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ASSESSING GERMINATION, SURVIVAL AND GROWTH OF COTTON AND FLOWER CROPS BY USING TREATED TANNERY EFFLUENT AND DOMESTIC WASTEWATER FOR IRRIGATION

*Jagathjothi N. & Mohamed Amanullah, M.
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India,
*Corresponding author email: jothinarayanan2000@gmail.com

ABSTRACT
A pot culture experiment was conducted at the Common Effluent Treatment Plant (CETP), Dindigul, Tamil Nadu, India to assess the effect of treated tannery effluent and domestic wastewater irrigation on germination, survival and growth of cotton and flower crops. Pot culture experiment was laid out in completely randomized design with four replications. The results revealed that among the mixing proportion of irrigation sources application of 25% treated tannery effluent (TTE) + 75% domestic wastewater (DWW) recorded higher seed germination percentage in cotton and higher survival percentage in flower crops *viz.*, chrysanthemum, marigold and jasmine. Similarly, plant height, root length and dry matter production was higher in the same treatment (1:3 ratio) at 120 days after sowing (DAS) in cotton and 120 days after planting (DAP) in all flower crops when compared to other mixing ratios of treated tannery effluent and domestic wastewater.

KEYWORDS: Cotton, flowers, germination, effluent, wastewater.

INTRODUCTION

Tanning is one of the oldest industries in India and ranks amongst the five top most export-oriented industries of the country. However, in another side it has the harmful consequences of environmental impact due to unsystematic disposal of its waste (Soyalsan and Karaguzel, 2007). It is estimated that nearly 30 to35 litre of water is used per kilogram of the processed skin. It generates and discharge huge quantity of effluent daily. The discharged effluent is loaded with the high concentration of sodium, chloride, sulphate, bicarbonate, calcium and magnesium. Hence, indiscriminate disposal of this 'chemicals rich' tannery effluent results in extensive degradation of productive agriculture land surface and groundwater.

Common Effluent Treatment Plant's (CETP) are established to treat the toxic effluents for diminishing the pollution risks of soil and ground water. In Tamil Nadu, there are 61 tanneries situated in and around of Dindigul. The effluents generated in these tanneries are pumped to the Common Effluent Treatment Plant for treatment (CETP). With high generation of effluent from the tannery industries, there is the possibility to use effluent as irrigation source. Utilizing the effluent for crop production is an effective method of disposal through which the plant nutrients and water could be recycled and pollution may be minimized besides achieving an additional income (Vasudevan *et al.,* 2010). Domestic wastewater generation in the Dindigul city is also more than five time of tannery effluent generation per day. Domestic wastewater comprises organic materials and plant nutrients. Thus, the mixing of domestic wastewater and tannery effluent for irrigation will be an effective and reliable technology for reducing environmental pollution. However, it requires detailed studies on the mixing ratio of tannery effluent and domestic wastewater, its effect on crops. With this point, the present investigation was carried out to study the effect of irrigating treated tannery effluent with domestic wastewater on cotton and flower crops.

MATERIALS & METHODS

Pot culture experiment was carried out during kharif season at the common effluent treatment plant (CETP), Dindigul, Tamil Nadu, India to study the influence of treated tannery effluent and domestic wastewater irrigation on germination, survival, plant height, root length and dry matter production of cotton and flower crops. The soil of the pot culture experiment was red sandy loam in texture. The experimental soil was low in available nitrogen, medium in available phosphorus and high in available potash. The pot culture was laid out in completely randomized design with four replications. Treatment comprised six levels of irrigation sources *viz.*, I_1 - 25% treated tannery effluent (TTE) + 75% domestic wastewater (DWW), I_2 - 50% TTE + 50% DWW, I_3 - 75% TTE + 25% DWW, I_4 - 100% TTE, I_5 - 100% DWW and I_6 - control (normal water). Cotton and flower crops *viz.*, chrysanthemum, jasmine and marigold were used as test crop for this study. In pot culture experiment, seeds of cotton were dibbled at one seed pot^{-1}. 30 days old rooted cuttings of chrysanthemum, cuttings of jasmine and seedlings of marigold were planted at one seedling pot^{-1}. The well decomposed FYM at the rate of 12.5 tonnes ha^{-1} for all crops and recommended dose of 120:60:60, 125:120:25, 90:90:75 and 60:120:120 kg NPK ha^{-1} was applied in cotton, chrysanthemum, jasmine and marigold, respectively. Fertilizer was applied in the form of urea, single super phosphate and muriate of potash. All manure

and fertilizers were applied to the crop based on the quantity of (10 kg) soil contained in mud pot (1 ha = $2x10^6$ kg soil). As per the treatment, equal quantity of irrigation water for each pot was added throughout the experiment period.

