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Impact of Textile Waste Water on Seed Germination and Some Physiological Parameters in Pea (*Pisum sativum* L.), Lentil (*Lens esculentum* L.) and Gram (*Cicer arietinum* L.)

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Abstract: The use of industrial waste water for irrigation purposes has emerged an important way to utilize its nutrients and removal of its pollutants load by growing tolerant plant species. An experiment was conducted to evaluate the impact of textile factory effluents (0, 10, 25,50 and 100% concentration) on germination and some physiological parameters like biomass production, chlorophyll contents, root development in three leguminous crops viz., pea (*Pisum sativum* L.), lentil (*Lens esculentum* L.) and Gram (*Cicer arietinum* L.). Plants were raised first in perti dishes and then in plastic pots in triplicate and irrigated with various concentrations (0, 10, 25, 50 and 100%) of effluent. Germination %, biomass production, chlorophyll contents and various attributes of root development were determined in plants grown under different treatments. Plants exhibited a substantial reduction in total germination, root and shoot DW, number of root branches/plant, Mean Extension Rate (MER), Relative Multiplication Rate (RMR), Relative Growth Rate (RGR) and chlorophyll contents when grown with higher concentration (50 and 100% concentration) of textile effluents. However, the effect of textile effluents was promotive rather than inhibitory on these parameters when applied in low concentrations (10 and 25%). Crops performed differentially to the effluent imposition as lentil performed relatively well as compared to other crops. It has been inferred that the effect of textile effluent was crop specific depending on the concentration and stage of growth. It was suggested that waste water from textile factory could be utilized for irrigation purposes after proper dilution and may contribute, at least in part towards solving the problem of textile effluent disposal. However, such recommendation needs some more extensive work to minimize the risk.

Key words: Biomass, chlorophyll, relative growth rate, root development

INTRODUCTION

Increasing population in developing countries has put a tremendous pressure on already shrinking natural resources in order to meet their ever-growing demand. Scarcity of water is an important concern in arid areas such as Africa, Southern Asia and Middle East and even in some parts of the world where it may lead to a war crisis (Jaafarzadeh, 1996). In addition, continued population growth, increased per capital water consumption and increased water requirements for industry and irrigation have also resulted in considerable decrease of usable water resources (Naddafi *et al*., 2005). Since the demand for food and fodder is increasing rapidly in Ethiopia, it has brought up more and more land under cultivation and focused the attention on fertilizer and irrigation water (Barnett, 1999). In view of this scenario, there is an imperative need to exploit non-conventional resources to meet the irrigation water demand. Among others, one of the most important irrigation as well as nutrient resource is industrial waste water which consists of about 95% water and the rest as organic and inorganic nutrients.

Among industries, the textile industry is considered to be one of the world's worst polluters because it uses vast amounts of both chemicals and water which after processing becomes waste water. Traditionally, a textile finishing industry consumes about 100 L of water to process about 1 kg of textile material. Thus, after processing such a vast amount of wastewater damages the environment with its heat, its high pH levels and the dyes, bleaches and other harmful chemicals that it contains. Since, the disposal of textile effluent is a great concern in urban areas, applying the textile waste water to agricultural field instead of disposing off in lakes and rivers can make crops grow better due to presence of various nutrients like N, P, Ca, Mg etc. (Kanan *et al*., 2005; Khan *et al*., 2003).

In view of such perspectives, the present investigation was conducted to evaluate the impact of textile effluent on germination and some physiological

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characteristics in three leguminous crops viz., pea (*Pisum sativum* L.), lentil (*Lens esculentum* L.) and gram (*Cicer arietinum* L.). Moreover, the aim of the present study was also to asses the possibility whether treated waste water from textile could safely be used to irrigate crop plants and solve the problem of effluent disposal in an eco-friendly manner.

