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Effects of Industrial Effluents on Germination and Early Growth of Selected Agricultural Crops

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ABSTRACT
In Bangladesh, almost all the industrial units discharge their toxic liquid effluents to the nearby water bodies without any consideration of the environment. This study was carried out to show the effects of paper mill and textile and dyeing mill effluents on germination and early growth of selected agricultural crops namely green gram (*Phaseolus mungo*), mustard (*Brassica napus*) and jute (*Corchorus capsularis*). The study revealed that pH value of both paper mill and textile and dyeing mill effluents (8.90 and 11.00) crossed the usual range of water used for irrigation purpose. Besides, electric conductivity (5,150.00 $\mu S\ cm^{-1}$), TDS (2,580.00 $mg\ L^{-1}$) and Chloride (2240.00 $mg\ L^{-1}$) exceeded the usual range in case of textile and dyeing effluents only. The germination percentage was maximum for mustard (100%) treated with 100% concentrations of effluent in case of treatment with paper mill effluent, whereas, in case of textile and dyeing effluent, with the increase of concentrations, germination percentage of green gram, mustard and jute seeds was found to reduce and green gram showed highest germination percentage than the other two crops. On the other hand, shoot, root and biomass growth of green gram, mustard and jute found to be impacted more negatively by textile and dyeing effluent than that is of paper mill effluent.

Key words: Effluent, germination, industrial sludge, agricultural crops

INTRODUCTION

Environmental degradation has now become a global problem and maintaining ecosystem health is a serious issue being confronted by the environmentalists (Kumar, 2011). Among the various types of pollution, water pollution by waste discharge of industries offers tremendous problems to aquatic and agro-ecosystems by affecting directly or indirectly and ultimately the human life (Hussain *et al.*, 2002). With the industrial development in Bangladesh, the waste management systems did not develop accordingly. Almost all industries are seen to discharge their wastes into water and on land without any treatment or after partial treatment (Jolly *et al.*, 2012).

The treatment and disposal of industrial sludge is an environmentally sensitive problem because sludge is good fertilizer but may contain heavy metals which could reduce productivity and cause environmental risks (Hossain *et al.*, 2009). In Bangladesh, industrial effluents containing heavy metals like Cu, Zn, Pb, Cr, Cd, As, Hg, Mn and Fe are being discharged without treatments polluting soils and natural water systems as well as ground water endangering human health, aquatic lives and crop production in Bangladesh (Begum *et al.*, 2011). The major polluting industries such as textile and dyeing, paints, tanneries, oil refineries, chemical complexes, fish processing units, fertilizer factories, cement factories, soap and detergent factories including light industrial units discharge directly untreated toxic effluents in the rivers of Bangladesh. Approximately 30 million gallons of untreated industrial wastewater are discharged every day in and around Dhaka city (Jolly *et al*., 2012).

Wastewater can be considered both as a resource and a problem. Wastewater and its nutrient content can be used extensively for irrigation and other ecosystem services. Its reuse can deliver positive benefits to the farming community, society and municipalities (Hussain *et al*., 2002). In recent years, much attention has been paid to utilize industrial effluents after certain physical and chemical treatment for agriculture land application (Kumar, 2011). The utilization of industrial wastes for agricultural purpose could also provide a solution to the disposal problems (Chhonkar *et al*., 2000). However, forested sites are increasingly receiving attention as potential sites for the disposal and biological recycling of both waste water and sludge from industrial treatment plants. The main advantage of using sewage sludge is the enrichment of the soil at a lower cost that is possible with inorganic fertilizers (Hossain and Miller, 1994).

This study has been conducted to characterize the paper mill and textile and dyeing effluents in terms of their physicochemical properties and to know the effectiveness of application of effluents on germination and early growth of agricultural crops namely green gram (*Phaseolus mungo*), mustard (*Brassica napus*) and jute (*Corchorus capsularis*).

