-5-NaCl-0	0.12 § 0.02 c	0.13 § 0.05 c	0.86 § 0.02 ab	1.15 § 0.02 b	0.17 § 0.05 i	0.19 § 0.04 hi
Cd-5-NaCl-0.5	0.49 § 0.02 b	0.66 § 0.05 b	0.65 § 0.02 cd	0.70 § 0.04 f	0.90 § 0.02 g	0.94 § 0.03 g
Cd-5-NaCl-1.0	0.91 § 0.05 a	1.10 § 0.04 a	0.30 § 0.01 ef	0.39 § 0.05 i	1.55 § 0.02 c	1.64 § 0.02 c
Cd-10-NaCl-0	0.11 § 0.04 c	0.14 § 0.03 c	0.80 § 0.02 bc	1.05 § 0.06 c	0.18 § 0.01 i	0.20 § 0.02 h
Cd-10-NaCl-0.5	0.48 § 0.04 b	0.65 § 0.02 b	0.59 § 0.04 de	0.59 § 0.07 g	0.98 § 0.01 f	1.00 § 0.01 f

Cd-10-NaCl-1.0	0.91 § 0.05 a	1.12 § 0.01 a	0.27 § 0.06 fg	0.35 § 0.03 ij	1.65 § 0.03 b	1.78 § 0.05 b
Cd-15-NaCl-0	0.12 § 0.03 c	0.13 § 0.04 c	0.67 § 0.05 cd	0.90 § 0.01 d	0.20 § 0.04 i	0.21 § 0.06 h
Cd-15-NaCl-0.5	0.49 § 0.04 b	0.66 § 0.05 b	0.35 § 0.05 e	0.42 § 0.02 i	1.07 § 0.05 e	1.12 § 0.07 e
Cd-15-NaCl-1.0	0.92 § 0.02 a	1.14 § 0.03 a	0.20 § 0.03 h	0.28 § 0.05 jk	1.78 § 0.05 a	1.89 § 0.05 a

For each parameter, the values (mean § standard error of three replicates) sharing the same letter are not significantly different (LSD test, P D 0.05).

Table 3: Effects of various levels of Cd and salinity treatments on root and shoot Cd concentrations (mg kg^{-1}), root and shoot Cd uptake (mg plant^{-1}) and tolerance index (%) of A. nilotica in a pot experiment.

Cd and salinity levels	Root Cd concentration	Shoot Cd concentration	Root Cd Uptake	Shoot Cd Uptake	Tolerance index
Control	0.19 § 0.15 h	0.24 § 0.15 h	2.97 § 1.4 h	8.88 § 3.5 i	----
Cd-0-NaCl-0.5	0.2 § 0.21 h	0.23 § 0.12 h	2.7 § 1.5 h	7.36 § 3.0 i	90 § 5.0 ab
Cd-0-NaCl-1.0	0.21 § 0.15 h	0.24 § 0.15 h	2.31 § 1.0 h	5.52 § 3.6 i	81.3 § 3.0 c
Cd-5-NaCl-0	2.5 § 0.39 g	3.3 § 0.45 g	36.75 § 1.0 g	115.5 § 4.5 h	96.5 § 4.0 a
Cd-5-NaCl-0.5	3.8 § 0.3 f	4.7 § 0.24 f	47.5 § 1.0 e	141 § 2.5 g	84.1 § 3.0 bc
Cd-5-NaCl-1.0	4.5 § 0.3 e	5.4 § 0.3 ef	43.2 § 2.0 f	108 § 7.8 h	70.3 § 2.0 de
Cd-10-NaCl-0	4.1 § 0.3 ef	6.1 § 0.54 e	56.99 § 1.0 d	200.69 § 2.5 e	92.8 § 2.0 ab
Cd-10-NaCl-0.5	5.8 § 0.2 d	8.9 § 0.6 d	63.8 § 0.8 c	249.2 § 8.6 c	77.8 § 4.0 cd
Cd-10-NaCl-1.0	7.0 § 0.3 c	10.9 § 0.3 c	56 § 1.8 c	174.4 § 4.5 f	61.1 § 3.0 e
Cd-15-NaCl-0	5.8 § 0.45 d	9.3 § 0.66 d	75.4 § 2.5 b	291.09 § 4.5 b	88.1 § 3.0 b
Cd-15-NaCl-0.5	8.9 § 0.39 b	15 § 0.69 b	83.66 § 1.8 a	346.5 § 8.9 a	72.4 § 4.0 d
Cd-15-NaCl-1.0	11.2 § 0.36 a	18.5 § 0.39 a	72.8 § 2.0 b	231.25 § 5.0 d	51.5 § 2.0 f

