

Lead availability and phytoextraction in the rhizosphere of Pelargonium species (2020)

Table 1: Physiochemical characteristics of soil used in experiment

Parameters	Values
Soil pH	7.41
Soil EC (dS m^{-1})	0.55
Texture	Clay loam
Organic matter carbon (%)	0.48
Total nitrogen content (%)	0.033
Total phosphorus content (mg kg^{-1})	6.37
Potassium (mg kg^{-1})	731
Magnesium (mg kg^{-1})	303
Iron (mg kg^{-1})	2788

Table 2: Biomass and Pb uptake factors after 15 day of culture experiment. Results are significant at $p < 0.05$, as indicated by different letters

Parameters	<i>S. criniflorum</i>				<i>P. hortorum</i>			
Soil [Pb] mg kg^{-1}	500	1000	1500	2000	500	1000	1500	2000
TF	0.30	0.25	0.30	0.21	0.24	0.23	0.23	0.22
CF _r	0.93	0.60	0.48	0.38	1.40	0.86	0.73	0.64
CF _s	0.26	0.14	0.14	0.08	0.32	0.19	0.17	0.14
Biomass _r (g)	0.78 ^{bc}	0.58 ^d	0.50 ^{ed}	0.37 ^e	1.14 ^a	1.08 ^a	0.84 ^{bc}	0.67 ^{cd}
Biomass _s (g)	1.16b ^{cd}	1.20 ^{bcd}	1.00 ^{de}	0.76 ^e	1.63 ^a	1.49 ^{ab}	1.33 ^{a-d}	1.00 ^{de}

TF, CF_r, and CF_s correspond to translocation factor, root concentration factor, and shoot concentration factor; biomass_{r,s} corresponds to biomass of root and shoot, respectively.

Source: <https://link.springer.com/article/10.1007/s11356-020-08226-0>

Assessment of sunflower germplasm for phytoremediation of lead-polluted soil and production of seed oil and seed meal for human and animal consumption (2020)

Table 1: Field soil physiochemical properties.

Characters	Soil
Type	Interceptisol
Color	Red
Texture	Clay
pH	5.55 ± 0.07
CEC (cmol/kg)	10.40 ± 0.03
OM (%)	11.05 ± 0.03
Total N (g/kg)	3.17 ± 0.09
Total P (g/kg)	81.74 ± 2.25
Total K (g/kg)	247.91 ± 4.15
Total Pb (mg/kg)	106.46 ± 4.43

Soil pH measured in water: soil (1:1, m/V) mixture; Cation exchange capacity (CEC) measured by using ammonium acetate saturation method (Chapman, 1965); Organic matter (OM) was measured by using the Walkley-Black method (Walkley and Black, 1934); Soil texture was analyzed by the hydrometer method; Total N, P, K and Pb were measured by the acid digestion method.

Table 2: Total mineral content in seed meal of different sunflower germplasms.

Germplasm	Ca	(%)	Mg (%)	K (%)	Na (%)
1	0.131	± 0.015	0.116 ± 0.011	0.540 ± 0.056	0.004 ± 0.001
2	0.115	± 0.010	0.086 ± 0.008	0.416 ± 0.037	0.003 ± 0.001
3	0.138	± 0.016	0.106 ± 0.013	0.470 ± 0.054	0.002 ± 0.001
4	0.155	± 0.026	0.085 ± 0.014	0.487 ± 0.080	0.003 ± 0.001
5	0.238	± 0.021	0.164 ± 0.016	0.513 ± 0.046	0.003 ± 0.001
6	0.163	± 0.014	0.097 ± 0.008	0.450 ± 0.041	0.003 ± 0.001
7	0.176	± 0.013	0.131 ± 0.009	0.449 ± 0.034	0.004 ± 0.001
8	0.188	± 0.022	0.158 ± 0.020	0.529 ± 0.072	0.003 ± 0.001
9	0.181	± 0.029	0.092 ± 0.014	0.520 ± 0.084	0.004 ± 0.001
10	0.193	± 0.014	0.125 ± 0.010	0.492 ± 0.037	0.005 ± 0.001
11	0.185	± 0.029	0.127 ± 0.021	0.522 ± 0.084	0.003 ± 0.001
12	0.140	± 0.007	0.111 ± 0.006	0.386 ± 0.019	0.003 ± 0.001
13	0.085	± 0.006	0.085 ± 0.006	0.338 ± 0.028	0.002 ± 0.001
14	0.158	± 0.033	0.119 ± 0.025	0.357 ± 0.072	0.004 ± 0.001
15	0.191	± 0.027	0.126 ± 0.024	0.341 ± 0.049	0.002 ± 0.001
16	0.164	± 0.021	0.091 ± 0.010	0.383 ± 0.051	0.003 ± 0.001
17	0.161	± 0.017	0.094 ± 0.009	0.405 ± 0.033	0.003 ± 0.001
18	0.204	± 0.022	0.159 ± 0.016	0.749 ± 0.077	0.002 ± 0.001
19	0.129	± 0.017	0.116 ± 0.014	0.638 ± 0.080	0.003 ± 0.001
20	0.215	± 0.041	0.165 ± 0.032	0.988 ± 0.177	0.005 ± 0.002
21	0.183	± 0.014	0.165 ± 0.013	0.913 ± 0.069	0.005 ± 0.002
22	0.297	± 0.022	0.258 ± 0.017	1.00 ± 0.066	0.007 ± 0.001
23	0.180	± 0.031	0.103 ± 0.018	0.533 ± 0.098	0.003 ± 0.001
24	0.226	± 0.029	0.175 ± 0.020	0.660 ± 0.095	0.008 ± 0.003
25	0.237	± 0.048	0.213 ± 0.040	1.402 ± 0.255	0.006 ± 0.002
26	0.150	± 0.003	0.095 ± 0.007	0.859 ± 0.010	0.003 ± 0.001
27	0.106	± 0.013	0.120 ± 0.016	0.567 ± 0.079	0.002 ± 0.001
28	0.313	± 0.035	0.237 ± 0.030	1.297 ± 0.189	0.006 ± 0.002
29	0.146	± 0.005	0.106 ± 0.007	0.549 ± 0.029	0.003 ± 0.001
30	0.231	± 0.007	0.181 ± 0.021	1.034 ± 0.084	0.005 ± 0.002
31	0.123	± 0.003	0.103 ± 0.004	0.643 ± 0.016	0.002 ± 0.001
32	0.182	± 0.033	0.130 ± 0.022	0.548 ± 0.096	0.002 ± 0.001
33	0.213	± 0.006	0.183 ± 0.003	0.735 ± 0.014	0.004 ± 0.001

34	0.197	± 0.009	0.179 ± 0.012	0.836 ± 0.045	0.005 ± 0.001
35	0.094	± 0.007	0.200 ± 0.001	0.578 ± 0.033	0.003 ± 0.001
36	0.193	± 0.020	0.208 ± 0.022	0.795 ± 0.087	0.006 ± 0.001
37	0.151	± 0.012	0.168 ± 0.009	0.721 ± 0.098	0.004 ± 0.001
38	0.148	± 0.011	0.156 ± 0.010	0.664 ± 0.045	0.005 ± 0.002
39	0.138	± 0.004	0.144 ± 0.006	0.685 ± 0.015	0.004 ± 0.001
40	0.086	± 0.010	0.102 ± 0.011	0.451 ± 0.060	0.003 ± 0.001
* Values are Mean ± S.E. (n = 3 replicates).					

Table 3: Fatty acid (FA) profile of Pb-accumulator sunflower germplasm grown on Pb-contaminated soil.

