Screening of Heavy Metal Tolerant Jute Seeds by Germination Test

Abstract

Present study was the part of an ongoing green plant based contaminated soil remediation technology. The experiment was conducted in two phases.The 1st phase of the experiment was carried out in the laboratory of the department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensing with a view to screening different varieties of jute seeds against the single and combined toxicity of heavy metals viz. As, Pb, Cd by germination test to select heavy metal tolerant jute seeds. Initially 10 treatments were considered viz. 0.5, 10, 15, 20, 30, 50, 70, 100 and 150 ppm for As, Pb, Cd separately and in combination with As, Cd and Pb. The increased levels of heavy metals significantly decreased the germination percentage, seedling height, shoot and root length, fresh and dry weightof five jute varieties. Among five varieties height germination percentage seedling height, shoot and root length, fresh and dry weight were observed with BINA deshi pat-2 but the seedlings survived up to100 ppm single and combined doses of As, Cd and Pb. Germination and seedlingvigor of other four varieties were much less resistance of heavy metal treatments. After screening, BINA deshi pat-2 was used as a phytoremediant in the second phase of bioremediation process which such carried out in the net house from October 2009 onwards. Other two varieties namely BADC deshi pat (CVL-1) and atom pat-38 were selected from experiment conducted by other researcher. In the 2nd phase number of treatments were reduced to six from ten such as 0, 15, 40, 70, 100 and 150ppm single treatments of the experiment revealed that, seeds of the three varieties germinated in toxic soil environment but their primary growth was not satisfactory. Reasons behind the stunted growth might be due to off-season and unfavorable environmental condition. But our idea was to grow jute in successive seasons in a year. BINA deshi pat-2 though photosensitive variety but in pot trial in off season from October, 2009 onwards failed to grow at minimum height not only at toxic condition but also in non toxic soil i.e. in control treatment.

Keywords: Heavy Metal, Jute Seeds and Germination Test

Introduction

Contamination of agricultural soil by heavy metals viz. As, Pb, Cd, Cr is a great concern in Bangladesh and as well as over the globe. The term heavy metals indicate metal having density more than five times than that of water, air, plant and animals in their tissue.

Arsenic (As) is a toxic heavy metal, widely encountered in the environment, ecological component and abundance in the earth crust. Arsenic contamination in Bangladesh is probably geological in nature, originating from the fine alluvial sediments of the Ganges Delta.

In Bangladesh arsenic contamination of ground water was first confirmed in 1993 at ChapaiNawabganj district. At present 59 districts across the country are affected by arsenic poisoning. Consequently 80 million people are new exposed to the threat of arsenic and 10,000 people have shown the symptoms of arsenicosis(Zaman*et al*., 2005).

According to the World Health Organization (WHO,1999)about 80 million people in Bangladesh are threatened by arsenic poisoning.

The oxidation of arsenopyrite or ferrous hydroxide minerals may be responsible for the release of arsenic oxide in solution to the groundwater. Groundwater contamination by Arsenic (As) in Bangladesh appears to be the longest mass poisoning in the world. Arsenic can cause contamination in surface soil through arsenic contaminated groundwater irrigation which in term enhances the levels of soil arsenic. The presence of high concentration arsenic in surface soil may result in high concentration of arsenic in cereals, vegetables and agricultural product and contaminate the food chain affecting human health. According to WHO (1999), 0.01 mg As for drinking water, 0.2 mg As L^{-1} for livestock, 0.1 mgAs L^{-1} for irrigation are recommended where 100 times more than that in different regions are found. High concentration of Cd in soil represents a potential threat to human health because it is incorporated in the food chain mainly by plant uptake (Alvarez-Ayuso, 2008).

The toxicity of heavy metal is a part of ecological, evolutionary and environmental reasons (Nagajyoti*et. al*., 2008). Germination of seed is the vital phase for successful crop production. If germination is affected in any way thenproduction will fall drastically. Negative effects of Pb toxicity on seed germination and seedling growth were examined (Iqbal *et. al*., 2004). Lead (Pb) produced highly significant effects on shoot, root lengths and dry biomass of *Lythrumsalicanea* (Joseph *et. al*., 2002).Presence of excess amount of heavy metal in the growth media affects seed to germinate and subsequent seedling growth. To meet the challenge of food security of 21st century research emphasis should be given on pollution free water and soil of Bangladesh. Heavy metal contaminated underground water is randomly used for irrigation in Bangladesh agriculture which ultimately pollutes the soil. Growing of edible crops in contaminated soil is of ultimate threat to the human health as well as livestock. So, emphasis should be given on remediation of toxicant from contaminated soil is brought under cultivation by non-edible crops. This income generating technology will clean the heavy metal contaminated soil as well as farmers will be economically benefited.

