Germination Potential of Jute, Kenaf and Mesta to Chromium Toxicity

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Abstract

The study was carried out using seven varieties of jute, two varieties of kenaf and one variety of mesta to evaluate their germination potential to chromium (Cr) toxicity. Percent germination and primary growth parameters of these varieties in Cr contaminated medium were observed. Six levels (0, 20, 40, 80, 120 and 160 mg Cr L^{-1}) of Cr were applied in artificial germinating medium following CRD with three replication. All the jute, kenaf and mesta varieties showed decreasing trend of germination with increasing levels of Cr. Germination of kenaf (HC-95 and HC-3), mesta (Samu-93) and jute (CVE-3 and BJC-7370) were satisfactory levels up to 160 mgCr L^{-1}. The root and shoot lengths and fresh and dry weights also reduced with increased concentrations of Cr as the toxic effect of Cr retards the growth of meristematic tissues of young roots and shoots. Morphological deformities like twisting, curling of leaves and shoot and rottening of roots appeared at high concentrations of Cr. Due to receiving higher concentrations of Cr the color of the roots became dark brown to black. The potentiality of the varieties to Cr toxicity were kenaf HC-95 > kenaf HC-3 > mesta Samu-93 > jute CVE-3 and > jute BJC-7370. The findings of the present study can be applied for sowing kenaf, mesta and jute seeds in Cr contaminated soil.

Key words: Chromium, Germination, Jute, Kenaf, Mesta

Introduction

Chromium (Cr) is a toxic heavy metal. Environment pollution by Cr contamination is one of the important problems in the world. Chromium bearing rocks, minerals and releases of Cr from human activities are the main sources of Cr in the environment. Excessive release of Cr influences the Cr contamination in different component of environment. Human activities released 2 times more Cr than natural release (Khopkar, 2005). The main sources of chromium in the environment are paint, stainless steel and glass industries; electroplating bath and tanneries waste where $K_2Cr_2O_7$ is used for hides and skin cleaning and leather treatment. From the sources of origin, it is disseminated into the environment and contaminates soils. The dense industrially arable soils of Bhaluka upazila contained Cr ranged form 52.23 - 76.73 mg Cr kg^{-1} (Zabir, 2014); and 80.00 - 117.00 mg Cr kg^{-1} (Ahmed *et al*., 2004) ; and it was 61.00 - 900.00 mg Cr kg^{-1} in soils collected from the different industrial locations of Bangladesh (Begum, 2006). The rice and vegetable soils of southern Jiangsu, China contained Cr, Cd and Pb ranged from 58.2 -130.3 and 57.2 -149.9 mg kg^{-1}, respectively (Hongbin *et al*., 2010).

The soils of Jajmau and Unnao industrial areas of Uttar Pradesh, India significantly contaminated with Cr concentration of this element varied from 161.8 ï 6227.8 mg kg^{-1} (Gowd *et al*., 2010). Chromium is a toxic element it causes dermatitis ulceration, perforation of nasal septum, lung cancer, to workers working in paints, pigments and tannery industries (Khopkar, 2005). It has also adverse effect on plants but plants have wide range of tolerance to Cr toxicity. Several studies have shown that some plant species are potential to absorb toxic metals from the contaminated environment. Studies also conducted to evaluate the effects of different heavy metal concentrations on live plants (Raskin and Ensley, 2000). In most cases studies have been done using seedlings or adult plants (Islam *et al*. 2013; Pichtel *et al*., 2000) and sowing of seeds in contaminated soil (Bada and Kalejaiye 2010), (Nizam, 2014). For bioremoval of Pb and Cr from soil with *Cicer arietinum* (L.) was done by Dasguta *et al.* (2011) and observed the visible decrease in biomass production due to the effect of Pb and Cr toxicity.

Study on the exposed of seeds to the contaminated medium is limited (Xiong, 1998). Few studies have been conducted, seeds of alfalfa (*Medicago sativa*) exposed to Cr (VI) by Peralta *et al.* (2000). Seeds of jute, kenaf and mesta in Cd contaminated medium by Nizam *et al*. (2014), in Pb and Cr contaminated medium by Nizam *et al*. (2013); kenaf and jute in Pb and Cr contaminated medium by Akter (2011). In all cases they observed a certain levels of Pb, Cr and Cd tolerance of jute, kenaf and mesta at germination stage and also found that root and shoot growth of seedlings were affected at high concentrations. The survibility of plant species in contaminated media depends on its seed germination and is the first step of its growing. It is considered that if the seeds of a plant species are able to germinate in artificial contaminated medium and established their seedlings for a certain period and later on that might be grown on contaminated soil. The present study was designed to evaluate the germination potential of jute, kenaf and mesta to chromium toxicity.