MATERIALS AND METHODS

Collection of seeds and textile effluent: The whole experiment was framed into two parts and conducted in Botany lab during 2009-2010. The effect of textile effluents was examined on three leguminous crops viz., pea (*Pisum sativum* L.), lentil (*Lens esculentum* L.) and gram (*Cicer arietinum* L.). The seeds were procured from the local certified seed supplier located in Debrezeit town. The waste water (effluent) was collected from textile factory, Hawassa (SNNPR). The effluents were stored at 4°C to avoid any change in characteristics during storage. Fifteen sterilized Petri dishes were collected and lined with filter papers moistened with 0, 10, 25, 50 and 100% concentration of effluent. Seeds were disinfected with 1% sodium hypochlorite solution for 15 min and 10 seeds were kept in each Petri dish. Data for early growth and germination were recorded. The emergence of radicle was considered as criterion for germination.

Experimental designing: For pot culture, Plastic pots (size:15×14 cm) were filled with equal amount (2 kg) of sandy loam soil of medium fertility and five seeds of pea (*Pisum sativum* L.), lentil (*Lens esculentum* L.) and gram (*Cicer arietinum* L.) were sown in each pot after proper sterilization. The pots were provided with ½ strength Hoagland solution (Hewitt, 1966) along with different concentrations of effluents. Each pot was provided with 100 mL effluent followed by 50 mL of nutrient solution. Each treatment had three replications. A control set irrigated with DW was also maintained for comparison. The whole experiment was conducted during the year 2009-2010 in the Botany Lab of the department.

Analysis and determinations

Germination: Germination percentage of each crop from each treatment was calculated on the basis of radicle emergence from seeds.

Biomass: Plant samples were taken from each treatment and divided into root and shoot parts. Plants were dried in a hot air oven at 60°C for 48 h and dry weights were estimated.

Root development: Plants were uprooted from each treatment carefully separated into root and shoot, slightly rinsed for same time in each case and blotted dry. The number and lengths of root were studied with the aid of A×10 magnifying glass, of these primary, secondary, tertiary branches were counted. The root length was measured by ruler and various parameters of root development were calculated.

Mean Extension Rate (MER) and Relative Multiplication Rate (RMR): The length of root/plant, number of root branches/plant was measured at two time intervals and MER and RMR were calculated according to a formulae devised by Hunt (1978).

Chlorophyll contents: The chlorophyll content in leaves of all crops of different treatments was estimated by extracting fresh leaves in acetone according to Arnon (1949).

Statistical analysis: Values of different parameters are presented as mean of replications. The values are given with ±Standard Error. Data in this experiment were analysed statistically by using Duncan Multiple Range Test (DMRT) at 5% significance level.

RESULTS

Table 1 provides the values of various physical and chemical characteristics of the treated textile effluent. It was evident from the values in table that parameters like BOD, COD, TSS, TDS, Ca, Mg, K, Na, Cl were exceeding the permissible limit. The effluent colour was violet.

Germination and biomass production: The mean of percentage germination was variably influenced by textile effluent concentrations. It was observed that at lower concentration (0-25%), germination % was either unaffected or even stimulated followed by an enhancement in total biomass also. For example, at 10% effluent concentration, pea plants exhibited about 130 g root dry weight as compared with 120 g root dry weight at control (0% effluent). On the other hand, germination and biomass production were greatly decreased under higher concentration (50 and 100%) treatment. For instanc lentil plants showed about 50.0 g shoot dry weight at 50% effluent concentration as compared with

75.0 g shoot dry weight in control plants. Interestingly, this decreasing response of crops to higher concentrations of effluent was observed in all three crops studied. However, the extent of reduction was variable (Table 2). The overall performance of crops was observed as pea>gram>lentil in increasing order of their tolerance to higher concentration of effluent.