Serial no.	Fatty acid	Formula	Retention time (min)	Fatty acid (%)
1	Palmitic acid (16:0)	C ₁₆ H ₃₂ O ₂	16.46	6.14 ± 0.02 ^c
2	Stearic acid (18:0)	C ₁₈ H ₃₆ O ₂	19.68	1.952 ± 0.01 ^d
3	Oleic acid (18:1)	C ₁₈ H ₃₄ O ₂	20.19	59.522 ± 3.10 ^a
4	Linoleic acid (18:2)	C ₁₈ H ₃₂ O ₂	23.85	32.199 ± 2.01 ^b
5	Gadoleic acid (20:1)	C ₁₈ H ₃₂ O ₂	22.85	0.176 ± 0.001 ^d
* Values having similar letters represent non-significant difference ($P < 0.05$) of FAs for germplasm. Values represents Mean ± S.E. (n = 3).				

Table 4: Chromatograph and amino acid (AA) profile of high-accumulator sunflower meal grown on Pb-contaminated soil .

Serial no.	Amino acid	Formula	Retention time (min)	Concentration ng/20µl	Amino acid (%)
1	Aspartic acid	C ₄ H ₇ NO ₄	4.960	1453.845	10.74 ± 0.03 ^b
2	Threonine	C ₄ H ₉ NO ₃	5.607	597.657	4.41 ± 0.021 ^d
3	Serine	C ₃ H ₇ NO ₃	6.227	686.196	5.06 ± 0.015 ^d
4	Glutamic acid	C ₅ H ₉ NO ₄	6.927	3032.72	22.40 ± 0.05 ^a
5	Glycine	C ₂ H ₅ NO ₂	9.913	805.158	5.94 ± 0.014 ^d
6	Alanine	C ₃ H ₇ NO ₂	10.773	707.407	5.22 ± 0.011 ^d
7	Cysteine	C ₃ H ₇ NO ₂ S	12.160	184.491	1.36 ± 0.01 ^d
8	Valine	C ₅ H ₁₁ NO ₂	12.707	694.04	5.12 ± 0.02 ^d
9	Methionine	C ₂ H ₁₁ NO ₂ S	13.900	276.126	2.03 ± 0.01 ^d
11	Isoleucine	C ₆ H ₁₃ NO ₂	16.087	598.112	4.41 ± 0.01 ^d
12	Leucine	C ₆ H ₁₃ NO ₂	17.187	997.438	7.36 ± 0.02 ^c
13	Tyrosine	C ₉ H ₁₁ NO ₃	18.560	355.373	2.62 ± 0.01 ^d
14	Phenylalanine	C ₉ H ₁₁ NO ₂	19.633	715.304	5.28 ± 0.02 ^d
15	Lysine	C ₆ H ₁₄ N ₂ O ₂	22.247	534.178	3.94 ± 0.01 ^d
16	Histidine	C ₆ H ₉ N ₃ O ₂	24.520	326.783	2.41 ± 0.01 ^d
17	Arginine	C ₆ H ₁₄ N ₄ O ₂	28.633	1144.784	8.45 ± 0.03 ^c
18	Proline	C ₅ H ₉ NO ₂	7.52	426.526	3.15 ± 0.01 ^d
Values having similar letters represent non-significant differences ($P < 0.05$) of AAs for germplasm. Values represents Mean ± S.E. (n = 3).					

Source:

https://www.researchgate.net/publication/333707331_Assessment_of_sunflower_germplasm_for_phytoremediation_of_leadpolluted_soil_and_production_of_seed_oil_and_seed_meal_for_human_and_animal_consumption

Bioaccumulation of lead in different varieties of wheat plant irrigated with wastewater in remote agricultural regions (2020)

Table 1: Analysis of variance for Pb concentration in water

Source	Degree of freedom	Mean square
Water source	2	0.64**
Year	1	0.21 ^{ns}
Water source × year	2	0.07 ^{ns}
Error	18	0.109

1. **Significant at 0.01 level
2. ns, non-significant

Table 2: Mean concentration (mg/l) of Pb in different types of irrigation water

Cropping year	Groundwater	Sewage water	Industrial water	Mean
Year1	7.64 ± 0.13 ^{ab}	7.05 ± 0.14 ^c	7.45 ± 0.25 ^{abc}	7.38 ^a
Year 2	7.64 ± 0.13 ^{ab}	7.25 ± 0.14 ^{bc}	7.83 ± 0.17 ^a	7.57 ^a
Mean	7.64 ^a	7.15 ^b	7.64 ^a	-

Table 3: Analysis of variance for Pb concentration in soil

Source	Degree of freedom	Mean square
Variety	4	1.32**
Water source	2	2.09**
Year	1	1.54*
Variety × water source	8	0.32 ^{ns}
Variety × year	4	0.08 ^{ns}
Water source × year	2	0.001 ^{ns}
Variety × water source × year	8	0.11 ^{ns}
Error	90	0.34

1. *, ** = significant at 0.05 and 0.01 level
2. ns, non-significant

Table 4: Mean concentration of Pb (mg/kg) in soil used to grown different varieties of wheat in two cropping years

Cropping year	Irrigation sources	Wheat varieties					Mean
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013	
Year 1	Groundwater	6.67 ± 0.19 ^{def}	7.12 ± 0.19 ^{abcdef}	7.20 ± 0.19 ^{abcde}	6.50 ± 0.19 ^{ef}	6.32 ± 0.21 ^f	6.76 ^c
	Sewage water	6.94 ± 0.28 ^{abcdef}	7.27 ± 0.28 ^{abcde}	7.39 ± 0.28 ^{abcd}	6.74 ± 0.28 ^{cdef}	7.49 ± 0.28 ^{abcd}	7.17 ^{ab}
	Industrial water	6.95 ± 0.38 ^{abcdef}	7.36 ± 0.38 ^{abcd}	7.18 ± 0.38 ^{abcde}	6.76 ± 0.38 ^{bcdef}	7.56 ± 0.38 ^{abc}	7.16 ^{ab}
Year 2	Groundwater	6.99 ± 0.19 ^{abcdef}	6.99 ± 0.19 ^{abcdef}	6.99 ± 0.19 ^{abcdef}	6.99 ± 1.19 ^{abcdef}	6.99 ± 0.19 ^{abcdef}	6.99 ^{bc}
	Sewage water	7.14 ± 0.28 ^{abcde}	7.49 ± 0.28 ^{abc}	7.59 ± 0.28 ^a	6.94 ± 0.28 ^{abcdef}	7.74 ± 0.28 ^a	7.38 ^a
	Industrial water	7.14 ± 0.38 ^{abcdef}	7.54 ± 0.38 ^{abc}	7.57 ± 0.38 ^{ab}	6.94 ± 0.38 ^{abcdef}	7.74 ± 0.38 ^a	7.39 ^a
All years	Mean	6.97 ^{bc}	7.30 ^{ab}	7.32 ^a	6.81 ^c	7.31 ^a	-

Table 5: Analysis of variance for Pb in roots, shoot, and grains of various varieties of wheat irrigated with different sources of water in two cropping years

Source	DF	Roots	Shoot	Grains
Variety	4	1.91***	0.56***	0.003***
Water source	2	0.58***	16.14***	0.93***
Year	1	1.003***	0.41***	0.54***
Variety × water source	8	0.12*	0.08***	0.006***
Variety × year	4	0.08 ^{ns}	0.003 ^{ns}	0.00003 ^{ns}
Water source × year	2	2.13***	0.17***	0.13***
Variety × water source × year	8	0.04 ^{ns}	0.001 ^{ns}	0.00004 ^{ns}
Error	90	0.04	0.01	0.0002

1. *, *** = significant at 0.05 and 0.001 levels

2. ns, non-significant

Table 6: Mean concentration of Pb (mg/kg) in roots of various varieties of wheat plant irrigated with different sources of water in two cropping years