MATERIALS AND METHODS

Collection of industrial effluents: Approximately 10 L of effluents used for irrigation to seedling growing media were collected in clean plastic container from each point of disposal outlet of two different industries-Chittagong Asian Paper Mill Limited situated at Hathazari and Four Stars Textile and Dyeing mill situated at Chandgaon of Chittagong district in Bangladesh.

Physicochemical analysis: Different physicochemical parameters of industrial effluents collected from paper mill and textile and dyeing mill were analyzed. Before physicochemical analysis of textile and dyeing effluent, colors are removed by carrying out jar test through floc illuminator. Moreover, the physicochemical parameters of distilled water was also analyzed as because it is used as control of treatment. The whole analysis process was carried out in the Mohara Water Treatment Plant of WASA in Chittagong, Bangladesh by using standard methods.

Selection of agricultural crop species and experimental soil: Three agricultural crop species namely green gram (*Phaseolus mungo*), mustard (*Brassica napus*) and jute (*Corchorus capsularis*) were chosen and seeds of these three crop species were collected. The soil used in the experiment was sandy loam in nature. After collecting, the soil was strained properly and small pots were filled by this soil for experiment.

Experimental details: Five test solutions, viz. 0% (Control), 10, 25, 50 and 100% were prepared by diluting effluents of each type with distilled water for five treatments to investigate the effects of wastewater on germination and early growth of the seedlings. Twenty healthy and quality seeds of each species were evenly placed in each of fifteen petridishes which contained water soaked filter papers to show germination without soil media. These petridishes were arranged in completely randomized block design. Three replicates were used for each treatment. These were allowed to germinate in room temperature and germination counts were made at daily intervals until the germination ceased. Again, ten healthy and undamaged seeds of each species were sowed in each of fifteen small plastic pots to show effects of different concentrations of effluents on germination and early growth. These five test solutions were used as irrigation water in pots. For each treatment, three replications were taken and completely randomized block design was followed. The whole experiment was carried out in the Seed Research Laboratory of Institute of Forestry and Environmental Sciences, University of Chittagong (IFESCU), Chittagong, Bangladesh. Plants were grown in triplicates in the five groups.

Measurement of growth parameters: Different growth parameters of these three types of crop species were recorded after two weeks of their early growth. Shoot height (cm), root length (cm), fresh weight (gm), dry weight (gm) were measured with the help of cm scale, electronic balance and electronic oven. For measuring dry biomass of plants, sample seedlings were dried for 48 h at 60°C. Three seedlings from each replication were taken for measuring different parameters.

RESULTS AND DISCUSSION

The quality of water containing industrial effluents and distilled water which was used as control were assessed with respect to various physicochemical properties (Table 1). In case of paper mill, results revealed that the pH value of effluent exceeded than the usual range for irrigation water recommended by FAO (Table 1). On the other hand, in case of textile and dyeing mill, the value of Electric conductivity (ES), Total Dissolved Solid (TDS), pH and chloride of the effluent exceeded than the usual range for irrigation water recommended by FAO (Table 1). Textile industries produce chemicals with high concentrations of caustic chemicals resulting in high pH values varying between 10.0-11.0. The discharge from the textiles, also bear intense coloration derived from the dyes fibrous materials (Kanu and Achi, 2011).

Besides, the value of different parameters for distilled water are under usual range and are lower than the value of different parameters for water containing paper mill and textile and dyeing effluents (Table 1). For the agriculture sector pH value play an important role in plant growth. The standard pH value needed for agriculture is 7-8 (Begum *et al*., 2010). If the