Germination of cotton

Germination of cotton was recorded by counting the seeds germinated in number of pots at 7 days after sowing (DAS) to total number of pots in each treatment and expressed as percentage in pot culture.

Survival of flower cuttings

The survival of flower crops cuttings were recorded in pots of each treatment at 15 days after planting (DAP) as indicated below and expressed in percentage.

$$\text{Survival of cuttings} = \frac{\text{Number of cuttings survived}}{\text{Total number of cuttings planted}} x\ 100$$

Similarly, plant height, root length and dry matter production were recorded at 120 DAS or DAP by selected five plants at random in each treatment and tagged for taking growth observations. The mean of observations of five plants was arrived and expressed.

Statistical analysis

The data on various characters studied during the course of investigation were statistically analyzed as suggested by Gomez and Gomez (2010). Wherever statistical significance was observed, critical difference (CD) at 0.05 level of probability was worked out for comparison. But regarding germination and survival of crops, germination and survival % was transformed to arc sine transformation and then analysed statistically.

RESULTS

Germination percentage of cotton

There existed significant difference in germination of cotton due to different treatments (Table 1). Irrigation with normal water, 100% DWW and 25% TTE + 75% DWW recorded 100% germination followed by irrigation with 50% TTE + 50% DWW with 87.50%. The least germination percentage (66.67%) was recorded under 100% TTE.

Survival percentage of flower crops

Significant difference was observed in survival of chrysanthemum due to different irrigation treatments and survival percentage varied from 100 to 71 per cent (Table 1). Normal water and 100% domestic wastewater (DWW) irrigation showed 100 per cent survival. Among the mixing ratios of TTE and DWW, 25% TTE with 75% DWW (1:3) recorded higher survival per cent but was comparable with 50% TTE with 50% DWW and 75% TTE with 25% DWW. Use of 100% TTE for irrigation registered the least survival percentage (70.84%).

TABLE 1. Influence of TTE and DWW on germination of cotton and survival of flower crops

Treatments	Germination (%)		Survival (%)	
	Cotton	Chrysanthemum	Jasmine	Marigold
T_1: 25 % TTE + 75% DWW	100.00 (89.72)	95.83 (78.22)	100.00 (89.72)	95.83 (83.76)
T_2: 50 % TTE + 50% DWW	87.50 (69.30)	91.67 (73.23)	95.83 (78.22)	87.50 (75.02)
T_3: 75 % TTE + 25% DWW	83.33 (65.90)	87.50 (69.30)	91.67 (73.23)	66.67 (55.45)
T_4: 100 % TTE	66.67 (54.74)	70.84 (57.32)	79.17 (62.85)	66.67 (55.45)
T_5: 100 % DWW	100.00 (89.72)	100.00 (89.72)	100.00 (89.72)	100.00 (89.72)
T_6: Control (Normal Water)	100.00 (89.72)	100.00 (89.72)	100.00 (89.72)	100.00 (89.72)
SEd	6.00	6.49	7.09	7.81
CD (P=0.05)	12.61	13.63	14.89	16.41

(Figures in parenthesis are arc sine value)

TTE – Treated tannery effluent, DWW – Domestic wastewater

In jasmine, significant survival difference was observed due to different irrigation treatments. The survival percentage varied from 100 to 79 per cent (Table 1). Normal water, 100% DWW and a mixing ratio of 1:3 TTE and DWW (25% TTE +75% DWW) showed 100% survival. Application of 100% TTE registered the least survival percentage.

There existed significant differences in survival of marigold due to different irrigation sources and the survival percentage varied from 100 to 67 per cent (Table 1). Normal water and 100% DWW irrigation recorded 100 per cent survival. Among the mixing proportions, 25% TTE + 75% DWW recorded higher survival percentage of 95.83 compared to other mixing proportions. Irrigation with 100% TTE registered the least survival percentage (66.67%).

