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Impact Of Raw And Treated Textile Dyeing Effluent On Germination, Growth Of Selected Pulses And Cereals

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ABSTRACT

The physico-chemical characteristics of raw and treated textile dyeing effluents and its impact on germination and growth of the seeds/grains of *Vigna mungo* (Vm), *Vigna radiata* (Vr), *Oryza sativa* (Os), and *Triticum vulgare* (Tv) were analyzed. The raw & treated effluents were recorded for pH (4.1, 5.8) TDS (17900, 7054 mg/L), COD (16000, 4020 mg/L) and BOD (12000, 510 mg/L). Maximum germination [Vm (100%), Vr (100%), Tv (90%) and Os (90%)], Shoot length [Vm (7.69cm) Vr, (9.23cm), Tv (8.68cm) and Os (9.92cm)], root length [Vm (14.96cm), Vr (11.61cm), Tv (8.61cm) and Os (9.92cm)], number of roots and enhanced fresh and dry weights of Vm, Vr, Tv and Os were recorded in treated textile dyeing effluent and control. Whereas, raw textile dyeing effluent has reduced effect on all growth parameters. The present study proved that the treated effluent can be used for the irrigation purpose.

INTRODUCTION

Textile industry is one of the major industries to play a significant role in contributing industrial output by providing employment to over 45 million people and economy more than $400 billion in many countries (Ghaly et al., 2014). Textile industry is also a major consumer of dyes, colourants and intermediates worth US$ 24 billion of which dyes and pigments constitute $17 billion (71%) and dye intermediates $7 billion (29%) (Murthy, 2010). Textile dyeing industries are one of the main sources with severe pollution problems worldwide (Mahfuza et al., 2009; Rajamanickam and Nagan, 2010; Carmen and Daniela, 2012; Chequer et al., 2013).There are about 10,000 different textile dyes with an estimated annual production of 7x105 metric tons are commercially available worldwide of which 30% of these dyes are used in excess of 1,000 tons per annum (Robinson et al., 2001; Mohan et al., 2002; Aksu and Donmez, 2005; Daneshvar et al., 2007; Soloman et al., 2009; Baban et al., 2010). Among various synthetic dyes, azo dyes are the most important synthetic dyes (Fang et al., 2004; Puvaneswari et al., 2006; Joshni and Subramaniam, 2011; Ghaly et al., 2014). There are about 10-35% of textile dyes are lost during the textile dyeing process and 2 – 20% is directly discharged as effluents into ponds, streams and rivers. The textile dyeing effluents containing synthetic dyes are undesirable, toxic, carcinogenic or mutagenic to life forms (Suteu et al., 2011; Ratna and Padhi, 2012).

In India 4.25 billion gallons of water are being consumed by textile industries of which 2.6 billion gallons of textile dyeing effluents are being discharged daily. Tiruppur is a major textile city in Tamil Nadu, India having 754 dyeing units of which 502 industries jointly have 20 common effluent treatment plants and 252 dyeing industries have individual effluent treatment plants. These 754 industries discharge about 87,250 liters of wastewater every day in rivers and streams. Moreover, dyes without appropriate treatment are deleterious to the photosynthetic processes of the plants and also to many living organisms (Hao et al., 2000; Pinheiro et al., 2004; Lavanya et al., 2014). There are many physico-chemical processes such as membrane filtration, coagulation, flocculation, precipitation, floatation, adsorption, ion exchange, mineralization, advanced oxidation, electrolysis and chemical reduction are being followed to treat the effluents and these processes are expensive and generate large quantities of sludge having toxic by-products (Kumar et al., 2006; Adinew, 2012; Huber and Carre, 2012; Huang et al., 2014). Several microorganisms such as bacteria, fungi and yeasts decolourize textile dyes and textile dyeing effluents (Wesenberg et al., 2003; Saranraj et al., 2010; Arun Prasad and Bhaskara Rao, 2010; Stella et al., 2012; Perumal et al., 2012; Alalewi and Jiang, 2012; Manikandan et al., 2012; Hassan et al., 2013; Sriram et al., 2013; Olukanni et al., 2013; Pratap Singh et al., 2014; Hatice et al., 2014; Dastagir et al., 2014). The reutilization of treated textile dyeing effluent for agricultural irrigation is a promising way to recycle the waste water. A literature survey showed that much work has been focused on investigating the effectiveness and feasibility of new advanced technologies that are promising in terms of their performance and cost in the treatment and reuse of textile effluents. These technologies include membrane filtration, coagulation, flocculation, precipitation, floatation, adsorption, ion exchange, mineralization, advanced oxidation, electrolysis and chemical reduction.