Table 1: Physicochemical characteristics of industrial effluents

Parameters	Distilled water (control)	Effluent of chittagong asian paper mill limited	Effluent of four stars textile and dyeing (after color removal)	Usual range in irrigation water
EC (µS cm^{-1})	27.70	694.00	5,150.00*	0-3000.00[a]
TDS (mg L^{-1})	13.80	347.00	2,580.00*	0-2000.00[a]
Salinity (mg L^{-1})	0.00	0.30	2.80	0-20.00[a]
pH	7.20	8.90*	11.00*	6.50-8.50[a]
Chloride (mg L^{-1})	8.00	60.00	2240.00*	0-1065.00[a]
Total hardness (mg L^{-1})	2.20	204.00	250.00	-
Ca^{2+} (mg L^{-1})	0.64	53.60	72.00	0-400.00[a]
Mg^{2+} (mg L^{-1})	0.15	17.01	17.01	0-60.00[a]
Cr^{6+} (mg L^{-1})	0.00	0.02	0.05	1.0[b]
Sulphate (mg L^{-1})	0.00	8.00	72.00	-
NO_3-N (mg L^{-1})	0.10	3.08	0.90	0-10.00[a]
Nitrogen (mg L^{-1})	0.02	0.70	0.21	0-2.27[a]
Phosphorous (mg L^{-1})	0.09	0.37	0.11	-
Fe^{2+} (mg L^{-1})	0.02	0.80	0.72	2.00[b]
Copper (mg L^{-1})	0.08	0.36	0.28	3.00[b]
Mn^{2+} (mg L^{-1})	0.10	0.60	0.80	5.00[b]

*Values crossed the limits of FAO[a] and DoE[b] (FAO., 2013; Khanam *et al*., 2011), Ca^{2+}: Calcium, Mg^{2+}: Magnesium, Cr^{6+}: Chromium, NO_3-N: Nitrate, Fe^{2+}: Iron and Mn^{2+}: Manganese

Table 2: Effects of paper mill effluent on early morphological growth parameters of selected agricultural crops

Treatments	Green gram (*Phaseolus mungo*)			Mustard (*Brassica napus*)			Jute (*Corchorus capsularis*)		
	Shoot length	Root length	Total length	Shoot length	Root length	Total length	Shoot length	Root length	Total length
	(cm)								
T_0 (Control)	16.71[b*]	1.65[a]	18.36[b]	4.03[a]	1.83[a]	5.86[b]	5.13[a]	2.67[b]	7.80[a]
T_1 (10%)	17.21[b]	1.74[a]	18.95[b]	4.04[a]	1.78[a]	5.81[b]	5.27[a]	1.70[a]	6.97[a]
T_2 (25%)	14.93[a]	1.43[a]	16.37[a]	4.25[a]	1.94[a]	6.19[a]	5.07[a]	2.53[b]	7.60[a]
T_3 (50%)	15.63[ab]	1.80[a]	17.43[ab]	4.56[a]	1.92[a]	6.48[ab]	4.97[a]	2.20[ab]	7.17[a]
T_4 (100%)	16.97[b]	1.63[a]	18.63[b]	4.96[a]	1.55[a]	6.51[b]	4.07[a]	1.93[ab]	6.00[a]

*Followed by the same letter (s) in the same column do not vary significantly at $p<0.05$, according to Duncan's Multiple Range Test (DMRT)

pH value is higher than standard value then it affects the plant growth. Certain physical and chemical properties of water up to an adequate level are good for health but become toxic at excessive level (Nawaz *et al*., 2006).

The germination of selected crops (*Phaseolus mungo*, *Brassica napus*, *Corchorus capsularis*) were observed both in petridish and plastic pot with soil media along with the treatments of different concentrations (0, 10, 25, 50 and 100%) of paper mill and textile and dyeing effluents. In case of paper mill effluent, the highest germination percentage (100%) was found for mustard in different treatments both in petridish and pot, whereas, the lowest germination percentage (23.33%) was found for jute in pot (Fig. 1). In case of germination in petridish treated with paper mill effluent, seeds of green gram were found significantly varied in different treatments. On the other hand, germination both in petridish and pot was found significantly varied for mustard seeds in different treatments. There was no significant difference found for germination of jute seeds treated with different concentrations of paper mill effluent.