Materials and Methods

Healthy seeds of jute (var. CVE-3, BJC-7370, CVL-1, O- 9897, O-795, O-72, and OM-1), kenaf (var. HC-95 and HC-3), and mesta (var. Samu-93) were separated from the collected seeds. To protect fungal attack the seeds were surface sterilized by dipping 95% ethanol and washed with deionized water. Analytical reagent grade chromium oxide (Cr O_3) was used as a source of Cr. Initially 1000 mg Cr L^{-1} stock solution was prepared and then it was diluted to different concentrations. Six levels (0, 20, 40, 80, 120 and 160 mg Cr L^{-1}) of Cr was applied. A thin layer of Cr free cotton was placed in the clean dry petridishes for germinating media. In each dish, 25 seeds of each variety were placed on the layer of cotton. After placing seeds 10 ml of deionized water was added to controls and 10 ml of solution containing different levels of Cr were added in each dish for different treatments. CRD with three replication was followed for each treatment. The dishes were then covered with lids and kept in the laboratory at room temperature. After two days the lids were removed and after three days the cotton layers of the dishes were further moistened with 5 mL deionized water for controls and 5 mL of different levels of Cr containing solution for each treatment. Data were recorded five days after placing seeds when the germination was completed and seedlings were established; the time for germination was followed as mentioned by Islam and Rahman (2008). The root and shoot lengths were measured from the average of 10 seedlings. Fresh weight of seedlings per petridish was measured just after harvesting and dry weights were measured after drying at 70 ^{0}C for 72 hrs. Statistical analyses were done following methods outlined by Gomez and Gomez (1984). The analysis of variance (ANOVA) of various characters of seedlings of different varieties were done to determine the effect of treatments. Least Significant Difference (LSD) and Duncanȏs Multiple Range (DMRT) tests were performed to determine the statistical significance of the differences between means of treatments.

Results and Discussion

Germination

Percent germination showed decreasing trend with increasing levels of Cr, the seeds of some varieties were degenerated and some of the varieties reflected their germination potentiality at higher concentrations. The highest germination (100%) of seeds were found in kenaf (HC-95) and jute (O-9897) at control and the lowest (0.00%) were in jute varieties (O- 9897, O-72, OM-1 and CVL-1) at 120 and 160 mg Cr L^{-1} treatment but in case of jute O-795. The lowest value was at 160 mg Cr L^{-1} levels. Almost all the tested varieties showed better performance up to 80 mg Cr L^{-1}. Kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (BJC-7370 and CVE-3) varieties showed their better performance up to 160 mg Cr L^{-1} (Table 1).

Table 1. Effects of Cr on the germination of different varieties of jute, kenaf and mesta

Cr levels (mg L^{-1})	Germination (%)									
	Jute (CVE-3)	Jute (BJC-7370)	Jute (CVL-1)	Jute (O- 9897)	Jute (O-795)	Jute (O-72)	Jute (OM-1)	Kenaf (HC-95)	Kenaf (HC-3)	Mesta (Samu-93)
0	90.00a	88.33a	85.00a	100.00a	95.00a	93.33a	95.00a	100.00a	95.00	91.67a
20	88.33a	81.67ab	78.33ab	88.33b	88.33a	81.67b	91.67a	98.33a	91.67	83.33b
40	86.67a	78.33abc	73.33b	86.67b	88.33a	76.67bc	90.00a	98.33a	88.33	81.67b
80	86.67a	76.67abc	68.33b	85.00b	76.67b	75.00c	81.67b	96.67a	86.67	80.00b
120	83.33ab	71.67bc	0.00c	0.00c	75.00b	0.00d	0.00c	85.00b	85.00	78.33b
160	75.00b	68.33c	0.00c	0.00c	0.00c	0.00d	0.00c	81.67b	83.33	76.67b
Range	75.0-90.0	68.33-88.33	0.0-85.0	0.0-100.0	0.0-95.0	0.0-93.33	0.0-95.0	81.67-100.0	83.33-95.0	76.67-91.67
Mean	85.00	77.50	50.83	60.00	70.56	54.44	59.72	93.33	88.33	81.94
SE±	1.57	2.07	8.88	10.38	7.91	9.46	10.31	1.94	1.34	1.47
LSD	5.28	6.95	5.93	3.42	5.55	2.97	3.42	4.36	4.84	4.53
Sig. levels	*	**	**	**	**	**	**	**	NS	*