MATERIALS AND METHODS

Collection of textile dyeing effluents

Textile dyeing effluents were collected from Shri Vaibhav Processing Mills Pvt. Ltd., Erode, Tamil Nadu. The textile dyeing effluents were collected in a clean plastic container and were brought to the laboratory and stored at 4 ºC and utilized for further studies.

Characterization of textile dyeing effluents

The physico-chemical characteristics such as pH, Total dissolved solids (TDS), chemical oxygen demand (COD) and biological oxygen demand (BOD) of the textile dyeing effluents were analyzed by following the method as described in standard methods for the examination of water and wastewater – APHA (1989, 17th edition).

Germination of selected cereals and pulses by roll towel method

The seeds of Vigna mungo, Vigna radiata and the grains of Oryza sativa and Triticum vulgare treated under different treatments like water, raw textile dyeing effluent and treated textile dyeing effluent were evaluated for its toxicity on germination by following seed germination technique as described by Maynard and Hochmuth, 2007.

The study was conducted using roll towel method and the growth parameters such as germination percentage, fresh weight and dry weight, root and shoot length after 5 days of germination were determined. A polythene cover and Whatman No.1 filter paper (A4 size) were taken spread on a flat surface and moisten with water until it is thoroughly damp and the filter paper was placed on polythene sheet which was the same size of the filter paper. Each 10 seeds of Vigna mungo, Vigna radiata, Oryza sativa and Triticum vulgare were placed in a row on the wet filter paper. Moisten a second towel and carefully place onto the first paper towel, leaving the seeds sandwiched between the two towels. Gently rolled the two towels with the seeds in-between without disturbing the seeds and tied with a rubber band. The setups were placed in a 1 L beaker containing each 100 mL of textile dyeing raw effluent, treated textile dyeing effluent and tap water. The entire set up were kept undisturbed in dark condition for a period of two days at 37 ± 2 ºC. After two days the jars were kept in sunshade 37 ± 2 ºC for photosynthesis to take place. On the 5th day, removed the towels from the container and unwrapped the seeds carefully so that the fragile shoots are not destroyed.

Plant growth study at field condition

A set of three mud pots (30 cm X 10 cm) containing garden soil were added individually with good quality seeds of *Vigna mungo, Vigna radiata* and *Triticum vulgare were sowed and irrigated with the water, raw* effluent and treated effluent respectively and these set ups were incubated in open space for up to 15 days. At every 5 days interval, measured the growth of the seedlings, shoot length, number of leaves, number of roots, fresh and dry weight of leaves and roots.

Measurement of growth parameters of the seedlings of *Vigna mungo, Vigna radiata* and *Triticum vulgare*

Germination percentage

After a period of five days, the germination test was carried out by counting the number of germinated and non-germinated seeds and grains. The germination percentage was calculated based on the formula given below.

$$\text{Germination (\%)} = \frac{\text{Number of strongly germinating seeds} \times 100}{\text{Total number of seeds tested germinations}}$$

Root length

Ten normal seedlings were taken at random from each replication and the length of the root was measured from the collar region to tip. The average value was expressed as cm/seedling.

Shoot length

The seedlings collected from various treatments, the length of the shoot was measured from the collar to tip of primary leaf and the average value was expressed as cm/seedling.

Fresh weight

After measuring the root length and shoot length, the ten normal seedlings were placed in a polythene cover and their weight was measured using an electronic weighing balance. The average value was expressed as gram / seedling.

Dry weight

After measuring the fresh weight of the above ten normal seedlings, the seedlings were kept in hot air oven for 5 to 6 h at 60 °C, were cooled in a desiccator and weighed in an electronic weighing balance. The average value was expressed as gram/seedling.

Statistical analysis

The data recorded in all the experiments were subjected to One Way ANOVA procedures using SPSS software (Version 14). The significant differences among the means were compared by Tukey- HSD test and $P < 0.05$ was considered to be statistically significant.