Research work relating this topic is very scanty in the world and a well as in Bangladesh. However, an effort has been made to conduct a study with the following major objectives:

i) To screen different varieties of jute seeds against single and combine toxicity of heavy metal by germination test.

ii) To observe the germination and seedling growth of different varieties of jute seeds in heavy metal contaminated soil in pot culture.

Materials and Methods

Present study is the part of ongoing green plant based remediation technology. This chapter contains a brief description of experimental site, treatment, soil, climate, pot preparation, transplanting of phytoremediators, fertilizer application, intercultural operations, data recording and statistical analysis.

3.1 Experimental site:

An experiment was conducted in two phases. In first phase, screening of heavy metal tolerant different varieties of jute seeds was done by germination test in the laboratory of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensing from July to August, 2009.

After screening the jute seeds asaphytoremediants the second phase of the experiment was conducted in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensing, from October 2009 onwards.

3.2 Test Seeds:

Following five different varieties of jute seeds were used to germination test under increased levels of single and combined toxicity of arsenic (As), lead (Pb) and cadmium (Cd).

a) Tosh pat (0-9897)
b) BINA deshi pat-2
c) 400 GYP-15(2)
d) 400 GYP-65(2)
e) 400 GYP-198(2)

3.3 Experimental procedure of the first phase of the experiment:

Germination test of different varieties of jute seeds were conducted in this phase under different levels of single and combined toxicity of heavy metals viz. As, Cd and Pb.Ten(10) different treatments were used such as 0.5, 10, 15, 20, 30, 50, 70, 100 and 150 mgL^{-1} separately for As, Pb, Cd and combination of As, Cd and Pb. Twenty seeds of each test cultivars were placed in each petridish filled with cotton. Desired concentration of As, Cd and Pb were calculated from sodium arsenate ($NaAsO_2$), Cadmium nitrate [$Ca(NaO_3)_2$ $4H_2O$]and lead nitrate [($Pb(NaO_3)_2$] respetively. 10 ml of test solution was placed in each petridish. The cotton was kept moist constantly with distilled water. The experiment was arranged in a Completely Randomized

Design (CRD) with threereplicationss at room temperature (28±1ºC). Data were recorded after seven days from sowing the seeds in petridish.

3.4 Parameter studied:

Studied in this phase:

a) Number of seed after 7 days
b) Germination percentage(%)
c) Seedling height (cm)
d) Shoot length (cm)
e) Root length (cm)
f) Fresh weight (g)
g) Dry weight (g)

3.5 Experimental data:

Experimental data were collected on the following parameters:

3.5.1 Seed germination:

Germinated seeds were counted from the beginning of the seed germination up to complete germination.

3.5.2 Plant height (cm):

The plant height was recorded at the time of germination. The height was measured from the internal base of petridish to tip of the main stem in cm.

3.5.3 Shoot and Root length of seedlings:

The shoot and root length of seedlings were measured after 7 days of the respective germination setting.

3.5.4 Fresh weight of seedlings:

After 7 days of seedlings were harvested and immediately after harvesting fresh weight of the seedlings were recorded.

3.5.5Dry weight of seedlings:

The dry weights of seedlings were measured after 7 days of the germination settings. Immediately after harvesting seedlings were sun dried followed by oven drying, the actual weight was measured thereafter.

3.6 Statistical analysis:

The collected data on various parameterswere statistically analyzed. The means for all treatments were calculated and analysis of variance for all chapters performed by F-test. The significance of difference between the pairs of means was calculated by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3.7 Experimental procedure in the second phase of the experiment:

After screening desired varieties viz. BADC deshi pat (CVL-1), BINA deshi pat-2 and Atom pat-38 were used as a phytoremediant in the second phase of the study. Experimental procedure is as follows:

3.7.1 Collection and preparation of soil:

For second phase of the study soil was collected from the surroundings of the KarimBhawan of BAU, campus at 0-15 cm depth.