Pigment composition: Data presented in Table 3 clearly show the effect of different concentrations of effluent on various chlorophyll forms in three crops. It is obvious that the greening of plants increased when plants were treated with low concentration of effluents (10 and 25%). On the other hand, it is also clear from presented data that higher concentration are inhibitory to synthesis of all chlorophyll molecules particularly of Chl a. For example, at 100% effluent concentration, pea plants showed about 0.60 mg g^{-1} FW chl a as compared with 1.10 mg g^{-1} FW chl a in control plants.

Root development: Root development i.e., number of branching and other attributes like Mean Extension Rate (MER), Relative Multiplication Rate (RMR) and Relative Growth Rate (RGR) were differentially affected by effluent application depending upon the crops species. Lower concentrations of effluent were proved promotive to the number of root branches/plant and other parameters. For example Table 5 showed that gram plants exhibited about 35 secondary branches at lower concentration (10%) as compared with control (20 branches). This was a similar case for pea and lentil also. On the contrary, higher concentrations (50-100%) proved detrimental to all parameters of root development (Table 4). In all crops, primary root remained unaffected at all treatments. Lentil showed a less reduction in RGR over control at 50% effluent concentration showing its ability to cope relatively well than other crops with effluent toxicity. MER and RMR were also affected at higher concentrations and were found stimulated by lower concentration with few exceptions. For example, MER in lentil was recorded about 0.058 cm day^{-1} as compared with 0.051 cm day^{-1} in control plants at 10% effluent concentration. Moreover, other two crops i.e., pea and gram have also showed a similar behaviour to effluent imposition (Table 4). Such performance of crops shows the probability of using textile effluent for irrigation of crops.

Table 1: Physical and chemical characteristics of textile mill effluent

Characteristics	Textile effluent values
Colour	Bluish grey
Temperature (°C)	27
pH	8.5
Electrical conductivity (dS m^{-1})	4.5
Total solids (mg L^{-1})	1400
Total dissolved solids (mg L^{-1})	260
Total suspended solids (mg L^{-1})	940
BOD (mg L^{-1})	1010
COD (mg L^{-1})	230
Hardness	350
Chlorides (mg L^{-1})	1390
Sulphate (mg L^{-1})	287
Nitrate (mg L^{-1})	Traces
Zinc (mg L^{-1})	4.5
Potassium (mg L^{-1})	13
Sodium (mg L^{-1})	12.5
Calcium (mg L^{-1})	6
Magnesium (mg L^{-1})	Traces
Lead (mg L^{-1})	Traces
Copper (mg L^{-1})	Nil
Nickel (mg L^{-1})	1.4
Cadmium	Traces
Phosphate (mg L^{-1})	12
Manganese (mg L^{-1})	Nil

Table 2: Effect of textile effluents on germination and biomass in Pea, lentil and gram

Crops	Effluent Conc. (%)	Germination (%)	Root DW (g $plant^{-1}$)	Shoot DW (g $plant^{-1}$)	Total DW (g $plant^{-1}$)
	0	100±0.0	120.0±8.8	190.0±9.6	310.0±12.3
	10	100±0.0a	130.0±8.9a	210.0±10.3b	340.5±13.8a
Pea	25	100±0.0a	125.0±8.8b	205.0±10.1b	330.0±13.4b
	50	80±4.5b	80.0±4.6c	130.0±8.8c	210.0±10.3c
	100	90±5.7c	65.1±5.5d	110.0±9.5d	175.0±10.6d
	0	100±0.0	40.0±4.3	75.0±4.3	115.0±8.8
	10	100±0.0a	46.0±4.4a	85.0±5.2a	131.5±9.0a
Lentil	25	100±0.0a	42.0±4.3b	80.0±4.6b	122.0±7.9b
	50	90±5.7b	28.0±2.5c	50.0±4.7c	78.7±4.3c
	100	70±7.1c	23.0±2.0d	46.0±4.4d	69.0±7.1d
	0	100±0.0	80.0±4.5	170.0±10.3	250.0±11.8
	10	100±0.0a	88.5±5.7b	188.0±9.2a	276.0±11.8a
Gram	25	100±0.0a	84.0±5.6c	170.0±8.4b	254.0±11.9b
	50	90±5.7b	50.0±4.7d	110.0±7.7c	160.0±7.7c
	100	70±7.1c	45.0±4.5e	95.0±6.0d	140.0±8.8d

