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Effect of Treated Tannery Effluent with Domestic Wastewater and Amendments on Growth and Yield of Cotton

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Abstract: Pot culture and field experiments were carried out at the Common Effluent Treatment Plant (CETP), Dindigul during *kharif* 2011-12 to investigate the influence of irrigation of treated tannery effluent along with domestic wastewater on growth, yield attributes and yield of cotton. The pot culture was in a factorial completely randomized design and field experiment laid out in factorial randomized block design with four replications. The results revealed that the mixing proportion of 25% Treated Tannery Effluent (TTE)+75% domestic wastewater (DWW) application recorded taller plants, higher dry matter production, number of sympodial branches plant^{-1}, number of fruiting points plant^{-1}, number of bolls plant^{-1} and seed cotton yield with yield reduction of 15.28 and 16.11% compared to normal water irrigation under pot culture and field experiment, respectively. Regarding amendments, gypsum application registered higher seed cotton yield followed by VAM.

Key words: Cotton, treated tannery effluent, domestic wastewater, gypsum, VAM

INTRODUCTION

In India, leather industry contributes 15% of the worlds' total leather production (Alam *et al*., 2009) and it is the fourth largest foreign exchange earner with a share of around 7% in the country's total exports. It also provides employment opportunity to about 3 million people of economically weaker populations and thus leather industry occupies an important role in Indian economy. On the other hand, tannery wastes are ranked as the highest pollutants among all the industrial wastes (Soyalsan and Karaguzel, 2007).

Major tannery clusters of India are in Tamil Nadu, West Bengal, Uttar Pradesh and Punjab. Nearly 90% of the tanning capacity is concentrated in these four states only. In Tamil Nadu, 53% of the total Indian tanneries are functioning and contributing more than 50% of the export of finished leather and leather goods from India (Amarnath and Krishnamoorthy, 2001). Within Tamil Nadu State, tanneries are mainly concentrated in the districts of Vellore, Trichy, Dindigul and Erode. Dindigul district in Tamil Nadu, where the present study was taken up is known for its vegetable tanning leather industries. During leather making, tanning operations carried out using either vegetable tan barks or basic chrome salts. The major pollutant in vegetable tanning effluent is high Total Dissolved Solids (TDS) that means enriched with salts of Cl and SO_4 but in case of chrome tanning effluent chromium is major pollutant. Apart from industrialization, rapid growth of urban population also has resulted in generation of huge quantities of wastewater regularly. About 26, 254 million litres of wastewater per day is generated in the main towns of India. But municipal wastewater treatment capacity developed so far in India is about 7044 million litres per day accounting 27% of wastewater generation in these urban centres (Kumar, 2009).

Indian economy is agriculture based. Hence, more than 70% of water is being utilized for irrigation. Though agriculture sector in our country has been the major user of water, share of water allocated to irrigation is likely to be decreased by 10-15% in next two decades (Rattan *et al*., 2005). In this changing scenario, effective management techniques are required for a better utilization of the limited natural resources like water. Reuse of marginal quality water like effluent and domestic wastewater in agriculture for irrigating crop land appears to be a lucrative option (Bhise *et al*., 2007) where good quality water availability is limited. Hence, the present investigation was carried out to achieve specific irrigation option for non-edible crops by using treated tannery effluent along with domestic wastewater and amendments.

MATERIALS AND METHODS

Pot culture and field experiments were carried out during *kharif* 2011-12 at the Common Effluent Treatment Plant (CETP), Dindigul to study the effect of treated

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tannery effluent along with domestic wastewater on growth, yield attributes and yield of cotton. The soil of the pot culture and field was red sandy loam and red sandy clay loam in texture, respectively. The experimental soils were low in available nitrogen, medium in available phosphorus and high in available potash. The pot culture was laid out in a factorial completely randomized design and field experiment laid out in factorial randomized block design with four replications. Treatment comprises 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) treatments under factor A and three amendments viz., A_0-control (without amendment), A_1-gypsum and A_2-VAM as treatments under factor B.