3.7.2 Pot preparation:

An amount of 15 Kg soil was taken in a series of plastic pot each pot was 30 cm deep with 27 cm diameter at the top and 22 cm diameter at the bottom. Top surface area of each pot was 22 cm^2. The total no of pots used in this study was 36.

3.7.3 Treatments:

In the second phase of the experiment, treatment numbers were reduced fromten to sixviz. 0, 15, 40, 70, 100 and 150 $mgkg^{-1}$ soil separately for As and combination of As, Cd andPb. Urea, TSP, MoP and Gypsum were added at the rate of 135 $kgha^{-1}$, 100 $kgha^{-1}$, 70kgha-1 respectively each pot. Above recommended doses of fertilizer were applied three times in the soil.

3.7.4 Intercultural operations:

Necessary intercultural operations such as weeding, watering, fertilizing and pesticide application were done as and when needed.

Results and Discussion

This chapter represents the description and discussion of the results obtained from the study. The data were tabulated for 3 parameters viz. germination percentage, seedling height and biomass.

4.1 Effect of heavy metal on germination of different varieties of jute seeds

4.1.1 Effect of arsenic on germination

Increased levels ofAs significantly decreased the percentage of germination against the seeds of all the cultivar under test. Response of As on germination were identical at 5ppm As treatment and in control in case of Tosha pat (0-9897) and 400Gy P-15(2). Seeds of rest of the varieties showed negative effect at 5ppm As and onwards. The trend of germination reflected that the seeds of 400 Gy P-198(2) showed 0 percent germination at 70ppm As followed by 500 Gy P-65(2) at 100ppm As. But at 150ppm As treatment not a single seed of any variety germinated. With the increasing levels of As germination percentage gradually declined in all five varieties.

4.1.2 Effect of lead on germination

A significant negative relationship was obtained lead and germination of different varieties of jute seeds. Germination percentage ranged from 70-0, 75-0, 70-0, 70-0 and 65-0 in case of Tosha pat (0-9897), BINA deshi pat-2, 400 GyP-15(2), 500 Gy P-65(2) and 400 Gy P-198(2) variety respectively. Highest germination (15) and germination percentage (75) was found in case of BINA deshi pat-2 variety at controlled treatment while lowest was observed in Tosha pat (0-9897) and BINA deshi pat-2 variety at 100ppm of lead.

4.1.3 Effect of cadmium on germination

Negative impact of cadmium on germination of different varieties of jute seeds. Variety BINA deshi pat-2 and line 500Gy P-65(2) showed decreasing trend in case of germination. The highestgermination percentage was found inBINA deshi pat-2 (75%) followed by Tosha pat (0-9897), 400 Gy P-15(2) and 500 Gy P-65(2) having 75% germination at controlled treatment. Reason behind the decreasing trend of germination might be due to the detrimental effect of cadmium on physiology and cell division of jute seeds.

4.1.4 Combined effect of arsenic, lead and cadmium on germination

Germination of different varieties of jute seeds significantly decreased due to the combined toxicity of arsenic, lead and cadmium. Among the five varieties only BINA deshi pat-2 has showed its highest level of combined toxicity tolerance capacity at 100ppm arsenic, lead and cadmium. In fact the highest (60) and lowest (5) germination percentage was found in BINA desh pat-2 variety at 0 ppm and 100 ppm concentration respectively.

4.2 Effect of heavy metal on seedlings height of different varieties of jute

4.2.1 Effect of arsenic on seedlings height

Seedlings height decreased gradually with increased level of arsenic concentration. Seedlings height ranged from 5.9-0, 4.2-0, 4.3-0 and 4.2-0 for Tosha pat (0-9897), BINA deshi pat-2 and

400 Gy P-15(2); 500Gy P-65(2) and Gy P-198(2) respectively. Highest (5.9 cm) and lowest (0.7 cm) seedling height was obtained both in Tosha pat (0-9897) variety at 0 ppm and 100 ppm arsenic concentration respectively.

4.2.2 Effect of lead on seedlings height

Increased level of lead concentration gradually refunded the seedlings height of different varieties of jute seeds as showed in the table 1. Among the 5 varieties the tallest seedling (5.1 cm) was obtained in the control treatment of BINA deshi pat-2 variety. While the lowest seedling height (0.7 cm) was found in Tosha pat (0-9897) at 100 ppm Pb concentration.