Cropping year	Irrigation sources	Wheat varieties					Mean
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013	
Year 1	Groundwater	3.89 ± 0.02 ^{ijklm}	4.35 ± 0.03 ^{bcd}	3.91 ± 0.16 ^{ghijk}	4.82 ± 0.05 ^a	4.49 ± 0.03 ^b	4.29 ^a
	Sewage water	3.46 ± 0.11 ^{no}	4.19 ± 0.19 ^{cdef}	3.89 ± 0.11 ^{ijklm}	4.23 ± 0.02 ^{bcde}	3.84 ± 0.04 ^{ijklm}	3.92 ^d
	Industrial water	3.69 ± 0.03 ^{klmn}	4.45 ± 0.35 ^{bc}	3.96 ± 0.03 ^{fghij}	4.21 ± 0.04 ^{cdef}	4.17 ± 0.02 ^{defgh}	4.09 ^{bc}
Year 2	Groundwater	3.23 ± 0.01 ^o	3.63 ± 0.02 ^{mn}	3.26 ± 0.13 ^o	4.02 ± 0.04 ^{efghi}	3.74 ± 0.02 ^{ijklm}	3.58 ^e
	Sewage water	3.64 ± 0.11 ^{lmn}	4.05 ± 0.04 ^{efghi}	3.75 ± 0.08 ^{ijklm}	4.41 ± 0.02 ^{bcd}	4.03 ± 0.04 ^{efghi}	3.98 ^{cd}
	Industrial water	3.90 ± 0.03 ^{hijkl}	4.16 ± 0.05 ^{defgh}	4.17 ± 0.03 ^{defg}	4.42 ± 0.04 ^{bcd}	4.38 ± 0.02 ^{bcd}	4.21 ^{ab}
All years	Mean	3.63 ^d	4.14 ^b	3.82 ^c	4.35 ^a	4.11 ^b	

Table 7: Mean concentration of Pb (mg/kg) in different varieties of wheat grains irrigated with different sources of water in two cropping years

Site	n	CEC (cmol ⁺ kg ⁻¹)	Ca (cmol ⁺ kg ⁻¹)	K (cmol ⁺ kg ⁻¹)	Mg (cmol ⁺ kg ⁻¹)	Mn (cmol ⁺ kg ⁻¹)	Ni (cmol ⁺ kg ⁻¹)
01	3	17 [8.0–31] ab	5.7 [0.49–14]	0.15 [0.08–0.22] b	7.9 [5.5–12] bcd	0.40 [0.16–0.58]	0.19 [0.12–0.27]
02	6	27 [22–37] ab	11 [5.5–23]	0.28 [0.18–0.45] ab	12 [10–16] bcd	0.18 [0.11–0.28]	0.20 [0.09–0.50]
03	5	25 [22–30] ab	3.6 [1.9–6.4]	0.25 [0.21–0.30] ab	18 [15–20] bcd	0.11 [0.03–0.19]	0.07 [0.02–0.10]
04	3	33 [18–49] ab	11 [1.1–28]	0.26 [0.07–0.44] ab	18 [13–23] abcd	0.13 [0.02–0.33]	0.08 [0.03–0.17]
05	4	43 [36–53] a	1.0 [0.59–1.7]	0.60 [0.45–0.73] a	35 [27–47] a	0.33 [0.18–0.50]	0.16 [0.06–0.30]
06	8	30 [18–42] ab	5.8 [0.62–17]	0.37 [0.13–0.60] ab	19 [14–29] b	0.31 [0.09–0.80]	0.16 [0.05–0.25]
07	4	30 [24–43] ab	5.0 [2.1–7.7]	0.25 [0.17–0.33] ab	21 [15–30] abc	0.06 [0.01–0.22]	0.05 [0.01–0.16]
08	6	40 [18–76] a	14 [3.2–28]	0.35 [0.09–0.86] ab	20 [7.8–40] b	0.07 [0.01–0.11]	0.05 [0.02–0.09]
09	5	12 [6.9–24] b	2.7 [1.0–5.9]	0.15 [0.07–0.28] b	5.2 [2.3–13] cd	0.33 [0.02–1.29]	0.21 [0.08–0.45]
10	8	17 [8.7–33] b	8.2 [5.0–23]	0.15 [0.09–0.25] b	5.0 [1.0–7.9] d	0.06 [0.01–0.11]	0.13 [0.03–0.25]

Table 8: Mean concentration of Pb (mg/kg) in shoots of various varieties of wheat plant irrigated with different sources of water in two cropping years

Cropping year	Irrigation sources	Wheat varieties					Mean
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013	
Year 1	Groundwater	1.20 ± 0.02 ^{mno}	1.38 ± 0.07 ^{kl}	1.55 ± 0.04 ^j	1.17 ± 0.04 ^{no}	1.32 ± 0.09 ^{lmn}	1.32 ^e
	Sewage water	2.18 ± 0.08 ^{fgh}	2.12 ± 0.03 ^{gh}	2.20 ± 0.08 ^{fgh}	1.81 ± 0.03 ⁱ	2.12 ± 0.05 ^{gh}	2.09 ^d
	Industrial water	2.62 ± 0.06 ^{ab}	2.58 ± 0.03 ^{bc}	2.57 ± 0.02 ^{bc}	2.06 ± 0.03 ^h	2.45 ± 0.07 ^{cd}	2.46 ^b
Year 2	Groundwater	1.18 ± 0.02 ^{no}	1.35 ± 0.07 ^{klm}	1.50 ± 0.01 ^{jk}	1.14 ± 0.04 ^o	1.29 ± 0.09 ^{lmno}	1.29 ^e
	Sewage water	2.39 ± 0.08 ^{de}	2.34 ± 0.03 ^{def}	2.38 ± 0.01 ^{de}	2.09 ± 0.03 ^h	2.33 ± 0.05 ^{def}	2.31 ^c
	Industrial water	2.75 ± 0.09 ^a	2.75 ± 0.07 ^a	2.72 ± 0.03 ^{ab}	2.27 ± 0.04 ^{efg}	2.59 ± 0.09 ^{abc}	2.62 ^a
All years	Mean	2.05 ^{bc}	2.09 ^{ab}	2.15 ^a	1.76 ^d	2.02 ^c	-

Table 9: Pollution load index for Pb in soil in two cropping years

Cropping year	Irrigation sources	Wheat varieties				
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013
Year 1	Groundwater	0.82	0.87	0.88	0.80	0.78
	Sewage water	0.85	0.89	0.91	0.83	0.92
	Industrial water	0.85	0.90	0.88	0.83	0.93
Year 2	Groundwater	0.86	0.86	0.86	0.86	0.86
	Sewage water	0.88	0.92	0.93	0.85	0.95
	Industrial water	0.88	0.93	0.93	0.85	0.95
All years	Mean	0.86	0.90	0.90	0.84	0.90

Table 10: Bioaccumulation factor for Pb in wheat shoot/soil in two cropping years

Cropping year	Irrigation sources	Wheat varieties				
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013
Year 1	Groundwater	0.18	0.19	0.22	0.18	0.21
	Sewage water	0.31	0.29	0.30	0.27	0.28
	Industrial water	0.38	0.35	0.36	0.30	0.32
Year 2	Groundwater	0.17	0.19	0.21	0.16	0.18
	Sewage water	0.33	0.31	0.31	0.30	0.30
	Industrial water	0.39	0.36	0.36	0.33	0.33
All years	Mean	0.29	0.28	0.29	0.26	0.27

Table 11: Translocation factor for Pb in wheat shoot/root in two cropping years

Cropping year	Irrigation sources	Wheat varieties				
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013
Year 1	Groundwater	0.11	0.11	0.11	0.11	0.11
	Sewage water	0.25	0.24	0.22	0.24	0.35
	Industrial water	0.37	0.36	0.36	0.32	0.33
Year 2	Groundwater	0.11	0.11	0.11	0.11	0.11
	Sewage water	0.48	0.47	0.46	0.46	0.58
	Industrial water	0.63	0.62	0.62	0.62	0.58
All years	Mean	0.33	0.32	0.31	0.31	0.34