For each parameter, the values (mean § standard error of three replicates) sharing the same letter are not significantly different (LSD test, P D 0.05)

Source: https://www.tandfonline.com/doi/pdf/10.1080/15226514.2017.1413339?needAccess=true

Cadmium Uptake and Distribution in Fragrant Rice Genotypes and Related Consequences on Yield and Grain Quality Traits (2017)

Table 1: Effects of cadmium on rice yield and its parameter

Variety	Treatment	Panicles/pot	Spikelet number/pot	100-grain weight (g)	Seed setting rate (%)	Grain yield/pot (g)
V1	Cd0	30.33 ± 0.33^{a}	121.07 ± 0.58^{bc}	23.97 ± 0.33^{a}	89.1 ± 0.11^{a}	78.44 ± 1.40^{a}
	Cd1	23.66 ± 0.88^{b}	127.52 ± 3.88^{b}	19.88 ± 0.38^{b}	85.963 ± 1.45^{b}	51.48 ± 1.61^{b}
	Cd2	20.00 ± 0.57^{c}	142.34 ± 2.87^{a}	19.03 ± 0.32bc	82.293 ± 0.74^{c}	44.51 ± 0.48^{c}
	Cd3	17.33 ± 0.88^{d}	113.63 ± 5.25^{c}	18.1 ± 0.11c	79.92 ± 0.45^{c}	28.35 ± 0.05^{d}
V2	Cd0	27.67 ± 0.33^{a}	116.35 ± 2.46^{c}	23.60 ± 0.28^{a}	92.32 ± 0.84^{a}	70.12 ± 1.60^{a}
	Cd1	25.33 ± 0.33^{b}	132.01 ± 2.39^{ab}	21.55 ± 0.17^{b}	87.86 ± 1.49^{b}	63.41 ± 2.69^{b}
	Cd2	23.66 ± 0.33^{c}	123.49 ± 2.58^{bc}	19.05 ± 0.47^{c}	86.883 ± 0.32^{b}	48.31 ± 0.66^{c}
	Cd3	20.33 ± 0.66^{d}	140.32 ± 7.90^{a}	18.63 ± 0.19^{c}	80.697 ± 1.15^{c}	42.75 ± 1.38^{c}
V3	Cd0	32.33 ± 0.33^{a}	113.11 ± 2.03^{a}	24.98 ± 0.24^{a}	93.79 ± 0.72^{a}	85.63 ± 1.01^{a}
	Cd1	31.66 ± 0.33^{a}	111.66 ± 0.70^{a}	24.03 ± 0.12^{ab}	89.90 ± 0.25^{b}	76.37 ± 0.19^{b}
	Cd2	28.67 ± 0.33^{b}	110.93 ± 0.14^{a}	23.38 ± 0.47^{bc}	88.12 ± 0.42^{c}	65.5 ± 0.73^{c}
	Cd3	26.66 ± 0.33^{c}	98.58 ± 2.1^{5b}	22.66 ± 0.33^{c}	86.22 ± 0.43^{d}	51.42 ± 2.10^{d}
V4	Cd0	25.66 ± 0.33^{a}	131.33 ± 3.60^{b}	22.44 ± 0.67a	90.29 ± 0.96^{a}	68.37 ± 3.59^{a}
	Cd1	23.33 ± 0.33^{b}	139.15 ± 1.73^{ab}	21.05 ± 0.49^{ab}	87.67 ± 1.03^{a}	59.87 ± 1.46^{b}
	Cd2	21.66 ± 0.33^{c}	148.57 ± 6.18^{a}	19.66 ± 0.22^{bc}	83.54 ± 0.74^{b}	52.87 ± 2.43^{bc}
	Cd3	19.66 ± 0.33^{d}	150.92 ± 3.7^{2a}	19.30 ± 0.60^{c}	81.99 ± 0.47^{b}	46.95 ± 1.73^{c}
V5	Cd0	27.66 ± 0.33^{a}	130.58 ± 0.53^{ab}	24.04 ± 0.50^{a}	89.70 ± 0.55a	77.9 ± 1.43^{a}
	Cd1	25 ± 0.5774^{b}	117.65 ± 0.60^{bc}	23.44 ± 0.10a	80.05 ± 0.77^{b}	55.19 ± 1.42^{b}
	Cd2	24.33 ± 0.66^{b}	103.53 ± 11.81^{c}	21.83 ± 0.56^{b}	77.13 ± 3.54^{b}	41.94 ± 3.22^{c}
	Cd3	18.33 ± 0.66^{c}	147.21 ± 4.34^{a}	19.65 ± 0.21^{c}	76.98 ± 1.52^{b}	40.77 ± 1.36^{c}