RESULTS

The textile dyeing effluent utilized for this study was violet in colour. The physico-chemical characteristics of raw effluent were given in Table 1. Textile dyeing effluent was treated by biological system and the treated textile dyeing effluent physico-chemical characteristics were given in Table 2.

Effect of raw and treated textile dyeing effluent on germination, growth of selected pulses and cereals by roll towel method

Germination

The germination percentage of *Vigna mungo, Vigna radiata, Triticum vulgare* and *Oryza sativa* in raw and treated textile dyeing effluent were recorded after 5 days (Plate 1). The germination of V*igna mungo, Vigna radiata* and *Triticum vulgare* started on day 2 whereas Oryza sativa germinated on day 3. The treated textile dyeing effluent recoded for a positive effect on the germination and growth of *Vigna mungo, Vigna radiata, Triticum vulgare* and *Oryza sativa* whereas the raw textile dyeing effluent significantly inhibited the germination and growth of *Vigna mungo, Vigna radiata, Triticum vulgare* and *Oryza sativa*.

Maximum germination of *Vigna mungo* (100%), *Vigna radiata* (100%), *Triticum vulgare* (90%) and *Oryza sativa* (90%) was recorded in treated textile dyeing effluent and also in control whereas untreated raw textile dyeing effluent has reduced the germination of *Vigna mungo* (40%) and *Vigna radiata* (50%), *Triticum vulgare* (40%) and *Oryza sativa* (80%) (Plates 2, 3, 4 and 5).

Shoot length

Good growth of Shoot of *Vigna mungo* (7.69 ± 0.02 cm), *Vigna radiata*, (9.23 ± 0.03 cm), *Triticum vulgare* (8.68 ± 0.01 cm) and *Oryza sativa* (9.92 ± 0.09 cm) was recorded in treated textile dyeing effluent than the untreated textile dyeing effluent (Table 3 and Plates 2, 3, 4 and 5).

Shoot length *Vigna mungo* (2.3 cm), *Vigna radiata*, (0.83 cm) *Triticum vulgare* (4.0 cm) and *Oryza sativa* (0.5 cm) was recorded in raw textile dyeing effluent (Table 3 and Plates 2, 3,4 and 5).

Root length

Comparatively a better growth of roots, number of roots and root length of Vigna mungo (14.96 ± 0.07 cm), Vigna radiata, (11.61 ± 0.0 cm), Triticum vulgare (8.61 ± 0.04 cm) and Oryza sativa (9.92 ± 0.09 cm) were recorded in treated textile dyeing effluent than the untreated raw textile dyeing effluent. An enhanced root growth of *Vigna mungo* and *Triticum vulgare* was recorded in treated textile dyeing effluent than the control (Table 3 and Plates 2, 3, 4 and 5).

Fresh weight and Dry weight

Enhanced fresh and dry weights of *Vigna mungo*, *Vigna radiata, Triticum vulgare* and *Oryza sativa* were recorded in the treated textile dyeing effluent than the untreated textile dyeing effluent. Similar trend of enhanced shoot and root growth of *Vigna mungo* and *Vigna radiata* were also recorded in pot experiment containing treated textile dyeing effluent (Table 3 and Plate 6).

DISCUSSION

The composition of effluent from textile dyeing industry is subjected to regular variation depending upon the dyeing schedules and the types of dyes used in the dyeing processes. In the present study the physical appearances of the composite dye bath effluent was violet. The colour of the effluents indirectly indicates the dyes used in processing units. Effluents in general consist of a mixture of dyes. The effluent was acidic with the pH of 4.1 and reveals the excess usage of acetic acid during processing of dyeing. Several reports highlighted the alkaline and acidic nature of the textile dyeing effluents (Sreedar Reddy et al., 2008; Arun Prasad and Bhaskara Rao 2011; Ahmad et al., 2011; Varsha et al., 2013; Rajeswari et al., 2013; Sharma et al., 2013). In the present study the TDS in the textile dyeing effluent was 16800 mg/L and this could have emerged from the textile dyes used during the process might be released into the effluents. According to Carmen and Daniela (2012) wastewater that had high concentrations of organics mainly consisted of breakdown products and also the organic contents both in dissolved and colloidal form which indicates the high TDS. In the present study a very high content of COD (16000 mg/L) BOD (12000 mg/L) and chloride (780 mg/L) were estimated in the textile dyeing effluents.