Values are presented as ±SEM. Same letters in a column are not significantly different ($p\leq 0.05$)

Table 3: Effect of textile effluents on chlorophyll contents (mg g^{-1} FW) in Pea, lentil and gram

Effluent Conc. (%)	Pea Chl a	Pea chl b	Pea Total chl	Lentil Chl a	Lentil chl b	Lentil Total chl	Gram Chl a	Gram chl b	Gram Total chl
0	1.10±0.12a	0.60±0.06a	1.80±0.16a	0.95±0.09a	0.60±0.06a	1.65±0.15a	1.01±0.10a	0.58±0.05a	1.75±0.17a
10	1.20±0.12a	0.70±0.07a	2.10±0.20b	1.05±0.10b	O.70±0.07a	1.80±0.16a	1.10±0.11b	0.66±0.06a	1.87±0.18a
25	1.15±0.11b	0.65±0.06a	1.94±0.17b	1.00±0.10b	0.66±0.06b	1.70±0.15b	1.06±0.10c	0.63±0.06b	1.75±0.17b
50	0.70±0.06c	0.40±0.03b	1.25±0.13c	0.55±0.05c	0.46±0.04c	1.30±0.130c	0.65±0.06d	0.45±0.04c	1.30±0.13c
100	0.60±0.06d	0.35±0.03c	1.10±0.12d	0.48±0.04d	0.35±0.03d	1.20±0.12d	0.55±0.05e	0.40±0.04d	1.10±0.12d

Values are presented as ±SEM. Same letters in a column are not significantly different ($p\leq 0.05$)

Table 4: Effect of textile factory effluents on Mean Extension Rate (MER), Relative Multiplication Rate (RMR) and Relative Growth (RG) rate in pea, lentil and gram

Crops	Effluent conc. (%)	Mean extension rate (cm day^{-1})	Relative multiplication rate (No.root/day)	Relative growth rate (cm day^{-1})
Pea	0	0.068	0.008	0.115
	10	0.075a	0.008a	0.120a
	25	0.080a	0.007a	0.125a
	50	0.050b	0.006b	0.085b
	100	0.040c	0.003c	0.060c
Lentil	0	0.051	0.007	0.085
	10	0.058a	0.008a	0.090a
	25	0.068b	0.008a	0.090a
	50	0.040c	0.005b	0.065b
	100	0.030d	0.003c	0.040c
Gram	0	0.065	0.008	0.125
	10	0.080a	0.008a	0.125a
	25	0.085a	0.007a	0.120a
	50	0.060b	0.005b	0.070b
	100	0.050b	0.004b	0.060c

Values are presented as ±SEM. Same letters in a column are not significantly different ($p \leq 0.05$)

Table 5: Effect of textile effluents on number and various types of roots in pea, lentil and gram

Effluent	Primary roots			Secondary roots			Tertiary roots		
(Conc. %)	Pea	Lentil	Gram	Pea	Lentil	Gram	Pea	Lentil	Gram
0	1	1	1	20	20	45	40	30	40
10	1a	1a	1a	32a	24a	45a	42a	38a	35a
25	1a	1a	1a	35a	25a	48a	45a	30b	38a
50	1a	1a	1a	15b	18b	30b	30b	20c	30b
100	1a	1a	1a	10c	15c	20c	20c	18c	20c

Values are present as ±SEM. Same letters in a column are not significantly different ($p \leq 0.05$)