Plant height of cotton and flower crops

The plant height is one of the important morphological growth parameter (Table 2). In cotton, irrigation of normal water recorded taller plants of 62.24 cm at 120 DAS. This was comparable with 100% DWW. Among the mixing ratios, 25% TTE with 75% DWW (T_1) recorded taller plants than the other mixing ratios. The least plant height was observed under 100% TTE. In chrysanthemum, domestic wastewater application recorded taller plants of 40.67 cm at 120 DAP. This was comparable with normal water (T_6) irrigation followed by 25% TTE with 75% DWW (T_1). The least plant height was recorded under 100% TTE (T_4). With respect to jasmine, normal water irrigation recorded taller plants of 28.81 cm at 120 DAP. This was comparable with 100% DWW followed by 25% TTE with 75% DWW (T_1). The least plant height was recorded under 100% TTE. Plant height of marigold also showed the similar trend as that of jasmine.

Root length of cotton and flower crops

Irrigation treatments had significant influence on the root length of cotton and flower crops (Table 3). In cotton, normal water applied treatment recorded considerably higher root length (51.33 cm at 120 DAS) compared to other treatments at all the stages. This was followed by 100% DWW and 25% TTE with 75% DWW. The least root length was noticed under 100% TTE. Application of 100% DWW (T_5) recorded higher root length of 26.25 cm at 120 DAPS in chrysanthemum. Among the mixing

proportions of TTE and DWW, 1:3 ratio (25% TTE with 75% DWW) registered higher root length (20.50 cm). The least root length (10.00 cm at 120 DAP) was registered under 100% TTE (T_4). Similarly, irrigation treatments had significant influence on the root length of jasmine and marigold at the stage of observation. In jasmine and marigold, normal water application recorded higher root length of 27.00 cm and 18.50 cm at 120 DAP, respectively. This was followed by 100% DWW and mixing ratio of 1:3 TTE and DWW (25% TTE with 75% DWW). The least root length was registered under 100% TTE.

TABLE 2. Influence of TTE and DWW on plant height of cotton and flower crops

Treatments	Plant height 120 DAS (cm)	Plant height 120 DAP (cm)		
	Cotton	Chrysanthemum	Jasmine	Marigold
T_1: 25 % TTE + 75% DWW	52.44	32.90	26.60	86.27
T_2: 50 % TTE + 50% DWW	48.61	28.93	24.60	66.83
T_3: 75 % TTE + 25% DWW	48.11	27.70	23.77	64.33
T_4: 100 % TTE	44.55	19.57	21.00	59.23
T_5: 100 % DWW	54.92	40.67	28.20	100.13
T_6: Control (Normal Water)	62.24	38.80	28.81	99.37
SEd	2.55	1.29	1.45	4.70
CD (P=0.05)	5.35	2.72	3.06	9.87

TTE – Treated tannery effluent, DWW – Domestic wastewater, DAS – days after sowing, DAP – days after planting

TABLE 3. Influence of TTE and DWW on root length of cotton and flower crops

Treatments	Root length 120 DAS (cm)	Root length 120 DAP (cm)		
	Cotton	Chrysanthemum	Jasmine	Marigold
T_1: 25 % TTE + 75% DWW	42.85	20.50	24.00	15.70
T_2: 50 % TTE + 50% DWW	41.68	14.50	22.85	13.60
T_3: 75 % TTE + 25% DWW	41.23	13.60	19.60	11.50
T_4: 100 % TTE	36.70	10.00	17.80	9.85
T_5: 100 % DWW	47.91	26.25	24.73	17.75
T_6: Control (Normal Water)	51.33	25.55	27.00	18.50
SEd	2.18	0.78	0.96	0.85
CD (P=0.05)	4.58	1.65	2.01	1.79

TTE – Treated tannery effluent, DWW – Domestic wastewater, DAS – days after sowing, DAP – days after planting

Dry matter production of cotton and flower crops

Dry matter production (DMP) has direct relationship with crop productivity (Table 4). Irrigation with normal water recorded higher dry matter production of 74.89 g plant^{-1} at 120 DAS in cotton. This was followed by 100% DWW and 25% TTE + 75% DWW. The least dry matter production was recorded under 100% TTE. Irrigation with 100% DWW (T_5) recorded higher dry matter production in chrysanthemum at 120 DAP (27.00 g plant^{-1}). This was comparable with normal water (T_6) followed by irrigation with 25% TTE + 75% DWW. The least dry matter production was registered under 100% TTE (T_4). Higher DMP was observed under irrigation with normal water in jasmine and marigold with the value of 23.00 and 76.26 g plant^{-1} at 120 DAP, respectively. Among the mixing proportions, irrigation with 25% TTE + 75% DWW recorded higher dry matter production (19.60 and 72.16 g plant^{-1} at 120 DAP in jasmine and marigold). The least dry matter production was recorded under 100% TTE.