The well decomposed FYM at the rate of 12.5 tonnes ha^{-1} was applied at the time of land preparation. The recommended dose of 120:60:60 kg of NPK ha^{-1} was applied in the form of urea, single super phosphate and muriate of potash, respectively. Half the dose (50%) of N and K and full dose of P were applied as basal dose as band placement 5 cm away and 5 cm below the seed row. The remaining 50% of N and K were applied in two equal splits at the time of square initiation (45 DAS) combined with earthing up and boll formation stage (65 DAS).

In pot culture, all the manures and fertilizers were applied to the crop based on the quantity of (10 kg) soil contained in mud pot (1 ha = 2×10^6 kg soil). VAM inoculum (*Glomus intraradices*) at the rate of 5g $plant^{-1}$ was at the time of planting. Gypsum was finely powdered and uniformly applied to all the treatments as basal at the rate of 20 g pot^{-1}. As per the treatment, equal quantity of irrigation water for each pot was added throughout the experiment period. In field experiment, cotton was cultivated with a spacing of 90×60 cm. VAM was applied at the rate of 100 kg ha^{-1} and gypsum applied as basal at the rate of 4 t ha^{-1} as general recommendation. As per the treatment, equal quantity of irrigation water was given for each plot throughout the experiment period with the help of scale marked water tanks. Hybrid Bunny Bt was used as test hybrid for cultivation.

RESULTS AND DISCUSSION

Growth parameters: The plant height was recorded at different stages of crop from 40 DAS to harvest which showed an increasing trend with advancement in the age of the crop (Table 1). Significant difference in plant height was observed with both irrigation treatments and amendments.

In both pot culture and field experiment, the taller plants were observed under normal water followed by 100% DWW due to better uptake and utilization of nutrients (Kumar and Reddy, 2007). The least plant height was recorded under 100% TTE. The plant height increased with increased dilution of tannery effluent and higher dilution of 1:3 ratio of TTE and DWW registered taller plants among the other mixing ratios. Presence of sodium and chloride in the effluent led to increased osmotic pressure of water and plant growth suffered due to water stress. This was in conformity with the earlier findings of Nath *et al*. (2008) in cowpea.

The DMP was higher with application of normal water while irrigation with 25% TTE+75% DWW recorded higher DMP among all the mixing ratios of TTE and DWW (Table 2). The dilution of effluent with DWW might have reduced the salt concentration in the soil and increased the uptake of nutrients and the resultant better growth has lead to higher DMP. Similar findings have been reported by Sharma and Mehrotra (1993) in *Triticum aestivum*.

Table 1: Effect of TTE, DWW and amendments on plant height (cm) of cotton

	Pot culture 2011-12				Field experiment 2011-12			
Treatment	40 DAS	80 DAS	120 DAS	At harvest	40 DAS	80 DAS	120 DAS	At harvest
Irrigation water								
I_1: 25% TTE+75% DWW	17.65	52.27	58.20	63.12	21.53	56.37	69.02	73.67
I_2: 50% TTE+50% DWW	17.29	46.29	54.10	58.68	19.80	51.29	63.89	67.94
I_3: 75% TTE+25% DWW	16.48	42.87	50.50	55.26	17.23	48.21	60.39	64.09
I_4: 100% TTE	12.65	41.53	48.63	52.85	16.28	45.56	58.13	61.06
I_5: 100% DWW	18.68	53.60	60.44	64.76	21.70	58.94	72.20	77.98
I_6: Control (Normal Water)	19.58	59.96	66.67	72.05	22.43	62.13	74.76	80.59
SEd	0.20	0.62	0.75	0.59	1.01	2.35	2.66	2.71
CD (p = 0.05)	0.41	1.24	1.51	1.19	2.15	5.00	5.67	5.77
Amendments								
A_0: Control	17.23	46.71	53.46	55.58	17.19	49.71	61.9	66.16
A_1: Gypsum	17.76	52.03	59.11	65.21	21.92	57.11	71.1	75.42
A_2: VAM	16.18	49.52	56.70	62.56	20.34	54.43	66.2	70.61
SEd	0.14	0.44	0.53	0.42	0.82	1.67	1.88	1.92
CD (p = 0.05)	0.29	0.87	1.07	0.84	1.74	3.54	4.00	4.08

