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BRIEF COMMUNICATION

Phosphorus content and growth of fenugreek as affected by cadmium application

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Abstract

Changes in growth and phosphorus content in plants and seeds of fenugreek with increasing cadmium concentration was evaluated. Root length and shoot length ranged from 11.63 to 27.72 and from 9.70 to 54.78 cm, respectively. With the increasing Cd^{2+} concentration there was a significant decrease in root and shoot length, and fresh mass. Various phosphorus fractions of shoot decreased with increasing Cd^{2+} concentration except lipid P and nucleic acid P which increased at 65 and 95 d after sowing and protein P only increased at vegetative stage. In seeds (60 d after flowering) lipid P increased except at 2.5 $\mu g(Cd^{2+})\ g^{-1}$ (soil) while protein P decreased.

Key words: roots, seeds, shoots, *Trigonella foenum-graecum*

Increased industrialisation and urbanisation have resulted in the addition of large amounts of heavy metals in the environment. Among these, cadmium is more toxic than others because it not only disturbs various biochemical processes of plants but also posses a great threat to the health of animals and human beings.

Fenugreek seeds and leaves are rich in minerals, proteins and carbohydrates, but low in oil (Gad *et al.* 1982) and used as a new potential source for production of corticosteroids (Fazli and Hardman 1968). Therefore, the present study was undertaken to investigate the effect of different levels of cadmium on growth and prosphorus content of fenugreek.

Fenugreek (*Trigonella foenum-graecum* L.) cv. PEB (Pusa early bunching) was raised in earthenware pots filled with 5 kg of loamy soil in a naturally lit net house. Cadmium was applied in different concentrations *i.e.* 0 (control), 2.5, 5.0, 7.5, 10, 15 and 20 $\mu g\ g^{-1}$ (soil) in the form of cadmium chloride. Shoot were taken at 65, 95 and

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125 d after sowing (DAS) and seeds were taken at 40, 60 and 70 d after anthesis (DAF). The length of roots and shoots was recorded and the fresh mass of roots, shoots and seeds was determined. Then the sample was dried in an oven maintained at 70 °C to constant mass. Samples were pooled, ground and stored in air tight plastic bottles for estimation. Total phosphorus was estimated (Thomas and Chamberlin 1974) and phosphorus fractions were separated (Snell and Snell 1962).

At vegetative stage (65 DAS), root length initially increased reaching a maximum value at Cd^{2+} concentration 2.5 μg g^{-1}(soil) and then decreased. With the increasing Cd^{2+} concentration root length decreased significantly at 95 and 125 DAS (Table 1). Root branching reduced and the colour changed from brownish to cream colour. This decrease may be due to inhibition of root cell division (Vazduez *et al.* 1992). Branching of treated plants found to be more delicate. Fresh mass of root (per plant) decreased with increasing levels of Cd^{2+} at vegetative, flowering and maturity stage. Dry mass of root decreased by 93.4, 97.8 and 81.0 % at 65, 95 and 125 DAS, respectively.

The length of shoots decreased significantly with the increasing concentration of Cd^{2+} at all the three stages of growth. Cd^{2+} inhibited root elongation (Wojciechowska and Kouk 1987, Shaw 1995) and shoot growth (Salim *et al.* 1992) of different plants. The fresh mass of shoots also decreased with increasing Cd^{2+} concentration at vegetative, flowering and harvest stage. Similar trend was seen in dry mass of shoots which corresponded to results observed in roots and shoots of *Zea mays* (Nussbaum *et al.* 1988).

No regular trend in fresh mass of seeds was observed upto 10 μg(Cd^{2+}) g^{-1}(soil) at 40 DAF and then decreased to 150 mg per pod at 15 and 20 μg(Cd^{2+}) g^{-1}(soil). At 60 DAF, fresh mass was higher in all Cd^{2+} treatments as compared to control with a maximum value of 313 mg pod^{-1} at 10 μg(Cd^{2+}) g^{-1}(soil). At maturity, except at 2.5 and 7.5 μg(Cd^{2+}) g^{-1}(soil), it decreased with increasing Cd^{2+} concentration. Dry matter increased at 2.5 μg(Cd^{2+}) g^{-1}(soil) at all three stages and decreased later. Cd^{2+} severely affected fresh and dry mass of soybean pods (Huang *et al.* 1974).

At vegetative stage, total P decreased from 1.97 (control) to 1.32 and then increased to 1.86 mg g^{-1}(d.m.) at 20 μg(Cd^{2+}) g^{-1}(soil). Similarly at flowering and harvesting stage, total P decreased significantly from 2.22 to 1.76 and from 1.83 to 1.28 mg g^{-1}(d.m.) with the increase of Cd^{2+} concentration (Table 2).

Among phosphorus fractions, acid soluble P also decreased (with the increase of Cd^{2+} concentration) from 1.45 to 1.35, 1.87 to 1.15 and 1.39 to 0.95 mg g^{-1}(d.m.) at 65, 95 and 125 DAS. Maximum acid soluble P was present in control at flowering stage. At vegetative stage, acid soluble P decreased whereas lipid P, nucleic acid P and protein P increased. At flowering stage protein P and acid soluble P decreased. At maturity all P fractions decreased.