Table 12: Bio-concentration factor for Pb in wheat grains/soil in two cropping years

Cropping year	Irrigation sources	Wheat varieties				
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013
Year 1	Groundwater	0.01	0.01	0.01	0.01	0.01
	Sewage water	0.03	0.03	0.02	0.03	0.04
	Industrial water	0.04	0.04	0.04	0.04	0.04
Year 2	Groundwater	0.01	0.01	0.01	0.01	0.01
	Sewage water	0.05	0.05	0.05	0.06	0.06
	Industrial water	0.07	0.07	0.07	0.07	0.06
All years	Mean	0.04	0.04	0.03	0.04	0.04

Table 13: Enrichment factor for Pb in two cropping years

Cropping year	Irrigation sources	Wheat varieties				
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013
Year 1	Groundwater	0.04	0.03	0.03	0.04	0.04
	Sewage water	0.08	0.07	0.07	0.08	0.10
	Industrial water	0.12	0.11	0.11	0.10	0.10
Year 2	Groundwater	0.03	0.03	0.03	0.03	0.03
	Sewage water	0.15	0.14	0.13	0.15	0.16
	Industrial water	0.19	0.18	0.18	0.18	0.16
All years	Mean	0.10	0.09	0.09	0.10	0.10

Table 14: Daily intake of Pb (mg/kg/day) in two cropping years

Cropping year	Irrigation sources	Wheat varieties				
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013
Year 1	Groundwater	0.0004	0.0004	0.0004	0.0004	0.0004
	Sewage water	0.0009	0.0008	0.0008	0.0008	0.0010
	Industrial water	0.0010	0.0010	0.0010	0.0010	0.0010
Year 2	Groundwater	0.0004	0.0004	0.0004	0.0004	0.0004
	Sewage water	0.0020	0.0020	0.0020	0.0020	0.0020
	Industrial water	0.0020	0.0020	0.0020	0.0020	0.0020
All years	Mean	0.0011	0.0011	0.0011	0.0011	0.0011

Table 15: Health risk index of Pb via intake of *Triticum aestivum* in two cropping years

Cropping year	Irrigation sources	Wheat varieties				
		Seher-2006	Punjab-2011	Faislabad-2008	Watan	Galaxy-2013
Year 1	Groundwater	0.11	0.11	0.11	0.11	0.11
	Sewage water	0.25	0.24	0.22	0.24	0.35
	Industrial water	0.37	0.36	0.36	0.32	0.33
Year 2	Groundwater	0.11	0.11	0.11	0.11	0.11
	Sewage water	0.48	0.47	0.46	0.48	0.58
	Industrial water	0.63	0.62	0.62	0.58	0.58
All years	Mean	0.33	0.32	0.31	0.31	0.34

Source: <https://link.springer.com/article/10.1007%2Fs11356-020-09138-9>

In vitro lead tolerance and accumulation in three *Chrysanthemum* cultivars for phytoremediation purposes with ornamental plants (2020)

Table 1: Average biomass production (g dry weight \pm standard deviation) for each *Chrysanthemum* cultivar studied and treatment with different concentrations of Pb in the culture substrate.

Cultivar	0 mg/kg	300 mg/kg	600 mg/kg	900 mg/kg	1,500 mg/kg
<i>Chrysanthemum</i> 'Renella'	0.12 \pm 0.04	0.14 \pm 0.03 $p = 0.76908$	0.14 \pm 0.03 $p = 0.76908$	0.12 \pm 0.02 $p = 0.92707$	0.11 \pm 0.03 $p = 0.92077$
<i>Chrysanthemum</i> 'Reyellow'	0.12 \pm 0.06	0.12 \pm 0.01 $p = 0.78419$	0.13 \pm 0.02 $p = 0.62027$	0.06 \pm 0.02 $p = 0.34180$	0.05 \pm 0.01 $p = 0.22094$
<i>Chrysanthemum</i> 'Sheena'	0.21 \pm 0.02	0.16 \pm 0.00 $p = 0.31154$	0.17 \pm 0.07 $p = 0.46360$	0.05 \pm 0.02 $p = \mathbf{0.01348}$	0.07 \pm 0.01 $p = \mathbf{0.02675}$

Table 2: Root length (mm \pm standard deviation) for each *Chrysanthemum* cultivar studied and each concentration of Pb in the culture substrate.

Cultivar	0 mg/kg	300 mg/kg	600 mg/kg	900 mg/kg	1,500 mg/kg
<i>Chrysanthemum</i> 'Renella'	20.67 \pm 8.02	12.47 \pm 2.54 $p = 0.35915$	11.10 \pm 4.71 $p = 0.35915$	5.23 \pm 0.87 $p = 0.02658$	4.60 \pm 0.69 $p = 0.01789$
<i>Chrysanthemum</i> 'Reyellow'	8.77 \pm 3.02	11.97 \pm 4.05 $p = 0.58320$	5.57 \pm 1.60 $p = 0.28682$	6.60 \pm 2.25 $p = 0.48060$	3.47 \pm 1.27 $p = 0.15849$
<i>Chrysanthemum</i> 'Sheena'	22.67 \pm 9.29	10.00 \pm 6.14 $p = 0.31530$	6.93 \pm 5.40 $p = 0.13379$	1.10 \pm 0.85 $p = 0.02467$	1.50 \pm 0.40 $p = 0.03524$

The p values (obtained by the Conover test and Benjamini & Hochberg correction) indicate the probability that the root length reached with the Pb treatment is equal to the root length of the control (0 mg/kg). Significant p values ($p < 0.05$) are marked in bold.

Table 3: Average concentration of Pb in the tissues of plants (mg/kg \pm standard deviation) for each *Chrysanthemum* cultivar studied and each concentration of Pb in the culture substrate, as well as the average concentration values for all treatments.

Cultivar	0 mg/kg	300 mg/kg	600 mg/kg	900 mg/kg	1,500 mg/kg	Average values all treatments
<i>Chrysanthemum</i> 'Renella'	0.00 \pm 0.00	1431.57 \pm 173.46 $p = 0.16937$	1464.91 \pm 440.22 $p = 0.16937$	1699.98 \pm 239.18 $p = 0.07021$	5029.36 \pm 1031.69 $p = 0.00389$	1925.16
<i>Chrysanthemum</i> 'Reyellow'	0.00 \pm 0.00	1321.14 \pm 247.25 $p = 0.18985$	1178.46 \pm 138.00 $p = 0.19963$	3863.58 \pm 2700.26 $p = 0.02395$	3224.82 \pm 1895.88 $p = 0.02675$	1917.60
<i>Chrysanthemum</i> 'Sheena'	22.53 \pm 3.54	2289.01 \pm 986.20 $p = 0.11044$	2322.66 \pm 1945.12 $p = 0.08921$	3884.05 \pm 1388.57 $p = 0.01036$	1937.87 \pm 246.73 $p = 0.14412$	2091.22

The p values (obtained by the Conover test and Benjamini & Hochberg correction) indicate the probability that the amount of Pb in the tissues grown under different treatments is equal to that of the control treatment (0 mg/kg). Significant p values ($p < 0.05$) are marked in bold.

Table 4: Average bioaccumulation factor (BF) for each *Chrysanthemum* cultivar studied and each treatment with different concentrations of Pb in the substrate, as well as the average values for all treatments.