The untreated dyeing effluent may cause serious environmental and health hazards and are being disposed off in the water bodies. Thus it was found necessary to assess the phytotoxicity of the treated textile dyeing effluent on selected crops.

In the present study the phytotoxicity of treated textile dyeing effluents, raw textile dyeing effluents and water as control were evaluated for the germination and growth of selected pulses and grains at laboratory conditions. Seed germination and seedling growth of 2 pulses *Vigna mungo, Vigna radiata*, and 2 grains *Triticum vulgare* and *Oryza sativa* were grown on roll towel papers and mud pots containing garden soil and periodically irrigated with treated textile dyeing effluents and untreated effluents respectively.

Table 1: Physico-chemical properties of raw textile dyeing effluent collected from Shri Vaibhav Processing Mills Pvt. Ltd. Erode, Tamil Nadu.

Effluent	Appearance	pH	Total solids	Suspended solids	Dissolved solids	Chloride (ppm)	COD (ppm)	BOD (ppm)
E III	Violet	4.1	17900	1100	16800	780	16000	12000

Table 2: Physico-chemical properties of biologically treated textile dyeing effluent .

Effluent	Appearance	pH	Total dissolved solids	COD (ppm)	BOD (ppm)
E III	colourless	5.8	7054	4020	510

Plate 1: Effect of textile dyeing effleunt on germination and growth of selected cerals (*Triticum vulgare* and *Oryza sativa*) and pulses (*Vigna radiata* and *Vigna mungo* by roll towel method (a1) treated effluent (a2) raw textile dyeing effluent and (a3) control- water on day 1 and (b) set ups on day 5

Table 3: Effect of raw and treated textile dyeing effluent on germination, growth of selected pulses and cereals by Roll towel method.

Samples	Shoot length (cm)	No. of leaves	Shoot Fresh wt. (g)	Shoot Dry wt. (g)	Root length (cm)	No. of roots	Root Fresh wt. (g)	Root Dry wt. (g)	Germination (%)
Vigna mungo									
Water	7.17 ± 0.04^{d}	4.0	0.12 ± 0.001^{f}	0.01 ± 0b^{c}	13.08 ± 0.11^{h}	6.0	0.02 ± 0^{e}	0.005 ± 0^{ab}	100
Raw effluent	1.61 ± 0.16^{b}	0	0.02 ± 0.001^{b}	0.003 ± 0^{a}	1.71 ± 0.05^{b}	1.0	0.01 ± 0^{cd}	0.002 ± 0^{a}	60
Treated effluent	7.69 ± 0.02^{e}	4.0	0.13 ± 0^{f}	0.02 ± 0.006^{cd}	14.96 ± 0.07^{i}	6.0	0.03 ± 0^{e}	0.005 ± 0^{ab}	100
Vigna radiata									
Water	9.17 ± 0.04^{g}	4.0	0.27 ± 0^{g}	0.03 ± 0.001^{de}	11.55 ± 0.09^{g}	5.0	0.12 ± 0^{i}	0.01 ± 0^{b}	100
Raw effluent	0.78 ± 0.01^{a}	1.0	0.01 ± 0.001^{b}	0.001 ± 0^{a}	2.43 ± 0.04^{c}	2.0	0.007 ± 0^{b}	0.001 ± 0^{a}	50
Treated effluent	9.23 ± 0.03^{g}	4.0	0.28 ± 0.003^{h}	0.03 ± 0.001^{e}	11.61 ± 0.04^{g}	5.0	0.09 ± 0^{h}	0.01 ± 0^{ab}	100
Triticum vulgare									
Water	8.68±0.01^{f}	1.0	0.05 ± 0^{d}	0.007 ± 0^{ab}	8.97 ± 0.04^{e}	5.0	0.01 ± 0^{cd}	0.006 ± 0^{ab}	90
Raw effluent	3.80±0.12^{c}	1.0	0.01 ± 0.001^{b}	0.001 ± 0^{a}	4.00 ± 0.06^{d}	3.0	0.01 ± 0.001^{bc}	0.003 ± 0.001^{ab}	60
Treated effluent	8.68±0.01^{f}	1.0	0.03 ± 0.001^{c}	0.003 ± 0^{ab}	8.61 ± 0.04^{e}	5.0	0.01 ± 0^{d}	0.006 ± 0^{ab}	90
Oryza sativa									
Water	9.92 ± 0.09^{h}	1.0	0.06 ± 0.001^{e}	0.001 ± 0^{a}	2.77 ± 0.01^{c}	1.0	0.06 ± 0.001^{g}	0.001 ± 0.001^{a}	90
Raw effluent	0.51 ± 0.01^{a}	1.0	0.001 ± 0^{a}	0.0001 ± 0^{a}	0.51 ± 0.01^{a}	1.0	0.001 ± 0^{a}	0.0001 ± 0^{a}	20
Treated effluent	9.92 ± 0.09^{h}	1.0	0.03 ± 0.001^{c}	0.0007 ± 0^{a}	9.92 ± 0.09^{f}	1.0	0.03 ± 0.001^{f}	0.0007 ± 0.001^{a}	90