TABLE 4. Influence of TTE and DWW on dry matter production of cotton and flower crops

Treatments	DMP 120 DAS (g plant^{-1})	DMP 120 DAP (g plant^{-1})		
	Cotton	Chrysanthemum	Jasmine	Marigold
T_1: 25 % TTE + 75% DWW	62.64	24.50	19.60	72.16
T_2: 50 % TTE + 50% DWW	56.77	23.70	18.40	64.66
T_3: 75 % TTE + 25% DWW	51.70	22.60	18.03	61.87
T_4: 100 % TTE	44.36	22.03	15.78	56.53
T_5: 100 % DWW	71.62	27.00	20.40	76.26
T_6: Control (Normal Water)	74.89	25.75	23.00	78.18
SEd	2.58	0.93	1.00	2.46
CD (P=0.05)	5.42	1.95	2.10	5.18

TTE – Treated tannery effluent, DWW – Domestic wastewater, DAS – days after sowing, DAP – days after planting

DISCUSSION

The germination and growth parameters of cotton and flower crops were significantly influenced by different irrigation treatments.

Cotton germination and flower crops survival

In all the crops (cotton, chrysanthemum, jasmine and marigold) better germination or survival percentage was observed under normal water, 100% DWW and combination of TTE along with DWW at lower concentrations (25% TTE + 75% DWW and 50% TTE + 50% DWW). This might be due to lower concentration of chemicals in irrigation sources as reported by Mahmood *et al*. (2005). The lower germination or survival observed under 100% TTE was due to higher concentration of salts

which results in poor break down of starch by amylase activity as reported by Thevenot *et al.* (1992). Hence, the lower concentration of effluents showed favourable effect on germination. This result is in line with the findings of Karunayal *et al*. (1994) in cotton and Sumithabharathi (2011) in cockscomb.

Growth of cotton and flower crops

Plant height

Regarding plant height, application of normal water recorded taller plants which were comparable with 100% domestic wastewater. The presence of macro and micro nutrients and the resultant higher uptake might be the reason for better growth under 100% DWW. This is in accordance with the earlier findings of Singh *et al.* (1999) in *vicia faba*. Among the mixing proportions, the plants were taller under 25% TTE + 75% DWW while, plants were shorter under 100% TTE. The reduction of growth under higher concentration of TTE might be due to the stress caused by higher amount of salts present in the tannery effluent resulting in lesser uptake of nutrients.

Root length

With reference to root length, higher root length was recorded under normal water, 100% DWW followed by higher dilution of TTE with DWW (25:75) compared to lower dilutions (50:50, 75:25 and 100 %). The presence of high amount of salts in tannery effluent might have restricted the root growth by increased soil osmotic pressure. Similar finding has been reported by Kumarvelu *et al.* (2000).

Dry matter production

With respect to dry matter production of crops, higher DMP was observed under normal water which was comparable with 100% DWW. The higher availability and uptake of nitrogen results in an increased enzyme protein and improved the photosynthetic rate and carbohydrate translocation which in turn play a major role in increasing the dry matter production as reported by Borale *et al.* (2002) in finger millet. The least dry matter production was obtained under 100% TTE which might be due to low photosynthesis and chlorophyll and change in structure of chloroplast by excess heavy metal in effluent. This is in conformity with the earlier findings of Sumathi (2003) in *Typha angustifolia.*

CONCLUSIONS

In all the crops, germination, survival and growth characters were higher under normal water irrigation, which was either comparable or followed by 100% DWW. But considering our aim of effective utilization of wastewater for irrigation, application 1:3 ratio of TTE and DWW (*i.e*.) 25% TTE + 75% DWW had performed better and could be used for crop cultivation compared to other mixing ratios of TTE and DWW.

Among the crops tested, cotton and marigold are relatively better suitable for the irrigation with TTE and DWW because those crops showed better crop growth compared to jasmine and chrysanthemum even though all crops recorded better germination and survival.

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