4.2.3Effect of cadmium on seedlings height

Unlike arsenic and lead increased level of cadmium toxicity gradually declined the seedlings height of different varieties of jute seeds. Among the 5 varieties the tallest seedling (4.9 cm) was obtained in BINA deshi pat-2 variety at controlled treatment. While the lowest seedling height (0.7 cm) was obtained in Tosha pat (0-9897) at 100 cadmium toxicity. Seedlings height ranged from 5.7-0, 4.8-0, 4-0, 4.8-0, and 4.8-0 for Tosha pat (0-9897), BINA deshi pat-2, 400 Gy P-15(2), 500Gy P-65(2) and 400 Gy P-198(2) respectively.

4.2.4 Combined effect of arsenic, lead and cadmium on seedlings height

Seedlings height of different varieties of jute seeds drastically declined due to combined toxicity of arsenic, lead and cadmium. The highest seedling height (4.7 cm) was observed in Tosha pat (0-9897) and BINA deshi pat-2 variety both at controlled treatment. While the lowest seedling height (0.7 cm) was obtained in 500 Gy P-65(2) at 70ppm combined toxicity. Seedlings height ranged from 4.7-0, 4.7-0, 3.7-0, 4.1-0 and 1.8-0 for Tosha pat (0-9897), BINA deshi pat-2, 400 Gy P-15(2), 500 Gy P-65(2) and 400 Gy P-198(2) respectively. Reason behind such declined trend might be due to combined toxic effect of As, Pb and Cd on physiology and cell division of jute seedlings.

4.3 Effect of heavy metal on shoot and root length of different varieties of jute seeds

4.3.1 Effect of arsenic on shoots and roots length

Shoots and roots length also significantly decreased with increasing level of arsenic concentration. The reason behind such declined trend might be due to combined toxic effect of As, Pb and Cd on physiology and cell division of jute seedlings.

4.3.2 Effect of lead on shoots and roots length

A significant response in respect of shoots and roots length of different varieties of jute seedlings was observed at 1% level of probability. Shoots and roots length decreased gradually with the increase of Pb concentration (Table 2).

Table 1. Effect of Arsenic on shoots and roots length of different varieties of jute seeds

Varieties / Treatments (mgAsL^{-1})	Tosha pat 0-9897		BINA deshi pat-2		400 Gy P-15(2)		500 Gy P-65(2)		400 Gy P-198(2)	
	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)
0	5.6a	1.9a	4.6a	1.95a	4.0a	1.90a	4.0a	1.9a	3.9a	1.9a
5	5.0b	1.8ab	4.6a	1.85b	3.9a	1.85b	3.8a	1.8a	3.6a	1.8a
10	4.9b	1.8ab	4.4ab	1.75c	3.5ab	1.55c	3.5ab	1.6ab	3.1b	1.6ab
15	4.8b	1.7b	4.3b	1.65d	3.2b	1.45d	3.4ab	1.5abc	2.7bc	1.2b
20	4.5bc	1.6bc	4.2b	1.6e	2.0bc	1.15e	3.0b	1.2b	2.5bcd	1.0bc
30	3.5c	1.4c	4.1bc	1.5f	1.5c	0.7f	2.6c	1.0bc	2.1b	0.7bcd
50	2.1d	1.0d	2.1c	1.0g	1.0cd	0.5g	1.45cd	0.8bc	1.9bc	0.4b
70	0.7e	0.5e	1.4d	0.7h	0.8d	0.5h	0.9d	0.4c	1c	0.3bc
100	0.4ef	0.2ef	1.0e	0.6i	0.7e	0.4i	0e	0cd	0d	0abc
150	0f	0f	0f	0g	0f	0j	0e	0cd	0d	0abc
SE±	0.17	0.06	0.14	0.05	0.12	0.05	0.12	0.06	0.11	0.06
CV(%)	13.11	20.07	12.14	17.95	16.70	22.94	15.55	23.95	15.99	27.67
LSD	0.45	0.20	0.30	0.02	0.54	0.05	0.54	0.54	0.54	0.54

Note: P(≥0.01) means significant at 1% level of probability.

In a column figures with dissimilar letters differ significantly according to DMRT.