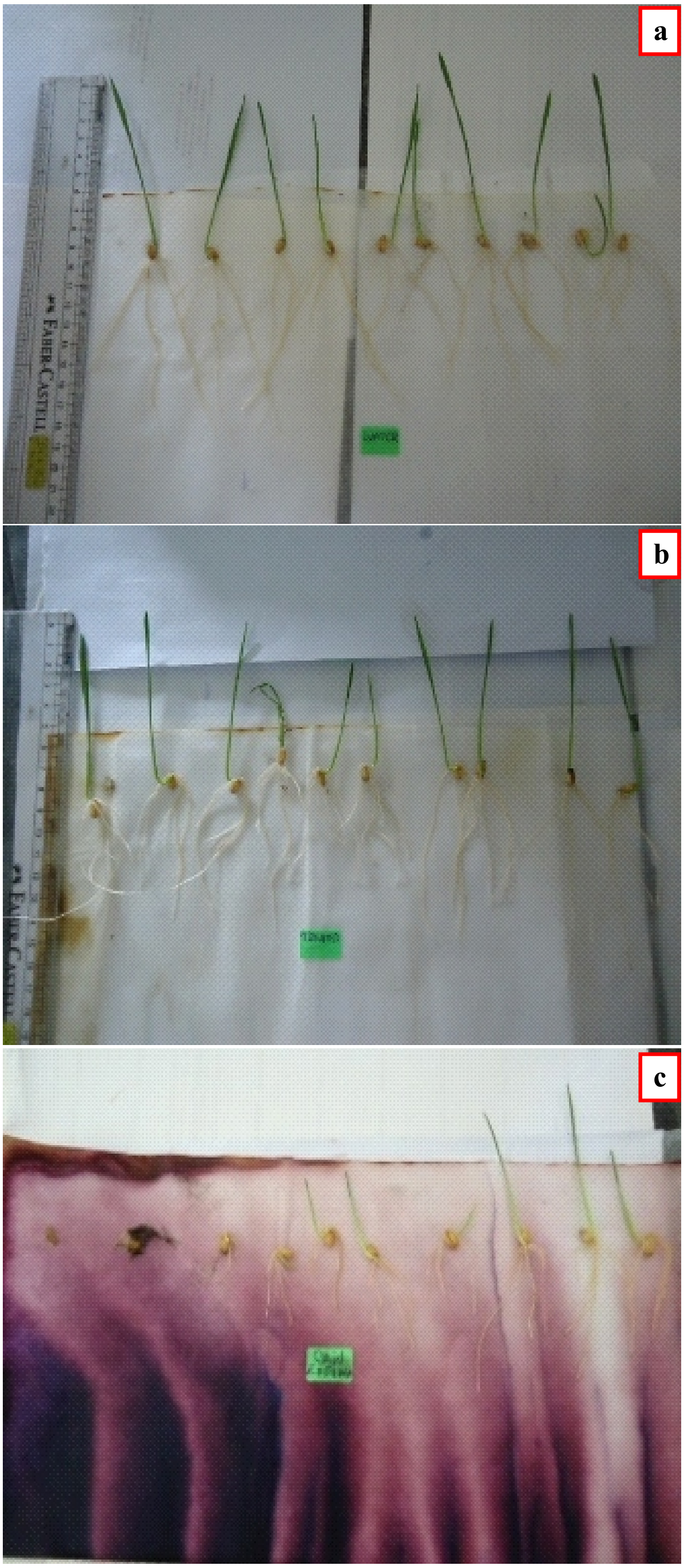

Plate 2 : Effect of textile dyeing effleunt on germination and growth of *Triticum vulgare* (wheat grain) by roll towel method (a) control (water), (b) treated textile dyeing effluent, (c) raw textile dyeing effluent