DISCUSSION

It is evident from our results that plants exhibited a stimulation in germination %, biomass, chlorophyll pigments and various attributes of root development at lower concentrations. In contrary, a substantial decrease was observed in these parameters at higher concentrations of textile effluent. Our results are in agreement with some earlier reports which have also demonstrated a same response of plants when irrigated with effluent (Mohammad and Khan, 1985; Srivastava and Sahai, 1987; Kaushik *et al*., 2005; Nawaz *et al*., 2006; Garg and Kaushik, 2008). It has been established by various analysis that effluents from industrial establishments and sewage contain heavy metals and also nutrients (Rodrigues *et al*., 1996; Dhevagi and Oblisami, 2002; Akbar *et al*., 2007; Amin *et al*., 2009) which affect plants and soils in a variety of ways. Industrial effluents have been found to increase the accumulation of various heavy metals like Fe, Mn, Zn, Ni, Pb, Cu in soil and NR activity and yield in plants (Al-Oud, 2008; Umebese *et al*., 2009). Tan *et al*. (1979) reported that different types of effluents influenced the growth of various crops. It is argued that imposition of effluent in plant nutrient medium may cause disturbances in the iso-osmotic relation of plants making water availability to roots more difficult. Moreover, the presence of heavy metals in effluent may also compete for essential nutrients leading to their deficiency in nutrient medium. Our results indicate that at lower concentration, the effect of effluent was either negligible or promotive which is indicative of minimum action of heavy metals in lower concentration. Singh *et al*. (2011) have noticed that tannery waste at lower concentration promotes vegetative growth and yield of *Chrysanthemum* cuttings and behaves as growth inhibitor at higher concentration. Kadar and Kastori (2003) and Ogunwenmo *et al*. (2010) have also reported a same trend for rapseed and *Amaranthus*, respectively. This may be attributed to the presence of several essential plant nutrients like N, P, K, Ca and Mg in the textile waste water (Kanan *et al*., 2005; Khan *et al*., 2003; Saravanamoorthy and Kumari, 2005). It may also be opined that heavy metals like iron, manganese may contribute to the synthesis of chl a that is resulted into stimulation of Chlorophyll under lower concentrations.

CONCLUSION

On the basis of overall performances as exhibited by three leguminous crops while subjected to textile effluent, it can be suggested that effluents released from various textile industry are a prospective source of nutrients and therefore, may be used for irrigation purposes. However, the extent of remediation depends upon the plant species, plant growth stage and dilution of the effluent applied. It is, therefore, obvious that some kind of treatment is necessary to minimize the pollution effects before the textile effluent is discharged on the land. After dilution, the effluent's characteristics come within the prescribed disposal limits and pollution load per unit effluent volume is decreased.

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REFERENCES

Akbar, F., F. Hadi, Z. Ullah and M.A. Zia, 2007. Effect of marble industry effluent on seed germination, post germinative growth and productivity of *Zea mays* L. Pak. J. Biol. Sci., 10: 4148-4151.

Al-Oud, S.S., 2008. Impact of municipal and industrial waste on the distribution and accumulation of some heavy metals in sandy soils of Al-Qassim region at central of Saudi Arabia. J. Environ. Sci. Technol., 1: 135-142.

Amin, A.W., F.K. Sherif, H. El-Atar and H. Ez-Eldin, 2009. Residual effect of sewage sludge on soil and several yield parameters of *Zea mays*. Res. J. Environ. Toxicol., 3: 86-93.

Arnon, D.I., 1949. Copper enzymes in isolated chloroplasts. Polyphenyloxidase in *Beta vulgaris*. Plant Physiol., 24: 1-15.

Barnett, T., 1999. The Emergence of Food Production in Ethiopia. Archaeo Press, Oxford, UK., pp: 225.

Dhevagi, P. and G. Oblisami, 2002. Effect of paper mill effluent on germination of agricultural crops. J. Ecobiol., 4: 243-249.

Garg, V.K. and P. Kaushik, 2008. Influence of textile mill waste water irrigation on the growth of sorghum cultivars. Applied. Ecol. Environ. Res., 6: 1-12.