TTE: Treated tannery effluent, DWW: Domestic wastewater

Table 2: Effect of TTE, DWW and amendments on dry matter production of cotton

Treatment	Pot culture 2011-12				Field experiment 2011-12			
	40 DAS	80 DAS	120 DAS	At harvest	40 DAS	80 DAS	120 DAS	At harvest
	g plant^{-1}				kg ha^{-1}			
Irrigation water								
I_1: 25% TTE+75% DWW	8.18	42.24	65.38	94.5	288	1276	1927	2318
I_2: 50% TTE+50% DWW	7.84	39.09	59.39	81.0	275	1040	1683	1994
I_3: 75% TTE+25% DWW	7.31	35.97	54.07	74.9	265	991	1508	1798
I_4: 100% TTE	6.81	32.55	46.62	66.5	259	905	1371	1593
I_5: 100% DWW	8.89	46.17	72.23	100.5	307	1352	2019	2436
I_6: Control (normal water)	9.02	48.34	79.14	109.4	344	1642	2403	2812
SEd	0.14	0.37	0.68	0.8	12	73	124	119
CD (p = 0.05)	0.28	0.75	1.36	1.5	26	155	264	253
Amendments								
A_0: Control	7.92	38.37	58.49	84.7	275	1131	1693	1984
A_1: Gypsum	8.21	43.52	68.12	91.4	307	1284	1973	2347
A_2: VAM	7.89	40.28	61.80	87.3	286	1188	1789	2145
SEd	0.10	0.26	0.48	0.5	9	51	88	84
CD (p = 0.05)	0.20	0.53	0.96	1.1	18	110	187	179

TTE: Treated tannery effluent, DWW: Domestic wastewater

Table 3: Effect of TTE, DWW and amendments on yield attributes of cotton

Treatment	Pot culture 2011-12			Field experiment 2011-12		
	No. of sympodial branch plant^{-1}	No. of fruiting points plant^{-1}	No. of bolls plant^{-1}	No. of sympodial branch plant^{-1}	No. of fruiting points plant^{-1}	No. of bolls plant^{-1}
Irrigation water						
I_1: 25% TTE+75% DWW	8.59	20.75	11.30	10.02	19.40	10.92
I_2: 50% TTE+50% DWW	7.45	19.22	10.39	9.50	17.51	9.60
I_3: 75% TTE+25% DWW	6.90	18.80	10.08	8.80	16.30	8.68
I_4: 100% TTE	6.35	18.38	9.69	8.23	15.43	7.80
I_5: 100% DWW	9.20	21.03	11.57	10.50	19.55	11.10
I_6: Control	10.28	22.53	13.03	11.05	20.90	12.23
SEd	0.09	0.22	0.13	0.45	1.15	0.58
CD (p = 0.05)	0.18	0.44	0.27	0.91	2.30	1.24
Amendments						
A_0: Control	7.81	19.67	10.54	9.32	17.18	9.41
A_1: Gypsum	8.48	20.52	11.42	10.10	19.12	10.68
A_2: VAM	8.09	20.18	11.06	9.55	18.24	10.08
SEd	0.06	0.16	0.90	0.30	0.80	0.41
CD (p = 0.05)	0.12	0.31	0.19	0.61	1.60	0.88

TTE: Treated tannery effluent, DWW: Domestic wastewater

Regarding amendments, gypsum registered higher DMP than VAM and control at all the stages. Gypsum might have helped for replacement of Na^+ with $Ca^+$and there by reduced the ESP and facilitated higher uptake of nutrients. Qadir *et al.* (1996) also reported higher biomass production in finger millet under saline-sodic condition due to gypsum application.

Yield attributes of cotton: The yield parameters of cotton *viz.*, number of sympodial branches plant^{-1}, number of fruiting point's plant^{-1} and number of bolls plant^{-1} were higher with normal water irrigation (Table 3). The better yield attributes might be due to better source and sink relation as reported by Brar *et al.* (1994) in cotton.