On the other hand, germination percentage was found to reduce with the increase of concentrations of textile and dyeing effluent for all the three crops and there was no germination at all for treatments with 100% effluent concentrations (Fig. 2). Moreover, seeds of mustard did not show further germination after treatment with 25% concentrations and seeds of mustard did not show further germination after treatment with 10% concentrations of textile and dyeing effluent (Fig. 2). There were found significant differences in germination for all of the three selected crops treated with different concentrations of textile and dyeing effluent. With the increase of concentrations of textile and dyeing effluent, germination percentage of green gram, mustard and jute was found to reduce. Similar result was fond in case of wheat by the Jolly *et al.* (2012).

The effects of paper mill and textile and dyeing effluents on early growth parameters were observed for two weeks old seedlings of the selected crop species separately. The highest total length (18.95 cm) was fond for green gram seedlings at T_1 (10% effluent concentrations) and the lowest total length (16.73 cm) was found with the treatment of 25% concentrations of paper mill effluent. On the other hand, slight variation was found for morphological growth parameters of green gram for the treatment of 100% concentrations of paper mill effluent than the seedling of control (Table 2). In case of mustard seedlings, shoot length was found to increase with the increase of concentrations of paper mill effluent and root length was found to increase up to T_3 (50% effluent concentrations) and root length was found to reduce with the treatment of 100% concentrations of study mill effluent (Table 2). Besides, lowest shoot length (4.0 cm) was found for the two weeks old jute seedlings with treatment of 100% concentrations of paper mill effluent and the lowest root length (1.70 cm) was observed for treatment of 10% concentrations of effluent of paper mill (Table 2).