*Legend: * = Significant at 5% level of probability, ** = Significant at 1% level of probability and NS = Not significant. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT*

Except kenaf HC-3 percent germination of different varieties of jute, kenaf and mesta seeds were significantly decreased with the increasing levels of Cr. No significant effect was found on the germination of kenaf HC-3 due to increasing levels of Cr application which indicates that the variety had high potentiality to Cr toxicity. In case of kenaf (HC-95) and jute (CVE-3 and BJC -7370) germination was identical from control to 80 mg Cr L^{-1}; whereas in mesta (Samu-93) it was identical from 20 to 160 mg Cr L^{-1} and it was identical for jute varieties O- 9897 and CVL-1 from 20 to 80 mg Cr L^{-1}. Jute O-9897, O-72, OM-1 and CVL-1 were able to germinate only up to 80 mg Cr L^{-1} (Table 1) and > 80 mg Cr L^{-1} was lethal for these varieties and treated as comparatively less tolerant varieties. On the other hand, varieties of kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC -7370) were able to germinate up to 160 mg Cr L^{-1} with the reasonable percent germination and was indicated as more tolerant varieties. The presented results were at par with Peralta *et al.* (2000), they mentioned that the germination of alfalfa (*Medicago sativa*) plants seed inhibited significantly by 55%, at a concentration of 40 ppm Cr (VI). Claire *et al.* (1991) also obtained similar results in a study using nickel and other heavy metals on cabbage, lettuce, millet, radish, turnip, and wheat. The results corresponded with the results of Islam (2010), who reported that increased level of Cr significantly decreased the germination of jute seeds. It was also consented with the findings of Akter (2011) and Nizam *et al.* (2013) who revealed that the seed germination of different varieties of kenaf, mesta and jute were slightly reduced with the increasing concentration of Cr. Similar had been the findings of Fragasova (2004) in case of mustard seedlings. It can be said that with respect to germination against different concentrations of Cr, the trend of tolerance of studied varieties are kenaf (HC-95) > kenaf (HC-3) > mesta (Samu-93) > jute CVE-3 > jute BJC-7370 > jute O-795 > Jute O- 9897 > OM-1 > jute O-72 > jute CVL-1.

Root length of seedlings

Results computed in the Table 2 indicated decreasing trends of root growth of the seedlings. Maximum root length (6.10 cm) of seedlings was measured in kenaf HC-95 followed by kenaf HC-3 (5.73 cm) at control and the lowest (0.00 cm) were in the jute varieties (O- 9897, O-795, O-72, OM-1 and CVL^{-1}) at 160 mg Cr L^{-1} treatment. The varieties of kenaf (HC-3 and HC-95) and mesta (Samu-93) showed their better root growth up to 120 mg Cr L^{-1}. Among the jute varieties, jute CVE-3 and BJC-7370 continued their root growth up to 160 mg Cr L^{-1} though the root lengths were very low (Table 2).

Table 2. Effects of Cr on the root length of seedlings of different varieties of jute, kenaf and mesta

Cr levels (mg L^{-1})	Root length (cm)									
	Jute (CVE-3)	Jute (BJC-7370)	Jute (CVL-1)	Jute (O-9897)	Jute (O-795)	Jute (O-72)	Jute (OM-1)	Kenaf (HC-95)	Kenaf (HC-3)	Mesta (Samu-93)
0	3.57a	3.43a	3.37a	3.00a	3.43a	3.67a	3.97a	6.10a	5.73a	3.70a
20	0.83b	1.00b	0.50b	0.77b	1.07b	1.17b	1.70b	5.30b	5.33ab	3.20b
40	0.47c	0.40c	0.33c	0.33c	0.53c	0.43c	0.53c	4.33c	4.77b	2.40c
80	0.33cd	0.33c	0.23c	0.20c	0.23d	0.23d	0.30c	3.70d	3.93c	1.70d
120	0.27de	0.27cd	0.00d	0.00d	0.20e	0.00e	0.00d	2.00e	2.57d	1.13e
160	0.13e	0.13d	0.00d	0.00d	0.00e	0.00e	0.00d	0.77f	1.37e	1.00e
Range	0.13-3.57	0.13-3.43	0.00-3.37	0.00-3.0	0.0-3.43	0.0-3.67	0.0-3.97	0.77-6.10	1.37-5.73	1.00-3.70
Mean	0.93	0.93	0.74	0.72	0.91	0.92	1.08	3.70	3.95	2.19
SE±	0.29	0.28	0.29	0.26	0.29	0.31	0.34	0.45	0.38	0.25
LSD	0.09	0.09	0.06	0.10	0.17	0.07	0.14	0.21	0.36	0.17
Sig. levels	**	**	**	**	**	**	**	**	**	**