With respect to different mixing ratios, application of 25% TTE+75% DWW recorded better yield attributes compared to other mixing ratios. However, a reduction trend in yield attributes was observed with increasing concentration of tannery effluent. This might be due to increased level of salts like chlorides and sulphates which might have inhibited the crop growth and development which has reflected in yield attributes. This result corroborates the findings of Nath (2009) who reported similar finding in Maize.

The yield parameters were higher under application of gypsum. This was due to the efficiency of gypsum on reduction of sodium content in soil and the resultant better uptake of nutrients and growth of crops as reported by Rashid *et al.* (2009) in wheat.

Yield of cotton: Significant difference in seed cotton yield was observed due to different irrigation treatments and amendments in both the pot culture and field experiments.

Among the irrigation treatments, higher seed cotton yield (56.35 g plant^{-1} and 1167 kg ha^{-1} under pot culture and field experiment, respectively) was obtained under

Table 4: Influence of TTE, DWW and amendments on seed cotton yield

	Pot culture 2011-12				Field experiment 2011-12			
	Amendments (g plant^{-1})				Amendments (kg ha^{-1})			
Irrigation	A_0	A_1	A_2	Mean	A_0	A_1	A_2	Mean
I_1: 25% TTE+75% DWW	43.08	51.78	48.36	47.74	920	1040	977	979
I_2: 50% TTE+50% DWW	35.24	41.69	37.23	38.05	694	754	734	727
I_3: 75% TTE+25% DWW	32.56	35.83	33.39	33.93	616	741	641	666
I_4: 100% TTE	27.95	32.63	30.22	30.27	568	678	590	612
I_5: 100% DWW	45.36	54.15	49.10	49.54	981	1072	1037	1030
I_6: Control (normal water)	49.90	61.18	57.98	56.35	1114	1215	1172	1167
Mean	39.01	46.21	42.71		816	917	859	
	Sed		CD (p = 0.05)		Sed		CD (p = 0.05)	
I	0.60		1.20		44		95	
A	0.42		0.85		32		67	
I×A	1.03		2.07		77		163	

TTE: Treated tannery effluent, DWW: Domestic wastewater, A_0: Without amendment (control), A_1: Gypsum, A_2: VAM

normal water irrigation. This was followed by 100% domestic wastewater due to better performance of various growth and yield components which in turn increased the seed cotton yield in cotton.

Regarding combination of TTE and DWW, irrigation with 25% TTE+75% DWW (1:3) recorded higher yield compared to other mixing proportions (2:2 and 3:1). The least seed cotton yield was obtained under 100% TTE (Table 4).

With respect to amendments, gypsum application registered higher seed cotton yield (46.21 g plant^{-1}) followed by VAM. Among the mixing ratios and amendments, irrigation of 25% TTE+75% DWW (I_1A_1) with gypsum recorded higher seed cotton yield (51.78 g plant^{-1} and 1040 kg ha^{-1} under pot culture and field experiment, respectively) than other combinations involving mixing of TTE and DWW.

The yield reduction was 16.11 and 47.56% with mixing ratio of 25% TTE+75% DWW and 100% TTE, respectively compared to normal water under field experiment. Likewise the yield reduction in pot culture was less than 20% and 50% in the respective treatments. This yield reduction might be due to lesser uptake of nutrients as the amount of recovery elements already present in effluent was in binding form with the other elements in the effluent or in non ionic form which is not easily available for absorption by plant roots as reported by Pandey and Sharma (2003). Regarding amendments, gypsum addition registered higher yield compared to VAM and control. Gypsum reduced the electrical conductivity and exchangeable sodium percentage in soil which resulted in enhanced growth and yield. This result is in agreement with the findings of Palanisamy (1998) in finger millet.

CONCLUSION

The mixing ratio of 1:3 (25% TTE+75% DWW) could be recommended for irrigation enabling the effective utilization of both effluent and wastewater for production of cotton and addition of gypsum further improved the efficiency of the treatments.

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