Cultivar	300 mg/kg	600 mg/kg	900 mg/kg	1,500 mg/kg	Average values all treatments
<i>Chrysanthemum</i> 'Renella'	4.77	2.39	1.89	3.35	3.10
<i>Chrysanthemum</i> 'Reyellow'	4.40	1.96	4.29	2.15	3.20
<i>Chrysanthemum</i> 'Sheena'	7.63	3.87	4.32	1.29	4.27

Source: <https://www.tandfonline.com/doi/full/10.1080/15226514.2020.1731730>

Lead induces oxidative stress in *Pisum sativum* plants and changes the levels of phytohormones with antioxidant role (2019)

Table 1: Quantification of Pb in different organs of *P. sativum*. Pb content ($\mu\text{g g}^{-1}$ DM), plant height (cm) and hormone content (ng g^{-1} FW) in control and Pb exposed pea plants. Values are means \pm SD (n = 3-6). For each line, different letters indicate significant differences between treatments at a significant level equal to 0.05.

		0 mg Pb Kg ⁻¹	10 mg Pb Kg ⁻¹	100 mg Pb Kg ⁻¹	500 mg Pb Kg ⁻¹
Plant height	Shoots	65.4 \pm 3.6 ^a	63.2 \pm 3.573 ^a	61.2 \pm 2.6 ^a	51.7 \pm 4.6 ^b
	Roots	20.3 \pm 3.9 ^a	21.1 \pm 5.6 ^a	19.4 \pm 5.6 ^a	13.4 \pm 2.3 ^a
Pb	Leaves	8.2 \pm 1.4 ^c	55.0 \pm 8.0 ^b	64.5 \pm 10.1 ^{ab}	75.2 \pm 15.6 ^a
	Roots	14.0 \pm 8.1 ^d	595.5 \pm 57.9 ^c	1238.0 \pm 278.8 ^b	2333.0 \pm 335.6 ^a
ABA	Leaves	28.7 \pm 1.5 ^b	29.5 \pm 1.9 ^b	31.5 \pm 4.9 ^b	56.1 \pm 4.9 ^a
	Roots	3.0 \pm 0.1 ^a	2.0 \pm 1.2 ^a	1.7 \pm 0.3 ^a	2.3 \pm 0.4 ^a
SA	Leaves	7.4 \pm 2.5 ^b	8.5 \pm 0.8 ^{ab}	10.8 \pm 0.5 ^{ab}	12.4 \pm 1.1 ^a
	Roots	2.9 \pm 1.1 ^c	7.5 \pm 2.5 ^{ab}	4.74 \pm 1.2 ^{bc}	9.8 \pm 2.1 ^a
IAA	Leaves	9.7 \pm 3.6 ^a	4.8 \pm 3.2 ^a	6.3 \pm 2.1 ^a	10.3 \pm 2.8 ^a
	Roots	nd	nd	nd	nd
JA	Leaves	37.9 \pm 9.3 ^b	153.0 \pm 50.1 ^a	132.8 \pm 59.8 ^a	82.3 \pm 18.3 ^{ab}
	Roots	76.0 \pm 4.8 ^c	257.1 \pm 18.1 ^a	144.6 \pm 16.1 ^b	159.0 \pm 23.2 ^b

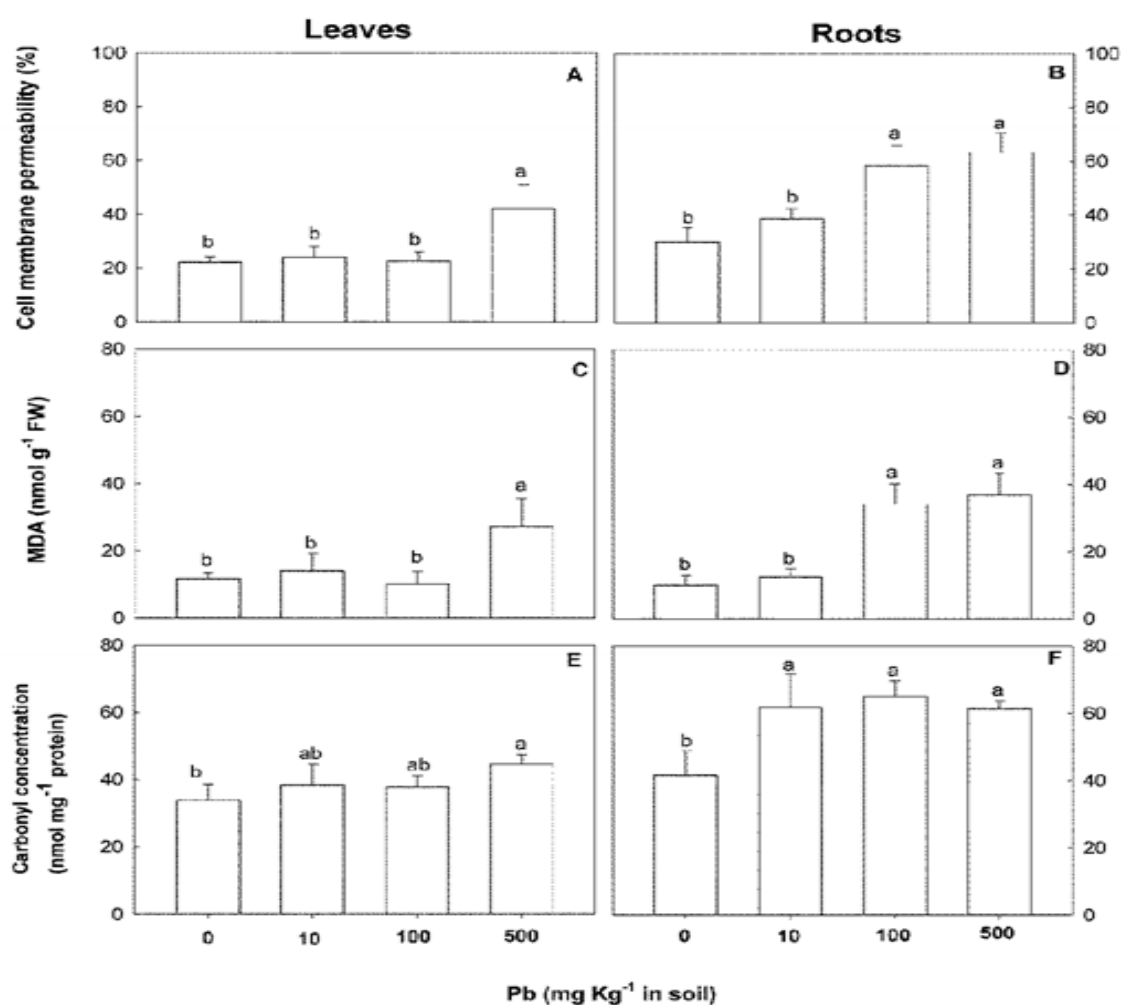
(ABA: abscisic acid; IAA: indolacetic acid; JA: jasmonic acid; nd: not detectable; SA: salicylic acid)

Lead accumulation in roots and shoots significantly increased with the increase of Pb content in the medium, with maximal accumulation values observed at 500 mg kg⁻¹. Most of the metal was accumulated in roots. Lead exposure did not induce plant death (100% survival rate). Also, leaves from all conditions had no symptoms of necrosis nor chlorosis. Whilst no differences were observed in roots' length in comparison to controls, plants exposed to 500 mg Pb kg⁻¹ had a shorter (P<0.05) aerial part (reduction of 21%).

Hormone levels showed different profiles in leaves and roots. ABA and SA levels increased significantly (49% and 40%, respectively) in leaves exposed to 500 mg Pb kg⁻¹ compared to control plants. In roots, ABA content were not affected ($P>0.05$) by Pb, while the SA content was significantly higher in 10 and 500 mg Pb kg⁻¹ compared to control plants (increased 61% and 70%, respectively). No significant differences were observed between IAA levels in control and Pb-exposed plants. The levels of this hormone in roots were below the detection levels. Leaves exposed to 10 and 100 mg Pb kg⁻¹ and roots exposed to all Pb content showed levels of JA higher.