Table 2. Effect of Lead on shoots and roots length of different varieties of jute seeds

Varieties / Treatments (mgPbL^{-1})	Tosha pat 0-9897		BINA deshi pat-2		400 Gy P-15(2)		500 Gy P-65(2)		400 Gy P-198(2)	
	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)
0	3.5a	1.5a	4.3a	1.6a	3.5a	1.7a	3.3a	1.2a	3.5a	1.2a
5	3.6a	1.3ab	4.1a	1.4ab	3.3ab	1.4b	3.2a	1.1ab	3.4ab	1.1ab
10	3.4a	1.2abc	3.6ab	1.2b	2.8b	1.2bc	2.8b	1.0b	2.8b	1.0b
15	3.2ab	1.1b	2.5b	1.0bc	2.4c	1.1c	2.7bc	1.0b	2.6bc	0.9bc

20	3.1b	0.9bc	1.7c	0.9c	1.9d	1.1c	1.9c	0.9bc	1.9c	0.7c
30	2.1bc	0.9bc	1.2cd	0.7cd	1.0e	0.5d	1.6d	0.7c	1.6cd	0.5d
50	1.9c	0.8c	1.1d	0.5d	0.6f	0.4de	1.1e	0.6cd	1.1d	0.4de
70	0.6d	0.5cd	1de	0.7cd	0.6f	0.4de	0.6f	0.5d	1.6cd	0.3e
100	0.4e	0.2d	0.8def	0.2e	0.5fg	0.3def	0g	0e	0e	0f
150	0f	0de	0e	0f	0g	0e	0g	0e	0e	0f
SE±	0.11	0.04	0.12	0.04	0.10	0.04	0.10	0.03	0.10	0.03
CV (%)	15.27	23.79	17.03	24.89	19.16	26.14	18.38	26.38	17.03	30.58
LSD	0.27	0.31	0.31	0.30	0.16	0.22	0.16	0.11	0.27	0.11

Note: P (≥0.01) means significant at 1% level of probability.

In a column figures with dissimilar letters differ significantly according to DMRT.

4.3.3 Effect of cadmium on shoots and roots length

Shoots and roots length of different varieties of jute seedlings declined gradually with the increase of Cd concentrations. The highest root length (1.9 cm) was recorded with BINA deshi pat-2 and 400Gy p-15(2) both at control treatment. Up to 5ppmCd concentration root length was statistically identical with all the five varieties (Table 3).

4.3.4 Combined effect of arsenic, lead and cadmium on shoots and roots length

Increased level of combined toxicity also significantly decreased the shoot and root length of different varieties of jute seedlings. Significant negative response also found on the root length of different genotypes with increased levels of combined toxicity. Reasons behind such decline trend might be due to the detrimental effects of As, Cd and Pb on meristematic root tip development (Table 4).

Table 3. Effect of Cadmium on shoots and roots length of different varieties of jute seeds

Varieties / Treatments ($mgCdL^{-1}$)	Tosha pat 0-9897		BINA deshi pat-2		400 Gy P-15(2)		500 Gy P-65(2)		400 Gy P-198(2)	
	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)
0	5.4a	1.7a	4.6a	1.9a	3.9a	1.9a	4.5a	1.8a	4.6a	1.8a
5	5.0b	1.6a	4.5ab	1.8b	3.7ab	1.8a	4.3ab	1.7ab	4.2ab	1.7a
10	4.7bc	1.6a	4.3b	1.7c	3.5ab	1.5ab	3.5b	1.5b	3.9b	1.6ab
15	4.6c	1.5ab	4.1bc	1.6d	3.2b	1.4b	3.4bc	1.4bc	3.2bc	1.2b
20	4.4cd	1.4ab	4.1bc	1.5e	2.0c	1.1bc	3.1c	1.0c	2.5c	1.0bc
30	3.4d	1.3b	3.8c	1.4f	1.3d	0.75c	2.7d	1.0c	2.1cd	0.7c
50	1.9e	1.0bc	2.1d	1.0g	0.8e	0.55cd	1.5e	0.8d	1.9d	0.4cd
70	0.6f	0.5c	1.4e	0.7h	0.8e	0.5cde	0.9f	0.4e	1e	0.3cde
100	0.4fg	0.2d	1.0f	0.6i	0.7ef	0.4d	0g	0f	0f	0d

150	0g	0e	0g	0j	0f	0de	0g	0f	0f	0d
SE±	0.17	0.05	0.13	0.05	0.12	0.06	0.13	0.05	0.13	0.06
CV (%)	13.45	20.83	12.26	18.15	17.20	23.72	15.25	23.80	15.55	27.81
LSD	0.35	0.28	0.30	0.05	0.54	0.54	0.27	0.11	0.54	0.54

Note: P (≥0.01) means significant at 1% level of probability.