Three replicated means (±SE) were calculated for each treatment. Values with different letters are significantly different at $p<0.05$.
Cd0 = 0 mg Cd/kg, Cd1 = 50 mg Cd/kg, Cd2 = 100 mg Cd/kg, and Cd3 = 150 mg Cd/kg

Source: https://www.hindawi.com/journals/jchem/2017/1405878/abs

Physiological responses of water hyacinth, Eichhornia crassipes (Mart.) Solms, to cadmium and its phytoremediation potential (2016)

Table 1: Dry biomass (g/plant) of different plant tissues along with root length (cm) and total leaf area (cm^2) of Eichhornia crassipes grown in different cadmium concentrations.

$CdCl_2$ (mg L^{-1})	**Day (d)**	**Root**	**Shoot**	**Leaf**	**Root length (cm)**	**Total leaf area (cm2)**
Control	0 d	0.44 ± 0.002	0.51 ± 0.003	0.62 ±0.009	9.9 ± 0.264	165.0 ± 8.88
	21 d	1.58 ± 0.36	2.13 ± 0.19	2.35 ± 0.22	20.3 ± 0.45	311.4 ± 4.20
5	0 d	0.44 ± 0.002	0.51 ± 0.003	0.62 ± 0.003	9.9 ± 0.173	165.6 ± 1.52
	21 d	0.86 ± 0.02* (–45.56%)	1.25 ± 0.25* (–41.31%)	1.22 ± 0.19* (–48%)	18.2 ± 0.50 (–10.34%)	276.5 ± 7.31* (–11.21%)
10	0 d	0.44 ± 0.003	0.51 ± 0.003	0.62 ± 0.003	9.9 ± 0.20	165.6 ± 3.21
	21 d	0.67 ± 0.01* (–57.34%)	0.76 ± 0.02* (–64.08%)	0.83 ± 0.008* (–64.46%)	17.2 ± 0.37* (–15.27%)	254.7 ± 10.14* (–18.21%)
15	0 d	0.44 ± 0.003	0.50 ± 0.002	0.62 ± 0.006	9.96 ± 0.251	165.3 ± 3.20
	21 d	0.55 ± 0.01* (–64.6%)	0.61 ± 0.01* (–71.12%)	0.72 ± 0.008* (–69.19%)	15.4 ± 0.40* (–24.13%)	225.9 ± 12.15* (–27.45%)
20	0 d	0.44 ± 0.001	0.50 ± 0.003	0.62 ± 0.009	9.9 ± 0.057	164.66 ± 4.5
	21 d	0.46 ± 0.01* (–70.75%)	0.53 ± 0.01* (–75.16%)	0.65 ± 0.01* (–72.17%)	14.5 ± 0.20* (–28.57%)	205.8 ± 4.32* (–33.91%)

* = significantly different from control at $P < 0.05$; values are mean ± SD of 3 replicates; values in the parentheses include percent decrease in mean values as compared to the corresponding control values.