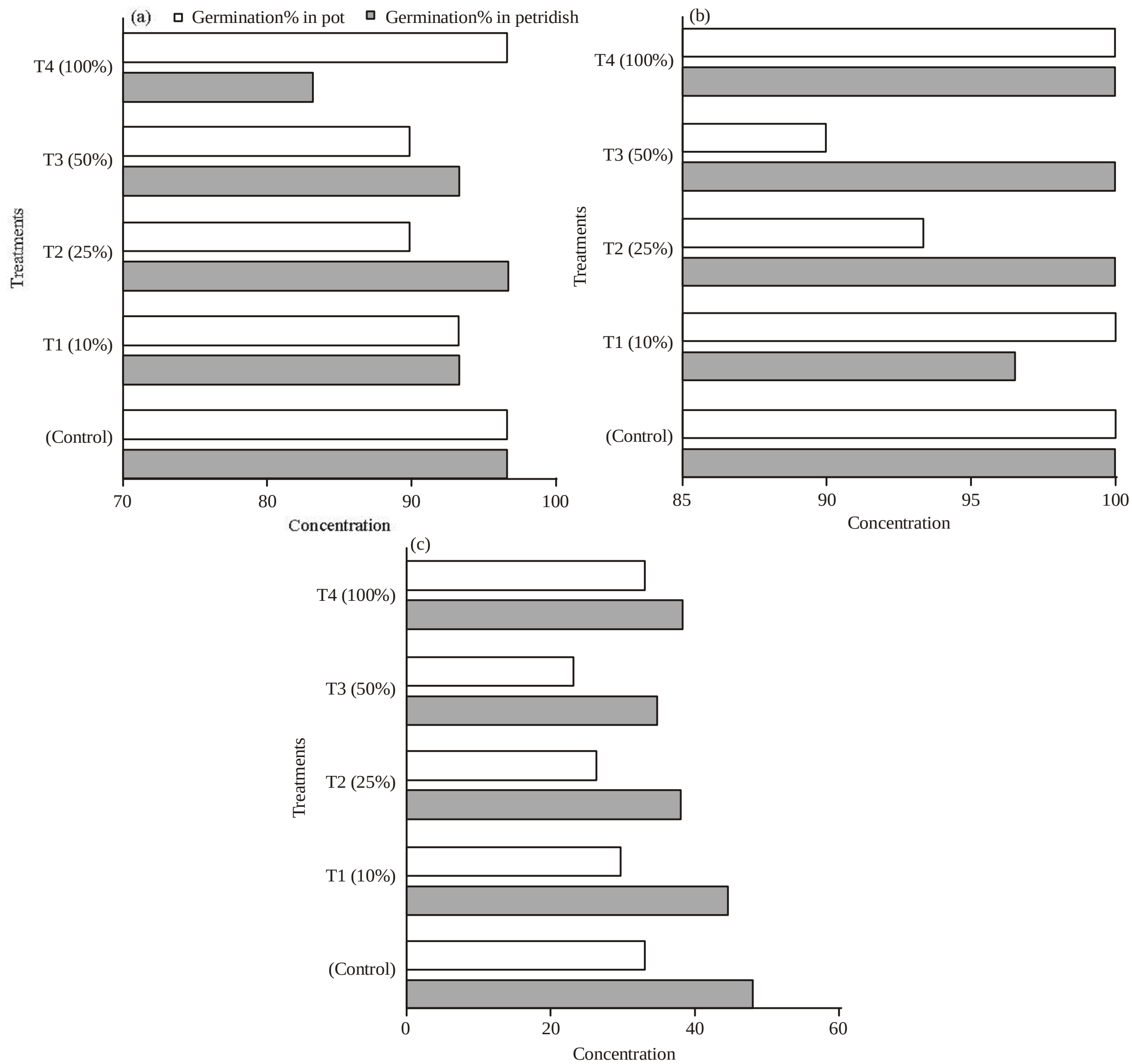

Fig. 1(a-c): Effects of paper mill effluent on germination of selected agricultural crops (a) Green gram (*Phaseolus mungo*), (b) Mustard (*Brassica napus*) and (c) Jute (*Corchorus capsularis*)

Table 3: Effects of textile and dyeing effluent on early morphological growth parameters of selected agricultural crops

	Green gram (*Phaseolus mungo*)			Mustard (*Brassica napus*)		
Treatments	Shoot length (cm)	Root length (cm)	Total length (cm)	Shoot length (cm)	Root length (cm)	Total length (cm)
T_0 (Control)	14.58^{b*}	2.16^b	16.73^b	3.69^c	2.04^b	5.73^c
T_1 (10%)	14.12^b	1.94^b	16.07^b	2.31^b	1.63^b	3.94^b
T_2 (25%)	12.17^b	2.33^b	14.40^b	0.00^a	0.00^a	0.00^a
T_3 (50%)	0.00^a	0.00^a	0.00^a	0.00^a	0.00^a	0.00^a

*Followed by the same letter (s) in the same column do not vary significantly at $p<0.05$, according to Duncan's Multiple Range Test (DMRT)

For textile and dyeing effluent, highest root length (2.33 cm) for green gram was found at T_3 (25% effluent concentrations) and there were found no further growth after treatment with 25% concentrations of textile and dyeing effluent (Table 3). In case of mustard, growth response was found only with treatment of 10% concentration of textile and dyeing effluent and the result was significantly varied (Table 3). On the other hand, jute seedlings did not survive due to toxicity of textile and dyeing effluent.

In two weeks old seedlings of green gram, fresh and dry biomass were highest (0.26 and 0.17 g) in T_1 (10% effluent concentrations) in case of paper mill effluent. On the other hand, highest fresh and dry biomass (0.21 and 0.09) were found for mustard seedlings in T_4 (100% effluent concentrations) and highest fresh and dry biomass for jute seedlings (0.13 and 0.06) were found in T_3 (50% effluent concentrations) in case of paper mill effluent (Table 4).