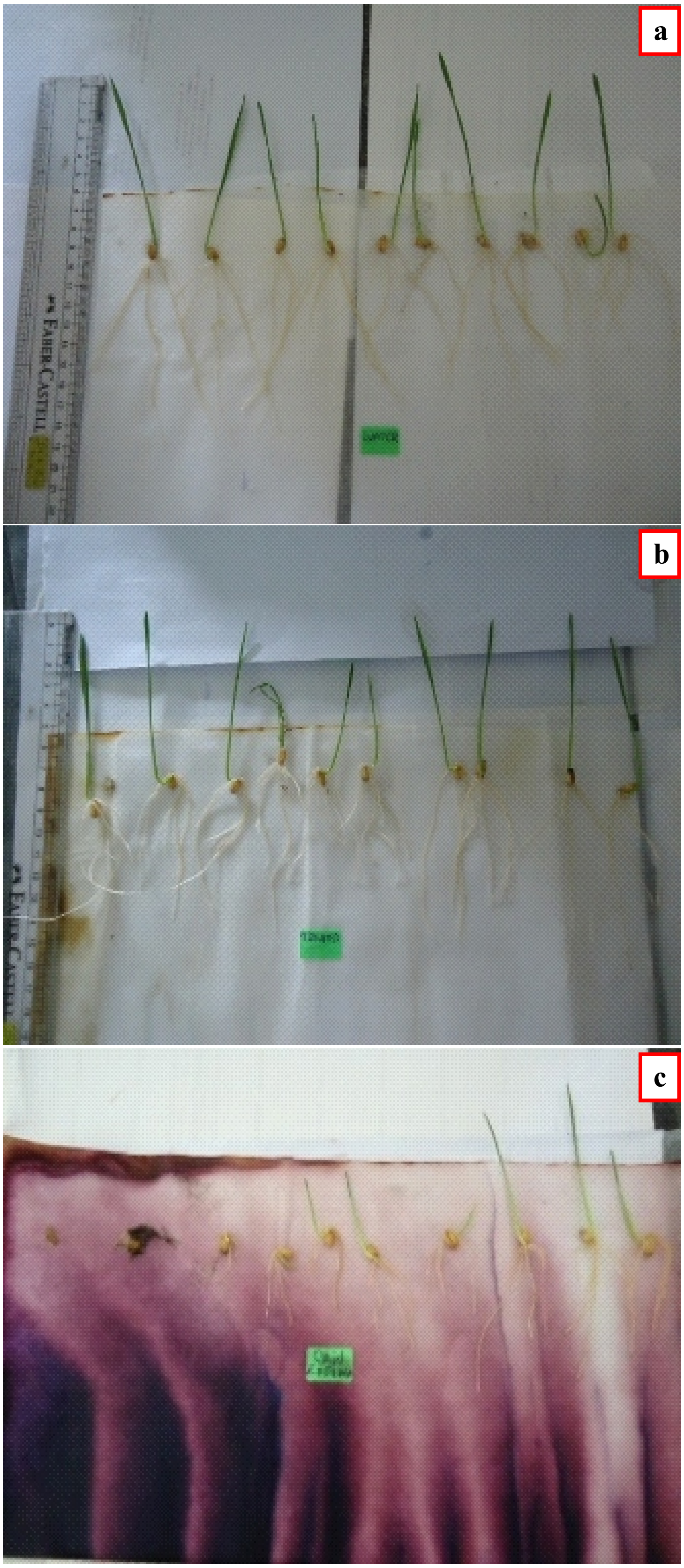

Plate 3 : Effect of textile dyeing effleunt on germination and growth of *Oryza sativa* (paddy) by roll towel method (a) control (water), (b) treated textile dyeing effluent, (c) raw textile dyeing effluent

Senthil Kumar and Mohamed Jaabir, 2013 reported a remarkable performance in the germination percentage of Brassica nigra and Cyamopsis tetragonolobus under biologically-treated wastewater, whereas the present investigation reported for a maximum germination of *Vigna mungo* (100%), *Vigna radiata* (100%), *Triticum vulgare* (90%) and *Oryza sativa* (90%) in treated textile dyeing effluent and control. The untreated raw textile dyeing effluent has reduced the germination of Vigna mungo (40%) and Vigna radiata (50%), Triticum vulgare (40%) and Oryza sativa (80%).