Table 2: Effect of cadmium treatments on leaf pigment contents of *Eichhornia crassipes* after 21 days

$CdCl_2$ (mg L^{-1})	**Chlorophyll (mg g^{-1} fresh weight)**			**Carotenoid**
	C_a	C_b	C_{a+b}	C_{x+c}
0	6.15 ± 0.081	1.67 ± 0.143	7.83 ± 0.225	2.09 ± 0.035
5	5.69 ± 0.09*	1.86 ± 0.072**	7.55 ± 0.159**	1.8 ± 0.047*
10	4.07 ± 0.042*	1.30 ± 0.132*	5.38 ± 0.174*	1.49 ± 0.022*
15	2.27 ± 0.218*	0.767 ± 0.1*	3.04 ± 0.122*	1.49 ± 0.022*
20	1.48 ± 0.117*	0.202 ± 0.096*	1.68 ± 0.138*	0.687 ± 0.042*

Ca= chlorophyll a; Cb= chlorophyll b; Ca + b= total chlorophyll; Cx + c = carotenoid. Values are mean ± SD (n = 3); * = significantly different and ** = not significantly different at $P < 0.05$ at various doses of Cd for a particular plant pigment as compared to control values.

Table 3: Effect of cadmium treatments on leaf MDA and protein contents of *Eichhornia crassipes* after 21 days.

CdCl$_2$ (mg L^{-1})	**Control**	**5**	**10**	**15**	**20**
MDA (µmol g^{-1} FW)	5.69 ± 0.463	8.3 ± 0.325**	20.51 ± 2.79*	25.98 ± 2.26*	**33.55 ± 1.63***
Protein (mg g^{-1} FW)	**24.32 ± 0.58**	**20.0 ± 1.0***	**17.89 ± 0.84***	**13.46 ± 0.46***	**9.43 ± 0.51***

* = significantly different and ** = not significantly different from control at $P < 0.05$; values are mean ± SD of 3 replicates.

Table 4: Cadmium accumulation in different plant parts (roots, shoots, and leaves) of *Eichhornia crassipes* after 21 days.

CdCl$_2$	**Cadmium concentration (µg g^{-1} dry wt) in plant parts**			
(mg L^{-1})	Root	Shoot	Leaf	**Whole plant**
5	846.6 ± 43.22	937.9 ± 61.84	850.2 ± 52.47	**878.3 ± 51.68**
10	956.0 ± 43.44	986.0 ± 76.39	958.8 ± 68.24	**966.9 ± 61.16**
15	1908.6 ± 18.88*	1966.1 ± 28.58*	1908.6 ± 5.72*	**1927.8 ± 17.03***
20	**921.97 ± 38.13**	**967.33 ± 21.79**	**848.22 ± 76.77**	**912.5 ± 40.46**

Mean ± SD (n = 3); * indicates significance at $P < 0.05$ at different doses for a particular plant tissue.

Table 5: Bioconcentration factor (BCF), translocation factor (TF), and translocation efficiency (%) of cadmium in different parts of *Eichhornia crassipes*.

CdCl$_2$ (mg L^{-1})	**BCF$_{root}$**	**BCF $_{shoot}$**	**BCF $_{leaf}$**	**BCF $_{whole\ plant}$**	**TF**	**Efficiency (%)**
5	169.3 ± 8.64	187.5 ±12.3	170 ± 10.49	526 ± 31.0	1.0 ±0.017	**100.4 ± 1.76**
10	95.6 ± 4.34	98.6 ± 7.63	95.8 ± 6.8	290 ± 18.35	1.00 ±0.03	**100.2 ± 3.2**
15	127.2 ± 1.25	131.07 ±1.9	127.2 ±0.38	385 ± 3.40	1.0 ±0.007	**100 ± 0.78**
20	**46.09 ± 1.90**	**48.36 ±1.08**	**42.41 ±3.83**	**121 ± 33.76**	**0.92 ±0.05**	**91.8 ± 5.3**

Source: https://journals.tubitak.gov.tr/biology/issues/biy-16-40-1/biy-40-1-7-1411-86.pdf

Effect of cadmium on physiological parameters of cereal and millet plants—A comparative study (2016)

Table 1: Differential Cd assimilation and translocation ratio in wheat and kodo millet.