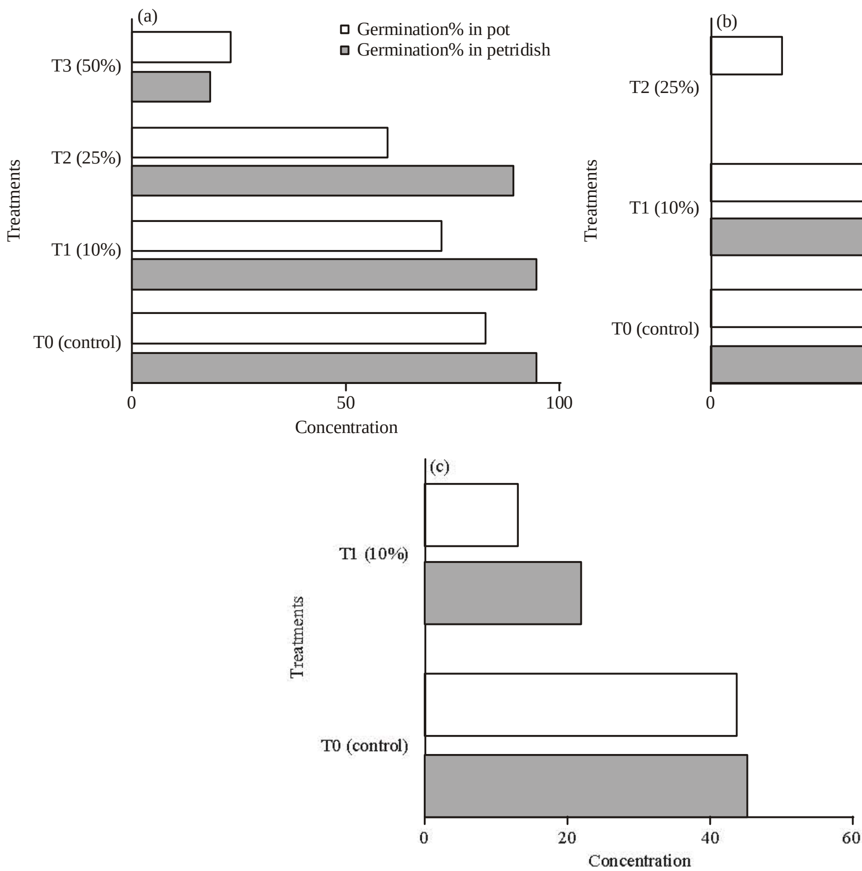

Fig. 2(a-c): Effects of textile and dyeing effluent on germination of selected agricultural crops (a) Green gram (*Phaseolus mungo*), (b) Mustard (*Brassica napus*) and (c) Jute (*Corchorus capsularis*)

Table 4: Effects of paper mill effluent on fresh and dry biomass of selected agricultural crops

	Green gram (*Phaseolus mungo*)		Mustard (*Brassica napus*)		Jute (*Corchorus capsularis*)	
Treatments	Fresh biomass (g)	Dry biomass (g)	Fresh biomass (g)	Dry biomass (g)	Fresh biomass (g)	Dry biomass (g)
T_0 (Control)	0.25^{b*}	0.14^{bc}	0.12^{a}	0.03^{a}	0.10^{ab}	0.03^{ab}
T_1 (10%)	0.26^{b}	0.17^{c}	0.15^{ab}	0.05^{a}	0.11^{ab}	0.05^{ab}
T_2 (25%)	0.21^{a}	0.10^{a}	0.17^{ab}	0.05^{a}	0.13^{b}	0.06^{b}
T_3 (50%)	0.22^{ab}	0.11^{ab}	0.19^{b}	0.08^{b}	0.10^{ab}	0.04^{ab}
T_4 (100%)	0.23^{ab}	0.13^{ab}	0.21^{b}	0.09^{b}	0.10^{a}	0.02^{a}

*Followed by the same letter (s) in the same column do not vary significantly at p<0.05, according to Duncan's Multiple Range Test (DMRT)

Table 5: Effects of textile and dyeing effluent on fresh and dry biomass of selected agricultural crops

