World Applied Sciences Journal 8 (Special Issue of Biotechnology & Genetic Engineering): 26-29, 2010
ISSN 1818-4952

Effect of Cadmium Toxicity on the Growth and Yield Components of Mungbean [*Vigna radiata (L.) Wilczek*]

Abdul Ghani

Department of Biological Sciences, University of Sagodha, Pakistan

Abstract : Experiment was conducted with 7 mungbean varieties to determine the effect of cadmium toxicity on the growth, yield and yield components. The decrease in seed yield per plant under cadmium toxicity was more pronounced with a reduced number of seeds per pod and number of seeds per plant. Consequently cadmium toxicity was more effective at seedling, vegetative and seed filling stages rather than seed development stage in all the 7 varieties. NM-98 was less affected which showed its adaptability for Cadmium stress conditions.

Key words: Cadmium toxicity · Mungbean · Varities · Growth · Yield

INTRODUCTION

Mungbean is an important legume species and provides an important source of human diet. A survey of literature reveals that genera *Vigna* and *Phaseolus* have not been extensively investigated with respect to Cd toxicity effects. Available reports depict that mungbean (used to be denoted by the genera *Vigna* and *Phaseolus*) shows sensitivity to Cd toxicity and the effects are discernible at molecular and physiological levels. Although genotypic differences exist [1], the Cd application decreases the shoot and root growth [2,3], leaf area [4] and ultimately the dry matter yield of mungbean [5,6]. It perturbs the stomatal regulation, abscisic acid content, water status of leaves [7] and nitrogen fixing ability and enzymes of ureid biosynthesis in the nodules [8]. Geuns *et al*. [9] suggests that based on changes occurring in growth and physiological attributes, mungbean can be regarded as bioindicator of Cd toxicity.

MATERIALS AND METHODS

The experiment was a pot trial carried out in the green house of Botanical Garden, University of Agriculture, Faisalabad under natural conditions. The seeds of all the mungbean varieties NM-54, NM-88, NM-92, NM-28, NM-13-1, NM-19-19 and NM-98 were obtained from Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad. The varieties selected for their trails showed contrasting seed characteristics. The plants were raised in earthen pots 30 cm in diameter lined with polythene bags, containing 8 kg of sun dried, homogeneous sandy loam soil and three plants were maintained per pot after thinning.

The pots were randomly placed in a green house. The physico-chemical characteristics of soil were; organic matter 1.4%; cation exchange capacity 11.5 meq l^{-1}; pH 7.6; EC 0.7 dS m-1; sodium absorption ratio 0.06 meq l^{-1}; Na+ 2.39 meq l^{-1}; Cl- 7.85 meq l -1; SO4 2 – 1.49 meq l^{-1} and Ca + Mg 14.7 meq l^{-1}. The average temperature during the experiment was between 33°C ± 4 to 40°C ± 3, relative humidity between 27% ± 4 to 35% ± 8 and rainfall ranged from 64mm to 86 mm. Cadmium chloride solution with 0, 3,6,9 and 12 mg/Kg were added to soil at different growth stages i.e., seedling, vegetative and maturity stages. Tap water was used for irrigation throughout the growth period as and when required. The EC of the tap water was also measured by EC meter, which ranged from 0.3 to 0.7 dS m-1 during the experiment. The data for growth yield and yield components were recorded at vegetative and maturity stages of crop. Data collected were statistically analyzed for significance [10].

RESULTS

Statistical analysis for the pod characteristics of economic value for mungbean (number of pods per plant, average pod length, fresh and dry weight of pod per plant) indicated highly significant ($p<0.01$) differences among the varieties with increased cadmium. Interactions of these factors was also highly significant ($p<0.01$) except in case of dry weight per pod. The increasing

Corresponding Author: Abdul Ghani, Department of Biological Sciences, University of Sagodha, Pakistan

levels of cadmium decreased all the pod characteristics of economic yield taken at maturity. All the varieties indicated distinct behavior for these economic yield parameters which was greatest in NM-98 while lowest in NM-28.

The analysis of variance for seed characteristics of economic yield e.g. number of seeds per plant, indicated highly significant results ($p<0.01$) except for the number of seeds per pod which was non significant ($p>0.07$). The increasing cadmium levels decreased all the seed characteristics of economic yield in all varieties at maturity during present studies.

However, the varieties indicated peculiar behavior for all the seed characteristics of economic yield parameters which was maximum in case of NM-98, while it was virtually nil in case of NM-28 as no pod formation was observed in this variety at the highest level of cadmium. Moreover, some changes occurred in growth characters of 7 mungbean varieties at 12 mg cd/kg of soil levels of cadmium at maturity.

DISCUSSION

Plants respond to environmental stresses by a variety of means. It is noted frequently in case of many crop species that tolerance to prevailing stress conditions changes with the advancing age of the plant. It is suggested that tolerance to metal stress should be determined at all the phenological stages [11-13]. This approach was adopted here for finding genotypic variability among seven mungbean varieties based on the visual effects of Cd stress and changes in growth attributes at seedling, vegetative and reproductive stages of growth along with pod and seed yield characteristics at maturity.