In a column figures with dissimilar letters differ significantly according to DMRT.

Table 4. Combined effect of arsenic, lead and cadmium on shoots and roots length of different varieties of jute seeds

Varieties / Treatments (mg As,Pb and Cd L^{-1})	Tosha pat 0-9897		BINA deshi pat-2		400 Gy P-15(2)		500 Gy P-65(2)		400 Gy P-198(2)	
	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)
0	4.4a	1.8a	4.6a	1.9a	3.6a	1.7a	3.8a	1.8a	3.9a	1.9a
5	4.3a	1.7a	4.5a	1.8a	3.5b	1.6a	3.8a	1.7a	3.9a	1.8a
10	4.2ab	1.6ab	4.3a	1.7a	3.4ab	1.5ab	3.7ab	1.6ab	3.8a	1.7a
15	4.1b	1.5b	4.1ab	1.6a	3.3b	1.1b	3.6b	1.5b	3.6ab	1.6ab
20	3.9bc	1.3bc	3.8b	1.5ab	2.5bc	0.8bc	3.0bc	1.3c	2.5b	1.0b
30	3.0c	1.2bc	3.5bc	1.0b	2.0c	0.7c	2.1c	0.9d	2.0bc	0.9b
50	2.8cd	1.0bcd	3.2c	0.7bc	1.6d	0.6cd	1.8cd	0.8de	1.5c	0.8b
70	1.6d	0.7c	2d	0.5bc	0e	0d	1.6d	0.7e	1.5c	0.7bc
100	0e	0d	1e	0.2bcd	0e	0d	0e	0f	0d	0c
150	0e	0d	0f	0c	0e	0d	0e	0f	0d	0c
SE±	0.14	0.05	0.13	0.06	0.12	0.05	0.12	0.05	0.12	0.06
CV (%)	13.06	21.47	11.49	22.37	17.44	29.04	14.65	22.23	15.41	23.41
LSD	0.3	0.38	0.58	0.54	0.27	0.30	0.11	0.11	0.54	0.54

Note: P (≥0.01) means significant at 1% level of probability.

In a column figures with dissimilar letters differ significantly according to DMRT.

4.4 Effect of heavy metal on fresh and dry weight of different varieties of jute seeds

4.4.1 Effect of arsenic on fresh and dry weight

Data from Table 5 revealed that increased level of arsenic significantly decreased the fresh and dry weight of different varieties of jute seedlings. Fresh weight of different varieties of jute seedlings declined gradually due to increased level of arsenic toxicity (Table 5).

4.4.2 Effect of lead on fresh and dry weight

Results from Table 6 showed that fresh weight of different varieties of jute seedlingswas significantly affected by increased level of Pb. The fresh weight reductions were statistically significant with 1% level of significance.

Table 5. Effect of arsenic on fresh weight of different varieties of jute seeds

Varieties / Treatments (mg As L^{-1})	Fresh weight (g)				
	Tosha pat o-9897	BINA desh pat-2	400 Gy P-15(2)	500 Gy P-65(2)	400 Gy P-198(2)
0	2.9a	2.8a	2.0a	2.0a	2.0a
5	2.8a	2.6b	1.9a	1.9a	1.9a
10	2.7ab	2.5bc	1.9a	1.8a	1.8a
15	2.6b	2.3c	1.8a	1.6ab	1.6ab
20	2.1bc	2.2cd	1.7ab	1.3b	1.1b
30	1.8c	1.8d	0.9b	1.0bc	1.0bc
50	1.3d	1.4e	0.7bc	0.9bc	0.8bc
70	0.9e	0.7f	0.6bc	0.7bcd	0.5bcd
100	0.7ef	0.6g	0.5bcd	0c	0c
150	0f	0h	0d	0c	0c
SE±	0.08	0.08	0.06	0.06	0.06
CV (%)	15.93	16.37	20.71	22.18	23.43
LSD	0.23	0.11	0.54	0.54	0.54

Note: P (≥0.01) means significant at 1% level of probability.

In a column figures with dissimilar letters differ significantly according to DMRT.