In the present study, highest seedling growth of *Vigna mungo, Vigna radiata, Triticum vulgare* and *Oryza sativa* were recorded in treated textile dyeing effluent and control than the untreated raw textile dyeing raw effluent. An enhanced fresh and dry weight of *Vigna mungo, Vigna radiata, Triticum vulgare* and *Oryza sativa* were also recorded in the treated textile dyeing effluent than the untreated raw textile dyeing effluent and similar results were also reported by Senthil Kumar and Mohamed Jaabir (2013).

Similar trend of enhanced shoot and root growth of *Vigna mungo* and *Vigna radiata* were also recorded in mud pots experiment containing garden soil periodically irrigated with treated textile dyeing effluent. The treated textile dyeing effluent significantly increased the seedling growth of *Vigna mungo, Vigna radiata* and *Triticum vulgare*.

The laboratory study on phytotoxicity concluded that the treated textile dyeing effluent did not inhibit the seedling growth of pulses and grains tested. Jayaprakashvel et al. (2014) reported that the decolorized dye solutions had no phytotoxic effect on seed germination and seedling growth parameters of Green

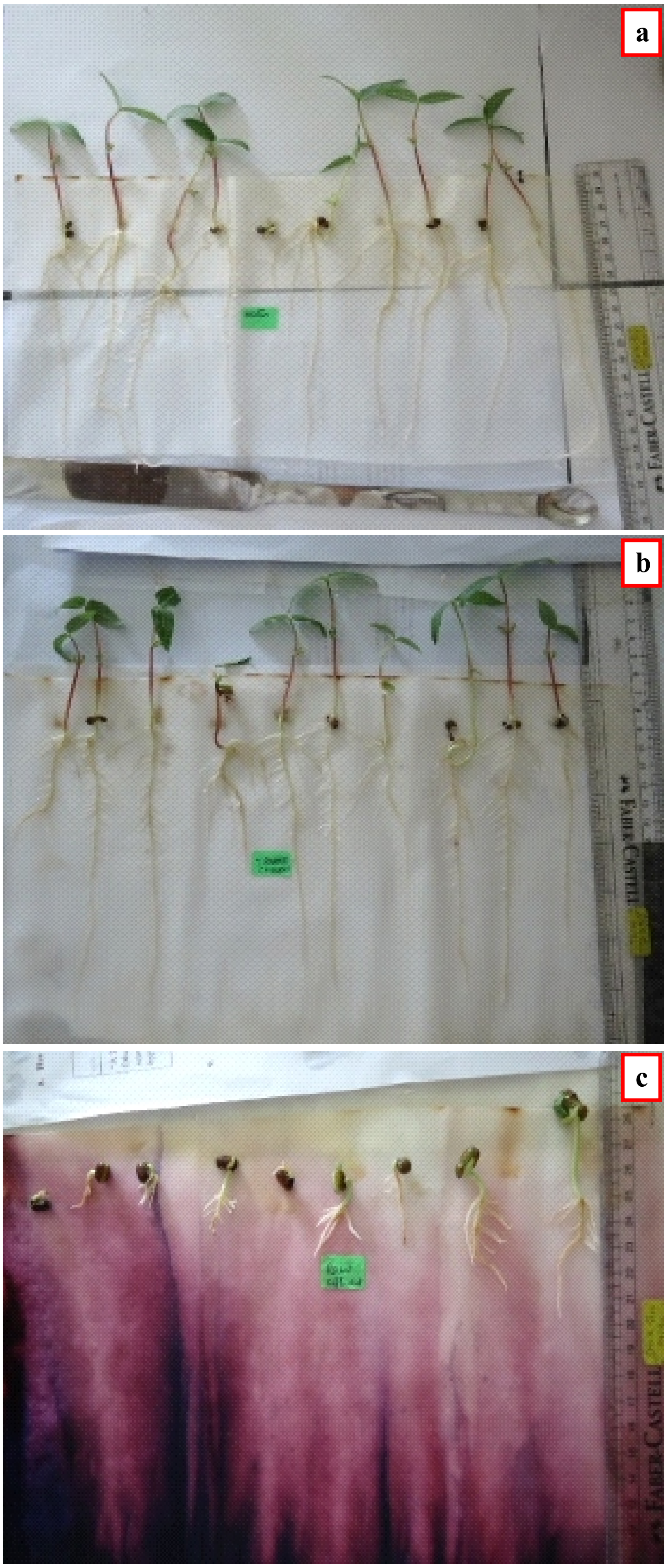