In seeds, total P content ranged from 2.18 (control; 70 DAF) to 3.41 mg g^{-1}(d.m.) (10 μg(Cd^{2+}) g^{-1}(soil), 70 DAF). With increasing Cd^{2+} concentration the total P at 70 DAF increased from 2.18 (control) to 2.68, while decreased at 60 DAF from 3.35 to 3.18 and at 40 DAF from 3.18 to 2.73 mg g^{-1}(d.m.) at 10 μg(Cd^{2+}) g^{-1}(soil) and increased to 3.34 mg g^{-1}(d.m.) at 20 μg(Cd^{2+}) g^{-1}(soil). Cd^{2+} mostly adversely effected the total P contents of the seeds similarly as that in shoots.

Table 1. Effect of cadmium on growth and fresh and dry matter yield of fenugreek plant. DAS - days after sowing, DAF - days after flowering

DAS	Treatment [$\mu g(Cd^{2+})\ g^{-1}$(soil)]	Root length [cm plant^{-1}]	fresh mass [mg plant^{-1}]	dry mass [mg plant^{-1}]	Shoot length [cm plant^{-1}]	fresh mass [mg plant^{-1}]	dry mass [mg plant^{-1}]	DAF	Seeds fresh mass [mg pod^{-1}]	dry mass [mg pod^{-1}]
65	0.0	24.71	346	152	14.73	1.803	0.248	40	230	72
	2.5	27.72	334	74	13.96	1.442	0.178		290	87
	5.0	20.66	183	35	11.34	0.790	0.693		250	79
	7.5	24.73	264	94	11.10	0.985	0.108		200	52
	10.0	21.43	55	38	10.96	0.730	0.088		260	50
	15.0	14.71	42	16	12.11	0.459	0.049		150	42
	20.0	14.52	29	10	9.70	0.501	0.048		150	42
95	0.0	24.16	1183	325	51.73	18.680	3.147	60	166	149
	2.5	24.13	1200	381	44.33	10.900	1.930		306	150
	5.0	22.50	683	266	40.93	9.275	1.704		240	138
	7.5	16.33	283	118	41.66	7.975	1.542		301	138
	10.0	11.63	200	62	34.70	4.025	0.722		313	146
	15.0	21.96	266	97	31.00	2.687	0.463		210	97
	20.0	16.86	73	7	35.60	2.137	0.468		181	93
125	0.0	21.66	330	275	54.78	6.815	5.212	70	120	118
	2.5	16.56	284	237	50.02	3.245	2.523		184	177
	5.0	18.16	255	225	54.66	2.267	1.460		102	96
	7.5	19.90	278	233	49.33	2.865	1.796		140	134
	10.0	16.95	166	112	40.33	1.179	0.806		116	101
	15.0	13.44	90	50	37.42	1.266	1.008		107	106
	20.0	16.41	135	52	34.78	0.858	0.568		72	66
CD_1 ($P < 0.05$) stages		2.51	157	5	2.01	1.620	0.559		28	3
CD_2 treatments		3.84	241	9	3.07	2.475	0.085		44	4
CD_3 stages × treatments		6.65	417	15	5.32	4.287	0.148		76	8

Table 2. Effect of Cd^{2+} on phosphorus content [mg g^{-1}(d.m.)] in developing fenugreek shoot.

DAS	Treatment [μg(Cd^{2+}) g^{-1}(soil)]	Total P	Acid soluble P	Lipid P	Nucleic acid P	Protein P
65	0.0	1.973	1.455	0.033	0.206	0.012
	2.5	1.837	1.455	0.045	0.159	0.026
	5.0	1.537	1.259	0.046	0.178	0.010
	7.5	1.570	1.247	0.027	0.208	0.014
	10.0	1.319	0.903	0.076	0.241	0.024
	15.0	1.760	1.236	0.175	0.215	0.071
	20.0	1.861	1.351	0.112	0.221	0.025
95	0.0	2.224	1.867	0.116	0.090	0.076
	2.5	2.050	1.587	0.138	0.134	0.080
	5.0	1.800	1.293	0.122	0.174	0.081
	7.5	1.982	1.512	0.191	0.125	0.074
	10.0	1.852	1.455	0.084	0.092	0.037
	15.0	1.919	1.618	0.090	0.133	0.045
	20.0	1.762	1.152	0.117	0.172	0.040
125	0.0	1.831	1.387	0.163	0.132	0.047
	2.5	1.079	0.804	0.041	0.042	0.023
	5.0	1.344	1.024	0.085	0.146	0.015
	7.5	1.762	1.020	0.066	0.079	0.027
	10.0	1.796	1.336	0.155	0.097	0.047
	15.0	0.972	0.751	0.100	0.037	0.010
	20.0	1.284	0.948	0.140	0.120	0.041
CD_1 ($P < 0.05$) stages		0.041	0.025	0.010	0.010	0.005
CD_2 treatments		0.062	0.038	0.016	0.015	0.008
CD_3 stages × treatments		0.107	0.066	0.028	0.025	0.014