*Legend: ** = Significant at 1% level of probability. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT*

Root length of different varieties of jute, kenaf and mesta seedlings were significantly reduced with the increasing levels of Cr. Gradual reduction of root growth was found for kenaf and mesta and drastic reduction was for jute varieties. In case of kenaf (HC-3) root length was identical at 20 and 40 mg Cr L^{-1} whereas it was identical at 40 to 80 mg Cr L^{-1} for jute varieties (O-9897, BJC-7370, OM-1 and CVL-1. Kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC-7370) varieties able to continue their root growth up to 160 mg Cr L^{-1} though the root lengths were lower at higher concentration. Jute varieties O-9897, O-72, OM-1 and CVL-1 were able to continue root growth up to 80 mg Cr L^{-1} (Table 11). Kenaf, mesta and jute varieties CVE-3 and BJC-7370 were more potential than other varieties of jute to grow their root in Cr contaminated medium. This is similar with the results of Islam (2010), who reported that increased level of Cr significantly decreased the root length of jute seedlings. It was also at par with the findings of Akter (2011) and Nizam *et al.* (2013), who disclosed that with the increasing concentration of Cr, the root lengths were gradually reduced for kenaf and mesta varieties of but drastically reduced for jute varieties. Similar had been the findings of Fragasova (2004) in case of mustard seedlings. Peralta *et al*. (2000) demonstrated a concentration-dependent inhibition of root growth of alfalfa (*Medicago sativa*) plants at the dose of 20 and 40 ppm of Cr (VI). It is assumed that kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC-7370) varieties had potentialities to elongate their root in Cr contaminated medium at a certain level. Morphological deformities like twisting, curling, and rottening of roots appeared at high concentration of Cr. The roots also turned into dark brown to black in colour. Such types of deformities might be due to the toxic effect of Cr on young roots and may lead to the gradual reduction of root growth and changes in root colour of tolerant varieties.

Shoot length of seedlings

As shown in Table 3, the shoot length of seedlings decreased with increasing levels of Cr. The highest shoot length (12.73 cm) of seedlings was found in kenaf (HC-95) followed by kenaf HC-3 (12.60 cm) and in mesta Samu-93 (11.17 cm) at control. The lowest (0.00 cm) were in the varieties of jute (O-9897, O-795, O-72, OM-1 and CVL-1) at 160 mg L^{-1} Cr treatment. The varieties of kenaf (HC-95 and HC-3) and mesta (Samu-93) showed their better shoot growth up to 160 mg Cr L^{-1}. Among the jute varieties, CVE-3 and BJC-7370 continued their shoot growth up to 160 mg Cr L^{-1} though the shoot lengths were very low at this concentration (Table 3).

Table 3. Effects of Cr on the shoot length of seedlings of different varieties of jute, kenaf and mesta

Cr levels (mg L^{-1})	Shoot length (cm)									
	Jute (CVE-3)	Jute (BJC-7370)	Jute (CVL-1)	Jute (O-9897)	Jute (O-795)	Jute (O-72)	Jute (OM-1)	Kenaf (HC-95)	Kenaf (HC-3)	Mesta (Samu- 93)
0	5. 07a	4. 83a	4.30a	3. 37a	2. 67a	3.70a	3. 67a	12.73a	12.60a	11.17a
20	3. 03b	2.63b	2.90b	1.50b	1.23b	1.77b	1. 97b	10.63b	9. 63b	8.10b
40	2. 60c	2. 27c	2.13c	1. 23c	1.10bc	1. 17c	1. 40c	9. 30c	9. 53b	7.77b
80	2. 07d	1.70d	1.90c	1.00d	1.00cd	0. 87d	1. 20c	8.70c	8. 20c	6. 53c
120	1. 47e	1. 23de	0. 00d	0. 00e	0.90d	0. 00e	0. 00d	7. 03d	7. 27d	6. 07c
160	1. 40e	1. 40e	0. 00d	0. 00e	0. 00e	0. 00e	0. 00d	5. 63e	6. 83d	4. 80d
Range	1. 40-5.07	1. 4-4. 83	0. 0-4. 30	0. 0-3. 37	0. 0-2. 67	0. 0-3.70	0. 0-3.67	5. 56-12.73	6. 83-12.6	4. 80-11.17
Mean	2. 61	2. 34	1. 87	1. 18	1. 15	1. 25	1. 37	9. 01	9. 01	7. 41
SE±	0. 30	0. 30	0. 37	0. 28	0. 19	0. 31	0. 31	0. 56	0. 47	0. 50
LSD	0. 14	0. 19	0. 13	0. 10	0. 09	0. 13	0. 16	0. 36	0. 46	0. 53
Sig. levels	**	**	**	**	**	**	**	**	**	**