Cd concentration in µm	Triticum aestivum			Paspalum scrobiculatum		
	Cadmium assimilation (mg/kg)			**Cadmium assimilation (mg/kg)**		
	Root	**Shoot**	**Shoot/Root Ratio**	**Root**	**Shoot**	**Shoot/Root Ratio**
10	14.50 ± 1.24^{a}	1.79 ± 0.40^{a}	1.79 ± 0.40^{a}	73.28 ± 0.88^{a}	7.32 ± 0.44^{a}	0.0996
20	11.08 ± 1.46^{b}	2.45 ± 0.64^{a}	0.22227	103.40 ± 1.6^{b}	19.59 ± 0.83^{b}	0.1986
50	17.52 ± 1.14^{c}	6.43 ± 0.31^{a}	0.3674	164.27 ± 1.5^{c}	57.33 ± 2.83^{c}	0.3488
100	46.29 ± 2.58^{d}	30.00 ± 1.9^{b}	0.6481	248.82 ± 2.4^{d}	150.13 ± 1.91^{d}	0.6028
500	97.32 ± 2.23^{e}	80.43 ± 1.4^{c}	0.8621	896.32 ± 1.9^{e}	896.32 ± 1.9^{e}	0.8182

The values followed by different letters are significantly different at a significance level of $p<0.05$

Source: www.tandfonline.com/doi/full/10.1080/15226514.2016.1207608?scroll=top...true

Effect of cadmium on physiological parameters of cereal and millet plants—A comparative study (2016)

Table 1: Effect of Cd on induction of PCs in leaves, stems and roots of cabbage variety Pluto

Plant	**Cd level**	**Concentrations of PCs and GSH**[a]				
Part	**(µg L^{-1})**	**PC_2**	**PC_3**	**PC_4**	**GSH**	**PCs + GSH**
		———————(mmol thiol [−SH] kg^{-1} DW)———————				
Leaves	Control[b]	0a	0a	0a	2.37a	2.37a
	500	0.20b	0.50b	0.46b	2.24a	3.40b
Stem	Control[b]	0a	0a	0a	5.60a	5.60a
	500	0.30b	0.25b	0.15b	5.50a	6.20b
Roots	Control	0.50 ± 0.03	0.80 ± 0.03	0.55 ± 0.01	4.10 ± 0.15	5.95 ± 0.20
	500	1.50 ± 0.12	2.50 ± 0.40	2.40 ± 0.30	4.85 ± 0.20	11.3 ± 0.80

Plants were harvested after 4 weeks of Cd exposure. For a plant part, means with the same letter are not significantly different ($P > 0.05$). LSD comparisons are valid only within the one plant part and one constituent

[a] Each value is the mean of four replicates

[b] Cadmium in the control is due to background contamination of the hydroponic solution (1 µg L^{-1})

Table 2: Effect of cadmium on selected minerals in different parts of the cabbage variety, Pluto

Plant	**Cd level**	**Measured element concentrations**						
Part	**(µg L^{-1})**	**————(mg kg^{-1} DW)————**			**—(% DW)—**			
		Cd	**Zn**	**Mn**	**Cu**	**Fe**	**Ca**	**S**
Leaves	1[a]	1.1a	64a	130a	13a	40a	4.29a	1.65a
	500	107b	36b	100b	11a	31b	3.94b	2.03b
Stems	1[a]	0.5a	51a	20a	8a	28a	1.92a	0.62a
	500	41b	36b	13b	7a	24b	1.73b	0.60a
Roots	1[a]	5.0a	260a	146a	319a	–[b]	1.19a	1.26a
	500	686b	173b	66b	302b	–[b]	1.03a	1.28a
Adequate foliar concentration[c]			20–200	25–200	5–15	30–200	1–3	0.3–0.7

The plants were harvested after 4 weeks of Cd exposure. Each value is the mean of four replicates. Means with the same letter are not significantly different ($P > 0.05$). Comparisons are valid only within one plant part for the one constituent

aThe concentration of Cd in the control treatment was due to background contamination

bValues for Fe in roots are not reported, as they were inflated by surface oxide deposits

cBryson et al. (2014)

Source: https://link.springer.com/article/10.1007/s11356-015-5779-6#Tab2