Plate 4 : Effect of textile dyeing effleunt on germination and growth of *Vigna radiata* (greengram) by roll towel method (a) control (water), (b) treated textile dyeing effluent, (c) raw textile dyeing effluent

Plate 5 : Effect of textile dyeing effleunt on germination and growth of *Vigna mungo* (blackgram) by roll towel method (a) control (water), (b) treated textile dyeing effluent, (c) raw textile dyeing effluent

CONCLUSION

Farmers are facing severe problem in agriculture production due to scarcity in ground water. The enormous volume of water expelled out of the textile industry may help in encountering the water crisis. The present study revealed the treated effluent can be used for the irrigation purpose.

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Disclosure statement

No potential conflict of interest was reported by the author.

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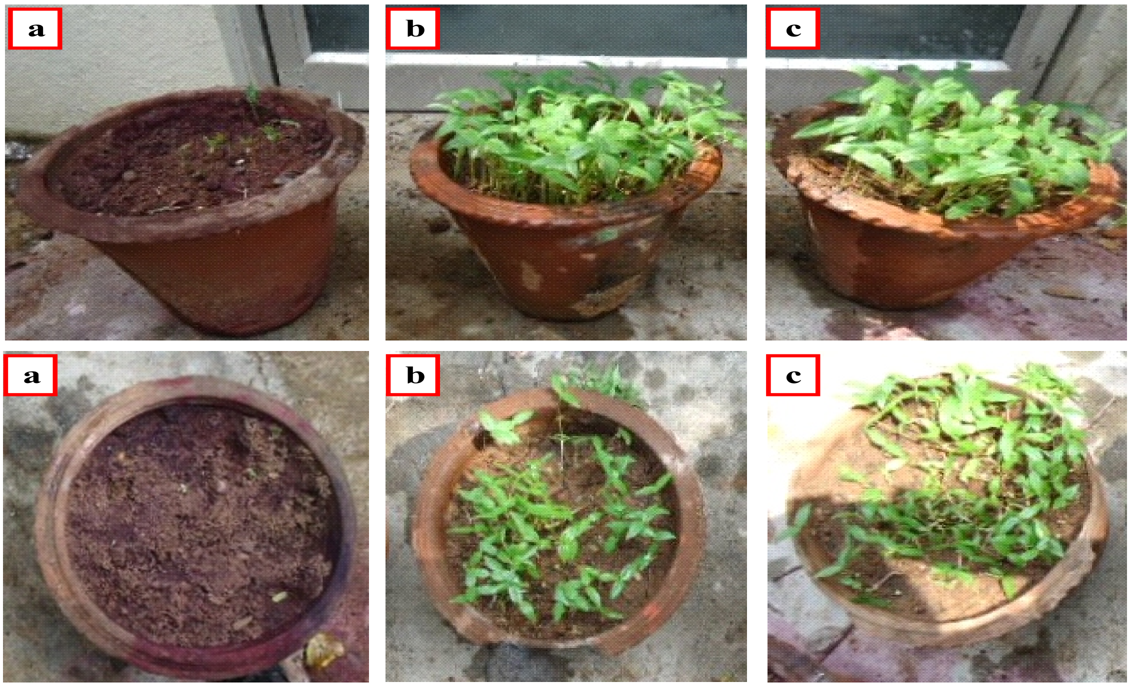

Fig. 6: Effect of textile dyeing effleunt on germination and growth of pulses (Vigna radiata -a, b, and c) and *Vigna mungo* (d, e and f) in mud pots maintied at open condition (a & d) raw textile dyeing effluent, (b & e) treated textile dyeing effluent and (c & f) control (water) on day 5

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