Source: <https://www.ncbi.nlm.nih.gov/pubmed/30772622>

Lead induces oxidative stress in *Pisum sativum* plants and changes the levels of phytohormones with antioxidant role (2019)



Evaluation of the leaves/roots damages. Effect of Pb exposure on cell membrane permeability, MDA (malondialdehyde) content and carbonyl concentration in leaves (A, C and E) and roots (B, D and F). Values are means \pm SD ($n = 6-8$). Different small letters indicate significant differences between treatments at a significant level equal to 0.05.

Source: <https://www.ncbi.nlm.nih.gov/pubmed/30772622>

Evaluation of sunflower (*Helianthus annuus L.*) for phytoremediation of lead contaminated soil (2019)

Table 1: Effect of lead concentrations on some physiological traits of sunflower plant.

Treatment	Dose Pb mg.kg ⁻¹						Mean	LSD 0.05
	0	50	100	150	200	250		
(%) RWC (Relative water content)	85	79	76	63	61	51	69	29.44
Chl a (mg.g ⁻¹ fresh weight)	5.62	5.51	4.81	5.03	4.61	4.24	4.97	N.S
Chl b(mg.g ⁻¹ fresh weight)	3.17	3.16	3.35	2.72	2.86	3.04	3.05	N.S
Carotenoids (mg.g ⁻¹ fresh weight)	2.59	2.90	2.34	2.31	1.99	2.10	2.37	N.S

The exposure to Pb ions decreased the relative water content. In the control plants a very high relative water content (RWC) was observed accompanied by very good cell turgor. Plants treated 250mg Pb.kg⁻¹ soil showed significant decrease in RWC by 67% at 250mg Pb.kg⁻¹ soil. Pb can alter the water relations by disturbing water balance throughout the effects on stomatal conductance, water transport and cell wall elasticity, and thereby influences the cell turgor pressure (Elzbieta and Mirosława, 2005). Results of current study reveal no significant change in chlorophyll a, and b and carotenoids, indicated that sunflower plant may has a high ability to tolerate Pb stress.

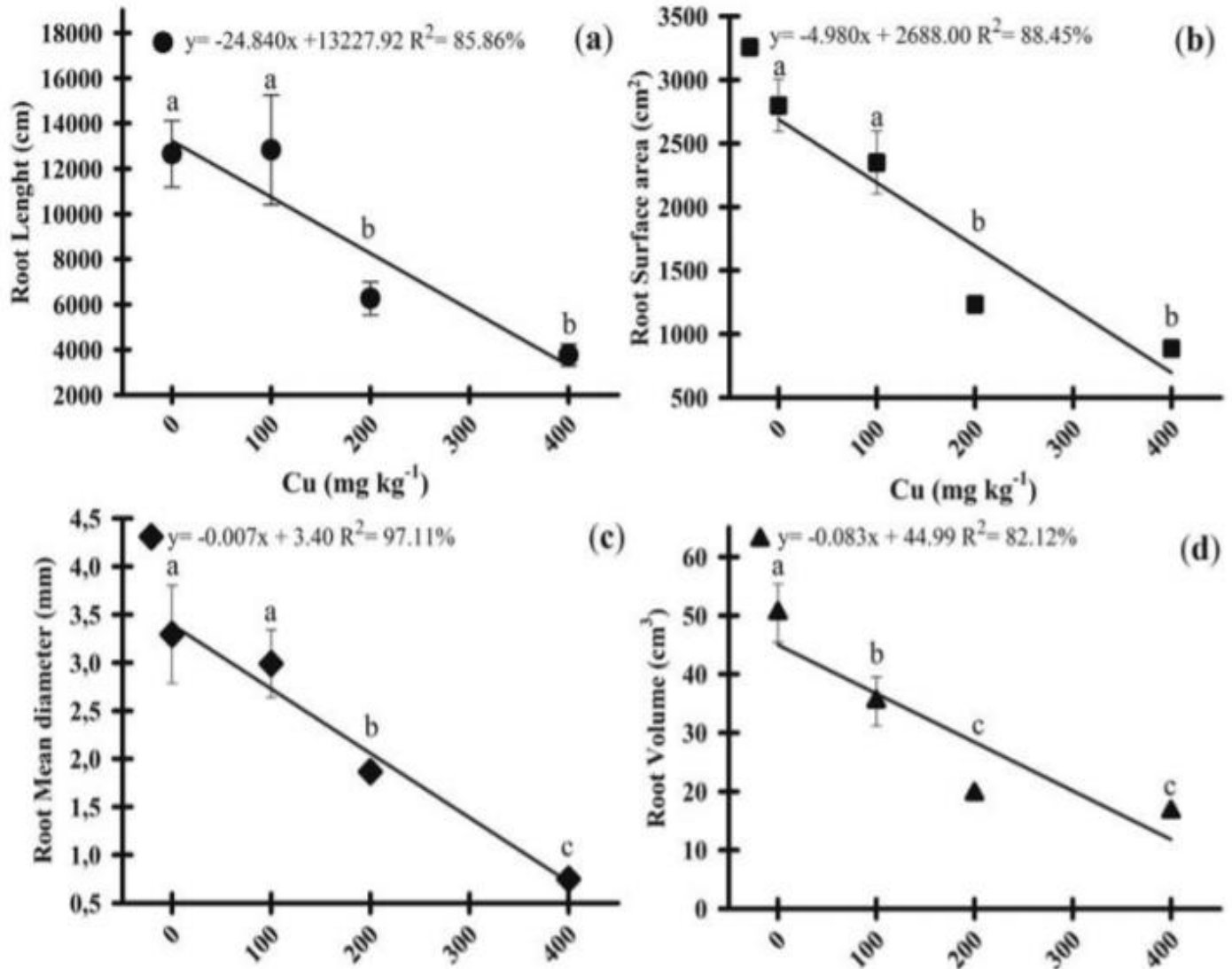
Table 2: Lead concentrations of tested soil before and after treatment with lead.

Test soil	Dose Pb mg.kg ⁻¹						Mean	LSD (Least significant difference) 0.05
	0	50	100	150	200	250		
Before treatment	3.88	3.88	3.88	3.88	3.88	3.88	3.88	-
After treatment	2.80	26.03	51.74	154.84	193.91	219.31	108.11	58.13

The findings of Fulekar (2016) have proved the potential of sunflower plants for remediation of metals from contaminated soil-water environment. After harvesting, Pb concentrations in the soil increased linearly ($p \geq 0.05$) with increase of Pb doses added to the soil, the higher rate was (219.31 mg.kg⁻¹) at 250 mg Pb.kg⁻¹ soil. Pb accumulation in soil increased significantly in Pb treatments ($p \geq 0.05$) compared to control treatment. The table shows that at the concentrations 150,200 and 250 mg.kg⁻¹ soil the effect of Pb was higher and gave 154.84, 193.91 and 291.31 mg.kg⁻¹ than at 50 and 100 mgPb.kg⁻¹ soil which gave 26.03 and 51.74 mg.kg⁻¹.