*Legend: ** = Significant at 1% level of probability. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT*

Shoot length of different varieties of jute, kenaf and mesta seedlings were significantly decreased with the increasing levels of Cr. Shoot growth was gradually reduced for kenaf and mesta; and drastic reduction was observed for jute varieties. In case of kenaf HC-3 and mesta Samu-93, shoot length was identical at 20 and 40 mg Cr L^{-1} whereas it was identical at 40 and 80 mg Cr L^{-1} for jute varieties OM-1 and CVL-1. Kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC-7370) varieties were able to continue their shoot growth up to 160 mg Cr L^{-1} though the shoot lengths were lower at higher concentration (Table 3). It indicates that the varieties might have some special characters to grow in Cr contaminated medium at a certain limit. Jute varieties O-9897, O-72, OM-1 and CVL-1 were able to continue shoot growth up to 80 mg Cr L^{-1} which indicates their less potentiality than other varieties. Kenaf, mesta and jute varieties CVE-3 and BJC-7370 were more potential than other varieties of jute to grow their shoot in Cr contaminated medium. Morphological deformities like twisting and curling of shoots were appeared at high concentration of Cr. These deformities might be due to the toxic effect of Cr on young shoots and may lead up to the gradual growth reduction of shoot of tolerant varieties. In spite of deformities, the genetic potentiality of kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC-7370) lead to their shoot growth in Cr contaminated medium at a certain level. The presented results consented with the results of Peralta *et al.* (2000) and they stated Cr (VI) at a 10 ppm dose, significantly reduced the shoot growth of alfalfa (*Medicago sativa*) plants and when the concentration was increased to 20 ppm, the shoot size diminished by 63.0%. Cr (VI) at 40 ppm concentration showed lethal effects over the alfalfa plants and the data were corresponded with those of Oncel *et al.* (2000). The results also similarly corresponded with the results of Islam (2010), who explained that increased level of Cr significantly decreased the shoot length of jute seedlings and also at par with the findings of Akter (2011), Nizam *et al.* (2013) and Nizam (2014) who disclosed that increasing concentration of Cr gradually reduced the root growth of kenaf and mesta varieties but drastically reduced for jute varieties. Similar had been the findings of Fragasova (2004) in case of mustard seedlings.

Fresh weight of seedling

Maximum fresh weight (5.97 g $petridish^{-1}$) of seedlings was measured in kenaf (HC-95) followed by kenaf HC-3 (5.47g $petridish^{-1}$) and mesta Samu-93 (3.07 g $petridish^{-1}$) at control and the lowest (0.00 g) were in the jute varieties (O-9897, O-795, O-72, OM-1 and CVL-1) at 160 mg Cr L^{-1} treatment. The varieties of kenaf (HC-95 and HC-3) and mesta (Samu-93) also showed their better performance in producing fresh weight up to 120 mg Cr L^{-1}. Among the jute varieties, CVE-3 and BJC-7370 continued their fresh biomass production up to 160 mg L^{-1} applied Cr, though the amount of biomass were very low at this concentration (Table 4). Except jute variety O-795 fresh weights of seedlings of different varieties of jute, kenaf and mesta were significantly reduced with the increasing concentrations of Cr. Insignificant variations in decreasing fresh weights was found for jute variety O-795. Like shoot and root growth, fresh weights also gradually decreased for kenaf and mesta; and drastically decreased for jute varieties. For kenaf (HC-95) and jute (O-72, OM-1) fresh weights were identical at 40 and 80 mg Cr L^{-1} whereas it was identical at 20 and 40 mg Cr L^{-1} for Kenaf HC-3. Kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC-7370) varieties were able to continue their fresh biomass production up to 160 mg Cr L^{-1} but the lower fresh weights were obtained at higher concentration (Table 4). It indicates that the varieties might have some special characters to produce biomass production in Cr contaminated medium at a certain limit. Jute varieties O- 9897, O-72, OM-1 and CVL-1 able to continue biomass production up to 80 mg Cr L^{-1} which indicates their less potentiality than other varieties. Dasgupta *et al.* (2011) observed visible decrease in plant biomass with increase in the concentration of heavy metals like Pb and Cr in the soil, which was similar to disclosed results. The present findings completely agreed with the findings of Akter (2011), Nizam *et al.* (2013) and Nizam (2014) who revealed that the fresh biomass of jute, kenaf and mesta seedlings were decreased with the increased levels of Cr. Kenaf, mesta and jute varieties CVE-3 and BJC-7370 were more potential than other varieties of jute to produce their fresh biomass in Cr contaminated medium. It is assumed that varietal and genetic potentiality of kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC-7370) help to their biomass production in Cr contaminated medium.