Table 6. Effect of lead on fresh weight of different varieties of jute seeds

Varieties / Treatments (mg Pb L^{-1})	Fresh weight (g)				
	Tosha pat o-9897	BINA desh pat-2	400 Gy P-15(2)	500 Gy P-65(2)	400 Gy P-198(2)
0	2.7a	2.7a	2.4a	2.5a	2.3a
5	2.5ab	2.5ab	2.2b	2.2b	2.1b
10	2.4abc	2.2abc	2.0c	2.0bc	1.9c
15	2.2b	2.0b	1.9d	1.9c	1.4d

20	1.9bc	1.9bc	1.6e	1.5d	1.0e
30	1.5c	1.7bcd	1.4f	1.2e	1.9f
50	1.3cd	1.4c	1.0g	0.9f	0.7g
70	0.8d	0.7d	0.8h	0.5g	0.5h
100	0.7ed	0.6de	0.5i	0h	0i
150	0e	0e	0j	0h	0i
SE±	0.07	0.07	0.06	0.07	0.07
CV (%)	16.73	17.23	18.07	21.11	22.14
LSD	0.31	0.56	0.11	0.27	0.16

Note: P (≥0.01) means significant at 1% level of probability.
In a column figures with dissimilar letters differ significantly according to DMRT

Table 6 also showed that dry weight production of different varieties of jute seedlings decreased significantly with increased level of Pb concentration. Possible reasons for such declining trend might be due to the increased detrimental effect of Pb on growth of jute seedlings.

4.4.3 Effect of cadmium on fresh and dry weight

A significant response in respect of fresh and dry weight of different varieties of jute seedlings was observed at 1% level of probability. Fresh and dry weight production decreased gradually with increased level of Cd concentration.

4.4.4 Combined effect of arsenic, lead and cadmium on fresh and dry weight

Fresh and dry weight of different varieties of jute seedlings was significantly affected by increased level of combined toxicity of As, Pb and Cd. Decreasing trend in terms of fresh and dry weight of seedlings due to increased level of toxicity was observed in all 5 varieties.

Table 7. Effect of cadmium on fresh weight of different varieties of jute seeds

Varieties / Treatments (mg Cd L^{-1})	Fresh weight (g)				
	Tosha pat o-9897	BINA desh pat-2	400 Gy P-15(2)	500 Gy P-65(2)	400 Gy P-198(2)
0	2.8a	2.8a	2.5a	1.9a	2.0a
5	2.7a	2.7ab	2.1b	1.8a	1.9a
10	2.6a	2.5b	2.0bc	1.7a	1.7a
15	2.5ab	2.3c	1.8bcd	1.6ab	1.5ab
20	2.1b	2.1d	1.7c	1.3b	1.4b
30	1.8bc	1.7e	1.4d	1.0bc	1.0c
50	1.3c	1.4f	1.0e	0.9bcd	0.8c
70	0.8d	0.7g	0.8ef	0.5c	0.5cd
100	0.7de	0.6h	0.5f	0cd	0d

150	0e	0i	0g	0cd	0d
SE±	0.08	0.08	0.06	0.06	0.06
CV (%)	16.22	16.51	18.19	22.94	23.09
LSD	0.37	0.11	0.27	0.54	0.54

Note: P (≥0.01) means significant at 1% level of probability.
In a column figures with dissimilar letters differ significantly according to DMRT.

Table 8. Combined effect of arsenic, lead and cadmium on fresh weight of different varieties of jute seeds

Varieties / Treatments (mg As, Pb and Cd L^{-1})	Fresh weight (g)				
	Tosha pat o-9897	BINA desh pat-2	400 Gy P-15(2)	500 Gy P-65(2)	400 Gy P-198(2)
0	2.5a	2.6a	1.9a	1.7a	1.9a
5	2.4ab	2.4a	1.8ab	1.6ab	1.8a
10	2.4ab	2.2a	1.7b	1.5b	1.7a
15	2.3b	2.1a	1.6bc	1.2c	1.6ab
20	2.2bc	2.0ab	1.1c	0.9d	1.1b
30	2.1bcd	1.8b	0.9d	0.7e	1.0b
50	2.0c	1.7bc	0.7e	0.65ef	0.9d
70	0.9d	1.0bcd	0f	0.6f	0.8bc
100	0.7de	0.7e	0f	0g	0c
150	0e	0d	0f	0g	0c
SE±	0.07	0.07	0.06	0.05	0.06
CV (%)	15.09	15.97	25.50	24.90	22.40
LSD	0.23	0.60	0.11	0.11	0.54

Note: P (≥0.01) means significant at 1% level of probability.
In a column figures with dissimilar letters differ significantly according to DMRT.