During present study it was observed that all the varieties showed significant reduction in shoot length, root length and overall plant biomass at the highest level of cadmium applied which is supported by the earlier reports showing that mungbean was sensitive to increased Cd-levels [2,3] and the effects were noted in

Table 1: Yield characteristics of mungbean varieties under cadmium stress at maturity

		Pod Parameters						Seed Parameters	
Verities	Cadmium levels (mg/Kg)	No. of pods/plant	Av. length of pod (cm)	Fr. Wt of single pod (g)	Dry wt. of single pod (g)	Tot. fr. Wt. of pods/ Plant (g)	dry wt. of all pods plant (g)	No. of seeds/pod	No. of Seeds/ plant
NM-54	Control	6	7.1	0.49	0.39	3.09	1.78	9	46
	3	4	6.7	0.38	0.29	2.17	0.93	7	13
	6	3	4.8	0.19	0.17	0.67	0.48	6	15
	9	2	3.9	0.17	0.09	0.33	0.18	7	9
	12	1	2.2	0.11	0.23	0.26	0.13	4	2
NM-88	Control	7	4.3	0.42	0.33	2.67	1.68	8	42
	3	4	3.8	0.29	0.28	1.13	1.09	7	11
	6	3	2.4	0.17	0.29	0.76	0.18	7	17
	9	2	2.2	0.12	0.19	0.21	0.07	3	7
	12	1	1.1	0.01	0.11	0.17	0.001	2	-
NM-92	Control	7	7.4	0.37	0.36	2.88	2.76	7	39
	3	7	4.9	0.26	0.32	1.67	1.29	6	2
	6	2	3.7	0.23	0.22	1.46	0.67	4	11
	9	1	2.9	0.19	0.17	0.68	0.44	3	5
	12	1	1.4	0.11	0.008	0.26	0.32	2	12
NM-28	Control	9	7.9	0.43	0.36	3.39	2.74	8	70
	3	6	4.7	0.39	0.22	1.69	1.63	7	29
	6	3	3.6	0.31	0.18	1.49	0.48	4	4
	9	2	3.4	0.26	0.14	0.29	0.39	3	8
	12	2	3.1	0.19	0.11	0.23	0.23	2	8
NM-13-1	Control	8	7.6	0.41	0.43	3.32	2.11	7	64
	3	6	4.7	0.37	0.18	1.79	1.07	4	15
	6	4	3.8	0.31	0.17	1.77	0.69	2	10
	9	2	3.6	0.21	0.13	0.29	0.79	1	11
	12	1	3.2	0.14	0.009	0.17	0.09	1	7

Table 1: Continued

NM-19-19	Control	7	4.7	0.38	0.27	2.78	1.78	8	44
	3	7	3.8	0.33	0.23	1.76	1.43	6	5
	6	3	3.6	0.23	0.18	1.73	0.19	4	13
	9	2	3.4	0.21	0.14	0.28	0.13	3	2
	12	1	3.2	0.11	0.11s	0.23	0.08	2	6
NM-98	Control	9	6.9	0.77	0.44	3.78	2.84	11	87
	3	7	7.7	0.49	0.34	3.76	2.11	8	18
	6	7	4.9	0.39	0.29	2.88	2.01	6	27
	9	3	3.6	0.33	0.26	1.79	1.67	7	14
	12	1	3.3	0.27	0.18	1.73	1.11	3	5

Table 1b: Yield characteristics of mungbean varieties under cadmium stress at maturity

Summary of significance of variance sources								
Varieties (V) 7	**	**	**	n.s	**	**	n.s	**
Cadmium levels 4 (Cd).	**	**	**	**	**	**	**	**
VxCd 28	**	**	**	n.,s	**	n.s	**	**

Significance at P.0.01 n.s Non significant

Table 2: Some growth parameters of mughbean varieties at 12 mg/Kg Cadmium stress

	Varieties						
Growth parameters	NM-54	NM-88	NM-92	NM-28	NM-13-1	NM-19-19	NM-98
Shoot length (cm)	27.17	28.16	29.17	19.3	24.9	26.4	32.79
Root length (cm)	9.7	8.49	9.17	6.3	7.78	6.97	17.17
Shoot Fr. Wt. (g)	7.9	7.78	6.98	4.4	6.74	7.82	10.19
Root Fr. Wt(. g)	2.17	3.16	4.27	3.18	3.42	3.26	8.26
Number of leaves	07	06	11	04	07	08	13
Leaf area per plant/ cm²	23.7	21.6	39.41	16.19	20.18	23.3	73.31

terms of reductions in shoot length and root length and overall plant dry mass [1]. Moreover, Cd-stress reduced the number of green leaves (Table 2) apparently by enhanced senescence and death of older leaves and producing injury symptoms on the younger leaves, thereby reducing the leaf area per plan (Table 2). The changes in plant growth attributes due to Cd-stress at reproductive stage were more crucial to seed yield attributes.

It was noted during the present study that pod characteristics of economic values for mungbean i.e. number of pods per plant, average pod length, fresh and dry weights of pods per plant showed highly significant differences among all the varieties with increased levels of cadmium (Table 1) which are attributed to the accumulation of Cd^{2+} in various plant parts absorbed from growing media [1,5,14,15], which ranges from six to nine folds in various mesophytes including *Vigna radiata* [16].

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