Table 4. Effects of Cr on the fresh weight of seedlings of different varieties of jute, kenaf and mesta

Cr levels (mg L^{-1})	Fresh weight (g petridish^{-1})									
	Jute (CVE-3)	Jute (BJC-7370)	Jute (CVL-1)	Jute (O-9897)	Jute (O-795)	Jute (O-72)	Jute (OM-1)	Kenaf (HC-95)	Kenaf (HC-3)	Mesta (Samu- 93)
0	0. 49a	0. 55a	0. 49a	0. 27a	0. 22a	0. 24a	0. 25a	5. 97a	5. 47a	3. 07a
20	0.3 1b	0. 24b	0. 25b	0. 13b	0. 13a	0. 12b	0. 16b	4. 43b	3. 77b	2. 57b
40	0. 26c	0. 18c	0. 22c	0. 13b	0. 12a	0. 09c	0. 14c	4. 03c	3. 77b	2. 10c
80	0. 23cd	0. 15cd	0. 19d	0. 11c	0. 09a	0. 08c	0. 13c	3. 73c	3. 23c	2. 00cd
120	0. 21d	0. 14cd	0. 00e	0. 00d	0. 07a	0. 00d	0. 00d	3. 10d	3. 17c	1. 67de
160	0. 19d	0. 12d	0. 00f	0. 00d	0. 00a	0. 00d	0. 00d	2. 63e	2. 60d	1. 60e
Range	0.19-0. 49	0.12-0. 55	0.0-0.49	0.0-0. 27	0.00-0.22	0.0-0. 24	0.0-0.25	2. 63-5. 97	2.6-5. 47	1.60-3.07
Mean	0. 28	0. 23	0. 19	0. 11	0. 83	0. 09	0. 11	3. 98	3. 67	2. 17
SE±	0. 03	0. 04	0. 04	0. 02	0. 72	0. 02	0. 02	0. 26	0. 22	0. 13
LSD	0. 03	0. 03	0. 01	0. 01	3. 11	0. 01	0. 01	0. 21	0. 18	0. 21
Sig. levels	**	**	**	**	NS	**	**	**	**	**

*Legend: ** = Significant at 1% level of probability and NS = Not significant. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT*

Table 5. Effects of Cr on the dry weight of seedlings of different varieties of jute, kenaf and mesta