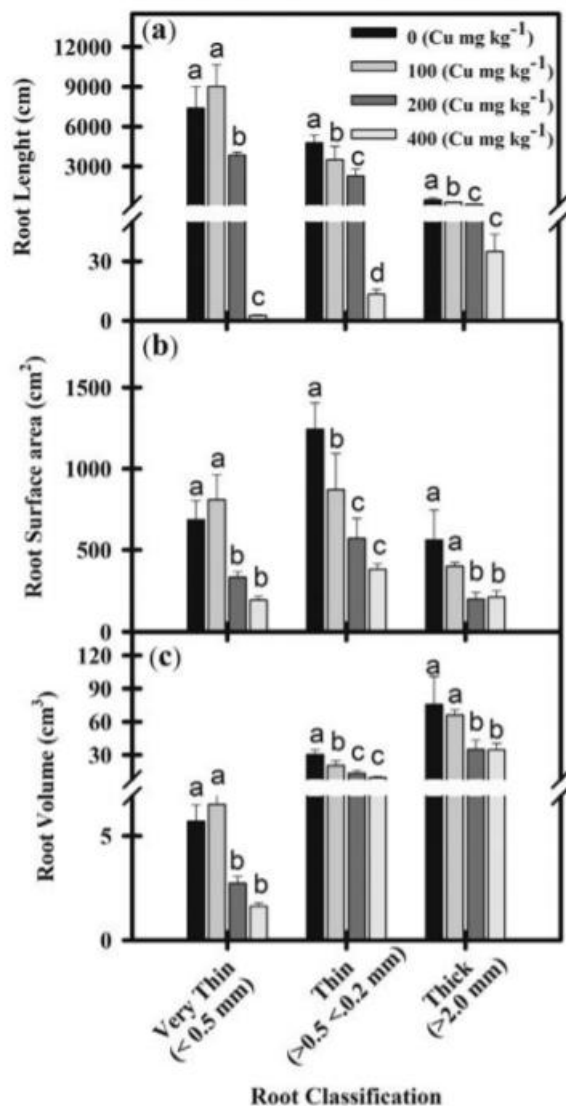
Source:<https://search.proquest.com/openview/7e4eea8c2ab721e20eb9481b4a2a96b0/1?pq-origsite=gscholar&cbl=54977>

Root morphology and leaf gas exchange in *Peltophorum dubium* (Spreng.) Taub. (Caesalpinioideae) exposed to copper-induced toxicity (2019)



Root and dry weight characteristics of *P. dubium* roots including the (a) length, (b) surface area, (c) mean diameter and (d) volume after plants were exposed to different copper concentrations ($p \leq .05$). Means between treatments followed by the same letter are not statistically different by the Skott-Knott test at 5% probability ($p \leq .05$). Each value indicates mean \pm SE.

As soil Cu concentrations increased, there was a linear decrease in length, surface area, mean diameter and root volume in *P. dubium* ($p \leq .05$). Plants grown in soil that contained 200 and 400 mg kg⁻¹ Cu had reduced root length (2.5 \times), root surface area (2.4 \times) and root mean diameter (2.4 \times) compared to plants treated with 100 mg kg⁻¹ Cu or the control treatments (Fig. a–c). In addition, plants exposed to 400 mg kg⁻¹ Cu presented a significant reduction in their root volume, which was 3 \times less than that measured in the the control plants (Fig. d).



Root length, (b) root surface area and (c) root volume organized by diameter class in *P. dubium* exposed to different Cu concentrations. Means between treatments followed by the same letter do not statistically differ from one another by the SkottKnott test at 5% probability ($p \leq .05$). Each value indicates mean \pm SE.

Approximately 90% of the *P. dubium* root system consists mainly of very thin roots (<0.5 mm). These thin roots were significantly reduced in length, surface area and volume (Fig. a–c) when grown in soil with 200 and 400 mg kg⁻¹ Cu compared to control plants ($p \leq .05$). Low Cu treatment (100 mg kg⁻¹) affects negatively TR and THR, but improved VTR, although this later effect was not significant. In addition, the number fine (TR) and thick roots (THR) were also reduced with the application of 400 mg kg⁻¹ Cu compared to control conditions (Fig. a–c).

Source: <http://sci-hub.tw/https://doi.org/10.1016/j.sajb.2018.11.007>

Mechanisms of copper stress alleviation in Citrus trees after metal uptake by leaves or roots (2018)

Table 1: Nutrient concentrations in the sap leakage from trunk and twigs of sweet orange trees 180 days after Cu application via soil or leaf sprays (CuSO₄ or Cu(OH)₂)

Cu treatment	N-NO ₃	N-NH ₄	P	K	Ca	Mg	S	Cu
Cu per plant (g)	mg L ⁻¹							
Soil application of CuSO₄								
8.0	3.8 ± 0.6§	4.0 ± 1.2	0.6 ± 0.2	100 ± 18	277 ± 30	76 ± 9	3.8 ± 0.5	1.5 ± 0.3
Foliar application of CuSO₄								
0.5	2.7 ± 0.4	4.7 ± 0.7	3.0 ± 0.9	9 ± <1	410 ± 26	36 ± 1	8.9 ± 2.2	10.3 ± 1.3
2.0	3.0 ± 0.2	4.3 ± 0.3	2.0 ± 0.9	9 ± 3	405 ± 12	55 ± 11	3.8 ± 0.3	15.5 ± 1.7
Foliar application of Cu(OH)₂								
2.0	3.1 ± 0.3	4.9 ± 0.8	1.7 ± 0.6	8 ± 2	459 ± 14	41 ± 4	6.9 ± 2.2	10.3 ± 0.4

Standard deviation of the mean (n = 4)

Source: <https://link.springer.com/content/pdf/10.1007%2Fs11356-018-1529-x.pdf>

Copper excess reduces nitrate uptake by Arabidopsis roots with specific effects on gene expression (2018)

Category	Product	N	Ni content (µg kg ⁻¹)			
			Mean	Minimum	P50	Maximum
Beer	Pilsener	46	4.5	1.5	4.4	8.1
	Top-fermented beer	67	7.7	2.0	6.7	21.4
	Sour beer	35	12.9	2.0	10.5	33.8
Coffee beverages ^a (prepared with ultrapure water through domestic protocol)	Ground	5	16.8	6.0	8.1	36
	Unground	5	7.0	3.0	5.4	13
Coffee beverages ^b (prepared with ultrapure water through Golden coffee protocol)	Ground	5	12	2.0	7.8	26
Commercial coffee drinks ^c		3	17	4.0	9.0	38
Tea beverages ^d (prepared with ultrapure water through domestic protocol)	Black tea	4	85	72	73	121
	Green tea	4	194	112	207	252
Tea beverages ^e (prepared with ultrapure water through ISO 3130 protocol)	Black tea	2	56	28	56	84
	Green tea	2	85	66	85	105
Ice tea	Without flavour	6	34	13	32	58
	Lemon	5	26	14	28	34

Elevated copper (Cu) affected the concentration of phosphorus (P), calcium (Ca), iron (Fe), manganese (Mn) and boron (B) in the shoots and Fe and Mn in the root of *Arabidopsis thaliana* supplied with different Cu levels in the nutrient solution for 72 h or 15 days (15d).

a

For the Cu treatments for 72 h different lowercase letters indicate mean values are significantly different among the [Cu] (0.16, 5.0, 10.0 and 20.0 µM) by Tukey's test (p < 0.05).

b

For the Cu treatments for 15 days different uppercase letters indicate mean values are significantly different between the [Cu] (0.16 and 5.0 µM) by Tukey's test (p < 0.05).

Source: <https://www.sciencedirect.com/science/article/pii/S0176161718302888>

Copper toxicity and date palm (*Phoenix dactylifera*) seedling tolerance: Monitoring of related biomarkers (2017)

Table: Copper (Cu) effect on different physiological parameters of date palm (*Phoenix dactylifera*) seed germination

Cu (mM)	SG (s/d)	MDG (s/d)	MGT (d)	PV (s/d)	SLM (%)	GI (%)
0	159.36 ± 5.6	0.163 ± 0.01	287.77 ± 6.4	0.49 ± 0.16	2.78 ± 0.33	100
0.02	167.2 ± 4.3	0.164 ± 0.04	289.28 ± 4.6	0.49 ± 0.03	2.78 ± 0.33	98.04
0.2	172.32 ± 5.3	0.166 ± 0.00	293.93 ± 2.4	0.66 ± 0.00	0 ± 1	84.36
2	138.09 ± 5.9	0.134 ± 0.01	234.11 ± 3.3	0.40 ± 0.02	3.05 ± 2.5	8.37

SG = speed of germination; MDG = mean daily germination; MGT = mean germination time; PV = peak value; SLM = seedling mortality; GI = germination index.