The experiment was conducted in the net house of the Department of Agricultural Chemistry, BAU, Mymensingh from October 2009 onwards to observe the growth performance of previously screened three jute varieties viz.BADC deshi pat (clv-1), BINA deshi pat-2 and Atom pat-38 in heavy metal contaminated soil. Results generated out of the second phase of the experiment revealed that, seeds of three varieties germinated inthe toxic environment but their primary growth was not satisfactory. Reasons behind the stunted growth might be due to the unfavorable environmental....that prevailed during the growing season since off-season....trial with jute seeds were made to have jute in two seasons. We know bright sunshine coupled with rainfall isfavorable for growth of jute plants but such environment was totally absent in the winter season.

Only primary growth of jute was studied in this phase of the experiment. Growth of different varieties of jute seedlings stunted severely in combined toxicity of heavy metal viz. As, Cd and Pb than singleAs contaminated soil. BINA deshi pat-2 though a photosensitive variety but in pot trial in off-season from October 2009 onwards failed to grow at minimum height not only at toxic condition but also under non-toxic soil as in control. If uptake of heavy metal by jute plants from contaminated soil is analyzed in the next season, then the heavy metal accumulating potentiality of jute could be assessed. This income generating phytoremediation technology will be easily taken up by the farmers to eliminate heavy metal, build up in soil.

Summary and Conclusion

Based on the results generated out of the first phase of the experiment following of jute seeds were made.

A. Grading of jute seeds against As, Pb and Cd toxicity

Sl. no.	Varietal class	Name of the jute variety
1.	Highly tolerant	BINA deshi pat-2
2.	Moderately tolerant	Tosha pat (0-9897)
3.	Tolerant	400 Gy P-15(2)
4.	Low tolerant	500 Gy P-65(2)
5.	Very low tolerant	400 Gy P-198(2)

B. Grading of jute seeds based on varietal potentiality considering the results of control treatment only

Sl. no.	Varietal class	Name of the jute variety
1.	Highly tolerant	BINA deshi pat-2
2.	Moderately tolerant	Tosha pat (0-9897)
3.	Tolerant	400 Gy P-15(2)
4.	Low tolerant	500 Gy P-65(2)
5.	Very low tolerant	400 Gy P-198(2)

The experimental findings of first phase revealed that BINA deshi pat-2 variety might have the potentially to serve in the toxic environmental conditions than the other four varieties. BINA deshi pat-2 variety was screened as the best variety to be used as a phytoremediant in the second phase of bioremediation process of removal of toxic heavy metal from contaminated soil.

Experimental findings of second phase of the experiment revealed that due to off season (from October 2009 onwards) pot trial seedlings of all the varieties failed to grow at minimum height not only at toxic environmental but also under non-toxic soil as in control. Unfavorable climatic conditions interrupted the primary growth of jute seedlings in pot culture. Only primary growth was studied in this phase. Heavy metal absorption by jute plants will be determined in the succeeding growing season. Metal accumulating efficiency of jute will be evaluated and jute will be recommended as phytoremediant for the removal of toxic heavy metals from contaminated soil.

References

Alvarez-Ayuso, E. 2008.Cadmium in soil-plant systems: an overview. International Journal of Environment and Pollution, 33(2-3): 275-291.

Iqbal, M.Z. and Y. Shazia. 2005. Reduction of germination and seedling growth of *Leucaenalucocephala*caused by lead and cadmium individually and combination. *Ekologia (Braslava),* 23(2): 162-168.

Joshep, L. U., L. C. Andrea and T. K. Mal. 2002.Effects of lead contamination on the growth of *Lythiumsalicaria*.Environmental Pollution. 120(2): 319-323.

Nagajyoti, P. C., N. Dinkar, T. N. V. K. V. Prasad, C. Suresh and T. Damodharam, 2008. Heavy metal toxicity: Industrial Effluent Effect on Groundnut (Arachishypogaea L.) Seedlings.Journal of Applied Sciences Research.4(1): 110-121.

WHO (World Health Organization). 1999. Arsenic in drinking water URL: http://www..who.int/inf-fs/en/fact.210.Htmail.

Zaman, M. W., Mollah, M. O. G., Rahman, M. M. and Nizamuddin, M. 2005. Identification of arsenic hyper accumulating weeds for the remediation of arsenic contaminated soil. Abstract. 9th International Symposium on Soil and Plant Analysis, 29 January- 04 February, Cancur, Mexico, p.14.