Cr levels (mg L^{-1})	Dry weight (g petridish^{-1})									
	Jute (CVE-3)	Jute (BJC-7370)	Jute (CVL-1)	Jute (O- 9897)	Jute (O-795)	Jute (O-72)	Jute (OM-1)	Kenaf (HC-95)	Kenaf (HC-3)	Mesta (Samu-93)
0	0. 03a	0. 03a	0. 03a	0. 02a	0. 02a	0. 019a	0. 02a	0. 37a	0. 35a	0. 26a
20	0. 022b	0. 019b	0. 02b	0. 014b	0. 015b	0. 013b	0. 017b	0. 31b	0. 28b	0. 17b
40	0. 022b	0. 017bc	0. 016c	0. 013c	0. 013c	0. 012b	0. 016b	0. 30bc	0. 26b	0. 19b
80	0. 020b	0. 016bcd	0. 016c	0. 012c	0. 011d	0. 008c	0. 014c	0. 29c	0. 26b	0. 19b
120	0. 019bc	0. 014cd	0. 00d	0. 00d	0. 011d	0. 00d	0. 00d	0. 29c	0. 26b	0. 17b
160	0. 016c	0. 012d	0. 00d	0. 00d	0. 00e	0. 00d	0. 00d	0. 28c	0. 26b	0. 16b
Range	0.016-0.03	0.012-0.03	0.0-0.03	0.0-0.02	0.0-0.02	0.0-0.02	0.0-0.02	0.28-0. 37	0.25-0.35	0.16-0.26
Mean	0. 02	0. 02	0. 01	0. 01	0. 011	0. 01	0. 01	0. 31	0. 28	0. 19
SE±	0. 00	0. 00	0.00	0. 00	0. 00	0. 00	0. 00	0. 01	0. 01	0. 01
LSD	0. 00	0. 01	0.01	0. 01	0. 01	0. 01	0.01	0. 01	0. 01	0. 01
Sig. levels	**	**	**	**	**	**	**	**	**	**

*Legend: ** = Significant at 1% level of probability. In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT*

Dry weight of seedling

Like fresh weight, dry weight of seedlings also decreased with increasing levels of Cr in germinating medium. The highest dry weight (0.37 g petridish $^{-1}$) of seedlings was found in kenaf HC-95 followed by kenaf HC-3 (0.35 g petridish $^{-1}$) and in mesta Samu-93 (0.26 g petridish $^{-1}$) at control and the lowest (0.00 g petridish $^{-1}$) were in the jute varieties (O- 9897, O-795, O-72, OM-1 and CVL-1) at 160 mg Cr L^{-1}. Like fresh weight the varieties of kenaf (HC-95 andHC-3) and mesta (Samu-93) also showed their better performance in producing dry biomass up to 160 mg Cr L^{-1}. Among the jute varieties, CVE-3 and BJC-7370 continued their dry biomass production up to 160 mg Cr L^{-1} application though the amounts of biomass were very minimum at this concentration (Table 5).

Dry weights of different varieties of jute, kenaf and mesta seedlings were significantly reduced with the increasing concentrations of Cr. Dry weights were gradually decreased for kenaf, mesta and jute varieties. For kenaf HC-95 and mesta Samu-93, dry weights were identical from 20 to 160 mg Cr L^{-1} and it was identical from 40 to 160 mg Cr L^{-1} for kenaf HC-3. Dry weights were also identical at 20 and 40 mg Cr L^{-1} for jute varieties O-72 and OM-1 whereas it was identical from 20 to 120 mg Cr L^{-1} for jute variety CVE-3. Varieties of kenaf, mesta and jute CVE-3 and BJC-7370 able to continue their dry biomass production up to 160 mg Cr L^{-1} though the fresh weights were lower at higher concentration (Table 5). It indicates that the varieties might have some special characters to produce biomass production in Cr contaminated medium at a certain stage. Jute varieties O- 9897, O-72, OM-1 and CVL-1 able to continue biomass production only up to 80 mg Cr L^{-1} which indicates their less potentiality than other varieties. Kenaf, mesta and jute varieties CVE-3 and BJC-7370 were more potential than other varieties of jute to produce their biomass in Cr contaminated medium. It might be due to the varietals and genetic potentiality of kenaf (HC-3 and HC-95), mesta (Samu-93) and jute (CVE-3 and BJC-7370) which lead their biomass production in Cr contaminated medium at a certain limit. The present findings were same as the findings of Akter (2011) and Nizam *et al*. (2013), who revealed that the dry biomass were decreased with the increased levels of Cr. Similar had been the observation of Dasguta *et al.* (2011) for bio removal of Pb and Cr from soil by *Cicer arietinum* L.

Conclusions

Increased in the applied Cr concentration decreased the percent germination, root and shoot growth of seedlings and fresh and dry biomass for almost all the varieties of jute, kenaf and mesta. All the varieties of jute, kenaf and mesta were germinated up to 160 mg Cr L^{-1} with a satisfactory rate of germination. The findings of this study expected that jute, kenaf and mesta would be able to germinate and grow in Cr contaminated soil. Therefore, these jute, kenaf and mesta varieties could be used for growing in Cr contaminated soil to remediate soil Cr contamination. More study that is detailed also needed on the other varieties of jute, kenaf and mesta on toxicity tolerance of Cr at germination stage.

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