	Green gram (*Phaseolus mungo*)		Mustard (*Brassica napus*)	
Treatments	Fresh biomass (g)	Dry biomass (g)	Fresh biomass (g)	Dry biomass (g)
T_0 (Control)	0.24^{c*}	0.13^{c}	0.09^{b}	0.03^{b}
T_1 (10%)	0.23^{bc}	0.12^{c}	0.07^{b}	0.02^{ab}
T_2 (25%)	0.19^{b}	0.09^{b}	0.00^{a}	0.00^{a}
T_3 (50%)	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}

*Followed by the same letter (s) in the same column do not vary significantly at p<0.05, according to Duncan's Multiple Range Test (DMRT)

Besides, fresh and dry biomass were observed to reduce with the increase of concentrations of textile and dyeing mill effluent for two weeks old of seedlings both of green gram and mustard. Moreover, fresh and dry biomass could not be measured for jute because of no survival of jute seedlings (Table 5).

The vigor index was calculated for seedlings of the three selected crops treated with two different types of effluents. In case of paper mill effluent, highest vigor index was found for all the three species at the treatment of 100% concentrations, whereas, the lowest vigor index for both green gram and mustard was found at treatment with 25% concentrations and lowest vigor index for jute was with treatment of 50% concentrations of paper mill effluent (Table 6). On the other hand, vigor index for green gram and mustard was found to decrease gradually with the increase of concentration of textile

Table 6: Vigor Index (VI) of selected crop species

Treatments	Green gram (*Phaseolus mungo*) Paper mill effluent	Green gram (*Phaseolus mungo*) Textile and dyeing mill effluent	Mustard (*Brassica napus*) Paper mill effluent	Mustard (*Brassica napus*) Textile and dyeing mill effluent	Jute (*Corchorus capsularis*) Paper mill effluent
Vigor Index (VI) = (MSL+MRL)×PG					
T_0 (Control)	1774.86	1394.94	586.00	573.00	259.97
T_1 (10%)	1768.60	1177.68	582.00	59.10	209.10
T_2 (25%)	1472.40	435.005	77.71	0.00	202.69
T_3 (50%)	1568.70	0.00	583.20	-	167.28
T_4 (100%)	1798.06	-	651.00	-	216.98

MSL: Mean Shoot Length, MRL: Mean Root Length, PG: Percentage of Germination

and dyeing effluent and vigor index for jute could not be measured because there was no survival of jute seedlings at all (Table 6).

All the growth parameters of selected agricultural crops (green gram, mustard and jute) showed negative trend in case of textile and dyeing effluent while crops showed relatively better results treated with paper mill effluent. Moreover, jute seedlings were not survived with the treatment of textile and dyeing effluent. Medhi *et al.* (2011) found for rice, mustard and pea results revealed that among various levels of irrigation with treated paper mill effluent lower concentrations proved beneficial and it had significant effect on growth and development of rice, mustard and pea than control soil where only water (without application of effluent) was used for irrigation (Medhi *et al.*, 2011). On the other hand, Nawaz *et al.* (2006) found that both of two different varieties of pea (*Cicer arientum*) reduced root length as compared to control in textile mill effluent (Nawaz *et al.*, 2006). Moreover, the adverse effects of textile dye for soybean crop was also observed more pronounced at 75 and 100% concentrations both with primary treated effluent and raw effluent due to high effluent concentrations (Ravi *et al.*, 2014).

CONCLUSION

Industrial effluents can be considered as a potential source of irrigation water and nutrients for the growth of agricultural crops in areas where industrial effluents are being discharged. However, proper treatment and removal of toxic substances are necessary before using industrial effluents for irrigation purpose. In this study, effluent of paper mill is found comparatively less toxic or germination and early growth of selected agricultural crops than the textile and dyeing effluent. Nevertheless, textile and dyeing effluent can be applied at lower concentrations of up to 10% for mustard and 25% concentrations of effluent for green gram, as because, no survival was found for higher concentrations of effluents due to toxicity. Besides, jute was not survived treated even with lower concentrations (10%) of textile and dyeing effluent. So, even lower concentrations of textile and dyeing effluent cannot be applied as irrigation water for jute seedlings.

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