Source: <https://setac.onlinelibrary.wiley.com/doi/full/10.1002/etc.4007>

Effect of copper on nutrients content (mg g⁻¹ dry wt.) of radish (45th day) (2017)

Copper added in the soil (mg kg ⁻¹)	N	P	K	Na	Ca	Mg
Control	32.66	6.31	43.52	1.70	13.56	3.99
50	37.35(+14.36)	6.97(+10.45)	52.09(+19.69)	2.11 (+24.11)	15.98 (+17.84)	4.91 (+23.05)
100	25.28 (22.59)	5.71 (-9.50)	36.78 (-15.48)	1.39 (-18.23)	12.25 (-9.66)	3.48 (-12.78)
150	23.73 (27.34)	5.06 (-19.80)	32.17 (-26.07)	1.28 (-24.70)	11.14 (-17.84)	3.05 (-23.55)
200	20.98 (35.76)	4.81 (-23.77)	30.37 (-30.21)	1.16 (-31.76)	11.30 (-19.05)	2.75 (-31.07)
250	18.07 (44.67)	3.90 (-38.19)	25.11 (-42.30)	1.10 (-35.29)	10.68 (-21.23)	2.11 (-47.11)

Average of five replications

Per cent over control values are given in parentheses

Source: <https://ijarbs.com/pdfcopy/apr2017/ijarbs12.pdf>

Changes in the plant height, root length, total dry weight, and leaf area of the lentil plants subjected to different treatments of copper stress and *P. vermicola* inoculation (2016)

	Plant height (cm)	Root length (cm)	Total dry weight	
T0	34.67±4.5 ^a	14.76±1.3 ^b	11.87±0.75 ^{ab}	110.00±3.79 ^b
T1	22.78±3.8 ^c	7.34±0.50 ^d	7.20±1.0 ^c	77.00±3.19 ^c
T2	37.30±5.9 ^a	16.80±1.15 ^a	12.40±1.4 ^a	136.00±5.03 ^a
T3	29.90±2.1 ^b	11.21±1.06 ^c	9.90±1.2 ^b	101.00±4.73 ^b

Values are means±S.E. (n=3). Values carrying different letters are significantly different at P ≤ 0.05 level As determined by Duncan's test T0 non-contaminated soil, T1 Cu amended soil, T2 non-contaminated soil+*P. vermicola* inoculation, T3 Cu amended soil+*P. vermicola* inoculation

Source: Environ Sci Pollut Res (2016) 23:220–233

P. vermicola inoculation and copper induced changes in different photosynthetic attributes of lentil plants (2016)

Treatments	Gs (mol m ⁻² s ⁻¹)	Ci (̑ mol mol ⁻¹)	E(mmol H ₂ O m ⁻² s ⁻¹)	A(̑ mol CO ₂ m ⁻² s ⁻¹)	A/E (̑ mol CO ₂ /mmol H ₂ O)
T0	0.049±0.003 ^b	281±5.568 ^b	0.512±0.012 ^b	10.36±0.606 ^b	0.291±0.011 ^b
T1	0.023±0.001 ^d	190±5.686 ^d	0.255±0.104 ^d	4.48±0.211 ^d	0.103±0.003 ^d
T2	0.079±0.002 ^a	327±8.686 ^a	0.595±0.014 ^a	13.33±0.620 ^a	0.331±0.007 ^a
T3	0.037±0.00 ^c	236±8.386 ^c	0.423±0.012 ^c	7.83±0.500 ^c	0.243±0.006 ^c

Values are means±S.E. (n=3). Values carrying different letters are significantly different atP≤0.05 level as determined by Duncan's testT0non-contaminated soil,T1Cu amended soil,T2non-contaminated soil+P. vermicolainoculation,T3Cu amended soil+P. vermicolainoculation

Source: [springer.com/static/pdf/568/art%253A10.1007%252Fs11356-015-5354-1.pdf](https://www.springer.com/static/pdf/568/art%253A10.1007%252Fs11356-015-5354-1.pdf)

Effect of Cu and castasterone on contents of various polyphenols (̑g g⁻¹) in 60 days old *B. juncea* plants (2016)

Polyphenol detected	Control	10 ⁻⁷ M CS	0.50 mM Cu	0.50 mM Cu +10 ⁻⁷ M CS
Catechin	nd	nd	32.348	161.128
Chlorogenic acid	96.824	108.236	91.516	63.064
Epicatechin	nd	nd	32.94	48.188
Caffeic acid	509.832	443.156	482.524	416.696
Coumaric acid	0.6	0.3	5.14	0.824
Rutin	37.9	31.548	44.676	55.04
Quercetin	2.524	0.832	nd	nd
Umbelliferone	nd	1.544	47.752	7.436
Ellagic acid	61.248	87.732	41.288	338.328
Kaempferol	nd	22.832	28.584	42.592
Tert-butyl hydroquinone	nd	nd	1.332	nd
Total content	708.928	696.18	808.1	1,133.296

Note: nd—not detected.

Poonam at al.(2016), Castasterone assisted accumulation of polyphenols and antioxidant to increase tolerance of *B. juncea* plants towards copper toxicity, Cogent Food & Agriculture

Source: <https://www.tandfonline.com/doi/full/10.1080/23311932.2016.1276821>

Relationship between copper concentration in growth medium and its uptake in crops. Copper was mainly accumulated in roots and less translocated to shoots. Cu in plant parts did not linearly increase with increasing Cu levels in the growth medium (2015)

Exp.	Cu concentration in medium	Duration (days)	Crop type	Uptake and accumulation (mg kg ⁻¹)	References
Hydroponics	50 to 150 µM	10	Rapeseed	Leaves 107.9–203.1	Ivanova et al. 2010
				Root 297.3–383.7	
	0.1 to 10 mM	6	Maize	Root 5.9–1668.2	Benimali et al. 2010
	10 to 50 µM	14	Rapeseed	Root 740.40–2478	Feigl et al. 2013
				Shoot 57.6–82.01	
				Shoot 5.83–594.8	
				Leaves 13.5–160.9	
	10 to 50 µM	14	Indian mustard	Root 686.1–3637	Feigl et al. 2013
				Shoot 49.7–88.2	
	4 to 80 µM	15	Maize	Root 299–7790	Ouzounidou et al. 1995
	75 µM	7	Wheat	Root 618.5	Gajewska and Sklodowska
				Shoot 21.5	2010
	10 ⁻³ M	6	Maize	Root 1070	Lin et al. 2003
				Shoot 56	
	1.6 to 192 µM	35	Soybean	Leaves 67	Sanchez-Pardo et al. 2014
Sand	20 mg kg ⁻¹	20	Cucumber	Root 299	Alaoui-Sossé et al. 2004
Soil	1338 mg kg ⁻¹	50	Green gram	Root 60	Wani et al. 2007
				Shoot 26.2	
	50 to 250 mg kg ⁻¹	45	Green gram	Shoot 46.6–150	Manivasagaperumal et al. 2011

Source:https://www.researchgate.net/profile/Muhammad_Rizwan16/publication/274963313_The_effect_of_excess_copper_on_growth_and_physiology_of_important_food_crops_a_review/links/5711f8c308aeff315ba038e1/The-effect-of-excess-copper-on-growth-and-physiology-of-important-food-crops-a-review.pdf