At 40 DAF with the increase in Cd^{2+} concentration [upto 10 μg g^{-1}(soil)] acid soluble P content decreased and at higher concentration of Cd^{2+} acid soluble P increased. At 60 DAF, acid soluble P decreased from 2.29 (control) to 1.75, nucleic acid P increased from 0.25 to 0.86, lipid P increased from 0.21 to 0.30 and protein P decreased from 0.33 to 0.18 mg g^{-1}(d.m.) at 20 μg(Cd^{2+}) g^{-1}(soil). At 70 DAF, the results were just reverse *i.e.* acid soluble P increased from 1.28 to 1.55, lipid P decreased from 0.33 to 0.06, protein P increased from 0.04 to 0.37 and nucleic acid P increased from 0.43 to 0.62 mg g^{-1}(d.m.) at 20 μg(Cd^{2+}) g^{-1}(soil). The interactions between stages and treatments were significant in both shoots and seeds.

References

Fazli, F.R., Hardman, R.L.: The spice fenugreek (*Trigonella foenum graecum* L.), its commercial varieties of seed as a source of diosgenin. - Trop. Sci. **10**: 68-78, 1968.

Gad, S.S., Mohamed, M.S., Zalaki, M.E.: Effect of processing on phosphorus and phytic acid contents of some Egyptian variety of legumes. - Food Chem. **8**: 11-20, 1982.

Table 3. Effect of Cd^{2+} on phosphorus content [mg g^{-1}(d.m.)] in fenugreek seeds.

DAF	Treatment [$\mu g(Cd^{2+})\ g^{-1}$(soil)]	Total P	Acid soluble P	Lipid P	Nucleic acid P	Protein P
40	0.0	3.189	1.998	0.244	0.579	0.089
	2.5	2.696	1.761	0.185	0.509	0.067
	5.0	2.501	1.881	0.210	0.269	0.037
	7.5	2.832	1.982	0.256	0.400	0.137
	10.0	2.730	1.628	0.260	0.331	0.106
	15.0	3.230	2.244	0.187	0.395	0.179
	20.0	3.349	2.587	0.268	0.262	0.158
60	0.0	3.353	2.289	0.206	0.248	0.332
	2.5	2.882	1.709	0.574	0.525	0.027
	5.0	3.100	2.275	0.203	0.274	0.092
	7.5	2.738	2.126	0.131	0.301	0.103
	10.0	2.558	1.382	0.258	0.702	0.168
	15.0	3.175	1.662	0.327	0.801	0.734
	20.0	3.183	1.754	0.300	0.856	0.185
70	0.0	2.185	1.278	0.330	0.428	0.042
	2.5	3.222	2.008	0.190	0.398	0.058
	5.0	2.896	1.397	0.326	0.530	0.069
	7.5	2.633	1.737	0.210	0.528	0.092
	10.0	3.406	1.358	0.415	0.680	0.129
	15.0	2.364	1.639	0.169	0.428	0.051
	20.0	2.684	1.554	0.062	0.617	0.370
CD_1 ($P < 0.05$) stages		0.069	0.037	0.013	0.016	0.014
CD_2 treatments		0.105	0.056	0.020	0.025	0.021
CD_3 stages × treatments		0.181	0.090	0.035	0.043	0.036

Huang, C.Y., Bazzaz, A.F., Van der Hoef, L.N.: The inhibition of soybean metabolism by cadmium and lead. - Plant Physiol. **54**: 122-124, 1974.

Nussbaum, S., Schmutz, D., Brunold, C.: Regulation of assimilatory sulfate reduction by Cd in *Zea mays* L. - Plant Physiol. **88**: 1407-1410, 1988.

Salim, R., Al Subu, M.M., Doulch, A., Chenavier, L., Hagemeyer, J.: Effects of root and foliar tratments of carrot plants with lead and cadmium on the growth, uptake and distribution of metals in treated plants. - J. Environ. Sci. Health (Part-A) Environ. Sci. Eng. **27**: 1739-1758, 1992.

Shaw, B.P.: Effects of mercury and cadmium on enzymes activities in the seedlings of *Phaseolus aureus* Roxb. - Biol. Plant. 37: in press, 1995.

Snell, F.D., Snell, C.T.: Colorimetric Methods of Analysis. - D. Van Nostrand Company, New York 1962.

Vazduez, M.D., Poschenrieder, C., Barcelo, J.: Ultrastructural effects and localisation of low cadmium concentrations in bean roots. - New Phytol. **120**: 215-226, 1992.

Wojciechowska, B., Kouk, H.: Effect of cadmium, cobalt and bismuth nitrate on the root meristem of *Vicia faba* L. - Pr. nauk. Uniw. sląsk. Katowicach O(932): 74-91, 1987.