Hewitt, E.J., 1966. Sand and water culture methods used in the study of plant nutrition. Technical Communication No. 22 (revised) Commonwealth Bureau of Agriculture and Plant on Crops. East Malling, Commonwealth Agriculture Beaurex. Forheim Royal England.

Hunt, R., 1978. Plant Growth Analysis. 1st Edn., Edward Arnold Ltd., London, ISBN-10: 0713126965, pp: 67.

Jaafarzadeh, N., 1996. Effect of wastewater of Shiraz city for crops irrigation on heavy metal increase in soil and plants. Proceedings of the 2nd National Water and Soil Congress (NWS'96), Agricultural Education and Development Organization, pp: 369-369.

Kadar, I. and R. Kastori, 2003. Effects of microelement loads on rape grown on calcareous chernozem soil. Agrokemia Talajtan, 52: 331-346.

Kanan, V., R. Ramesh and C. Sasikumar, 2005. Study on ground water characteristics and the effects of discharged effluents fro textile units at Karur District. J. Environ. Biol., 26: 269-272.

Kaushik, P., V.K. Garg and B. Singh, 2005. Effect of textile effluents on growth performance of wheat cultivars. Bioresour. Technol., 96: 1189-1193.

Khan, N.A., L. Gupta, S. Javid, S. Singh, M. Khan, A. Inam and Samiullah, 2003. Effects of sewage waste water on morphophysiology and yield of *Spinacia* and *Trigonella*. Ind. J. Plant Physiol., 8: 74-78.

Mohammad, A. and A.U. Khan, 1985. Effect of a textile factory effluent on soil and crop plants. Environ. Pollun. (Series A), 37: 131-148.

Naddafi, K., N. Jaaferzadeh, M. Mokhtari, B. Zakizadeh and M.R. Sakian, 2005. Effects of waste water stabilization pond effluent on agricultural crops. Int. J. Environ. Sci. Technol., 1: 273-277.

Nawaz, S., S.M. Ali and A. Yasmin, 2006. Effects of industrial effluents on seed germination and early growth of *Cicer arientum*. J. Biosci., 6: 49-54.

Ogunwenmo, K.O., O.A. Oyelana, O. Ibidunmoye, G. Anyaso and A.A. Ogunnowo, 2010. Effects of brewery, textile and paint effluent on seed germination of leafy vegetables-*Amaranthus hybridus* and *Celosia argentea* (Amaranthaceae). J. Biol. Sci., 10: 151-156.

Rodrigues, M.S., J.M. Lopez, H.C. Lee, M.D. Bertoleti, P. Sequi, B. Lemmes and T. Papi, 1996. Use of composted societal organic wastes for sustainable crop production. Sci. Comp., 1: 447-456.

Saravanamoorthy, M.D. and B.D.R. Kumari, 2005. Effect of textile waste water on morphophysiology and yield on two varieties of peanut (*Arachis hypogaea* L.). J. Agric. Tech., 3: 335-343.

Singh, P.K., V. Kumar and S. Singh, 2011. Management of tannery waste: Its use as planting medium for *Chrysanthemum* plants. J. Environ. Sci. Technol., 4: 560-567.

Srivastava, N. and R. Sahai, 1987. Effect of distillery waste on the performance of *Cicer arietinum* L. Environ. Pollut., 43: 91-102.

Tan, H.T., K.P. Pillai and D.J. Barry, 1979. Possible utilization of rubber factory effluent on cropland. Proceedings of the Rubber Research Conference (RR'79), Institute of Malaysia, pp: 154-154.

Umebese, C.E., O.E. Ade-Ademilua and B.O. Olonisakin, 2009. Impact of combined industrial effluent on metal accumulation, nitrate reductase activity and yield of two cultivars of *Vigna unguiculata* (L.) Walp. J. Environ. Sci. Technol., 2: 146-152.