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Influence of treated tannery effluent along with domestic wastewater on yield attributes, yield and nutrient uptake of cotton

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ABSTRACT

Field experiment was conducted at the common effluent treatment plant (CETP), Dindigul, Tamil Nadu during winter 2013 to investigate the influence of treated tannery effluent along with domestic wastewater on yield attributes, yield and nutrient uptake of cotton. The experiment was laid out in a randomized block design replicated thrice. Treatments comprised six levels of irrigation sources viz 25 per cent treated tannery effluent (TTE) + 75 per cent domestic wastewater (DWW), 50 per cent TTE + 50 per cent DWW, 75 per cent TTE + 25 per cent DWW, 100 per cent TTE, 100 per cent DWW and control (normal water) under factor A and three amendments viz control (without amendment), gypsum and arbuscular mycorrhiza (AM) under factor B. The results revealed that the mixing proportion of 1:3 ie application of 25 per cent TTE + 75 per cent DWW significantly increased the yield parameters (number of sympodial branches, number of fruiting points and number of bolls per plant), nutrient uptake (nitrogen, phosphorus and potassium) and yield of cotton. Regarding amendments, gypsum application registered higher seed cotton yield and nutrient uptake followed by AM.

Keywords: Cotton; treated tannery effluent; domestic waste water; gypsum; arbuscular mycorrhiza

INTRODUCTION

Tanneries play an important role in Indian exports and provide employment opportunity to about 3 million people of economically weaker populations. During the process of leather making several chemicals like NaCl, $Ca(OH)_2$, H_2SO_4 etc are extensively used. Therefore the resultant effluent is enriched with salts (Cl and SO_4). Disposal of chemicals-rich tannery effluent results in degradation of productive agriculture land, surface and groundwater. To reduce the degradation the general approach adopted in India for treatment of tannery wastewater from such units has been the commissioning of common effluent treatment plants (CETPs) for tannery clusters.

The increasing scarcity of water in the world along with rapid population increase in urban areas gives reason for concern and the need for appropriate water management practices. Out of about 38,000 million liter per day of sewage generated treatment capacity exists for only about 12,000 million liter per day (Anon 2009). However due to the trends in urban development, wastewater treatment deserves greater emphasis. Per day availability of domestic wastewater in Dindigul area is ten times more than that of tannery effluents.

Treated wastewater is now being considered as a new source of water that can be used for different purposes such as agricultural and aquaculture production, industrial uses, recreational purposes and artificial recharge. Using wastewater for agriculture production can help in alleviating food shortages through reduction of gap between supply and demand and also economical support to the farmers. But tannery wastewater contains valuable plant nutrients and also contaminants that might affect soil health and crop production. The salts in the tannery effluent are diluted when this is mixed with domestic wastewater for irrigation.

In India leather industry contributes 15 per cent of the world's total leather production (Alam et al 2009) and is the fourth largest foreign exchange earner with a share of around 7 per cent in the country's total exports. It also provides employment opportunity to about 3 million people of economically weaker population 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 (Soyaslan and Karaguzel 2007).

In Tamil Nadu 53 per cent of the total Indian tanneries are functioning and contributing more than 50 per cent of the export of finished leather and leather goods from India (Amarnath and Krishnamoorthy 2001). Within Tamil Nadu 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 operation is carried out using vegetable tan barks.

Cotton (*Gossypium* spp) is one of the most important fibre crops. Cotton crop not only provides fibre for the textile industry but also plays role in feed and oil nutrients with its seed rich in oil (18- 24%) and protein (20-40%). Among the natural fibres, cotton fibre is the only fibre that can be spun into yarn because of presence of convolution in it. World's cotton demand has increased steadily since the 1950s at an average annual growth rate of 2 per cent. In terms of global production cotton is the foremost fibre crop. Present world production is some 25.5 MT of seed cotton from 34.8 Mha. China, USA and India are the world's major cotton producing countries accounting for nearly 60 per cent of the world production (https://www.netafim.co.za/ offering/irrigation/agriculture/ field/cotton/?id=77).

Municipal wastewater is generally alkaline in nature along with very high EC, BOD, COD, SAR, RSC and TSS. The mineral concentrations were also found above threshold limits for the usage of irrigation purpose and could produce more negative effects on the crop productivity (Kakar et al 2010). Heavy metal content of wastewater collected from Rajasthan showed that average level of Zn, Cu and Ni (3.78, 0.015 and 0.006 mg/l respectively) was within the permissible limit. Chromium content was below the detectable limit and the concentration of Fe, Cd and Pb (1.004, 0.042 and 0.239 mg/l respectively) was found above the prescribed limit (Dutta and Meena 2010).

Niazi et al (2003) conducted a trial by addition of gypsum @ 0, 500 and 1000 kg/ha with two levels of fertilizers viz recommended dose (120:90:60 kg/ha) and half dose (60:45:30 kg/ha) of NPK in maize crop under normal soil and water condition. The results revealed that maximum grain (3,605 kg/ha) and stalk (9,922 kg/ha) yield was recorded with application of recommended dose of NPK with 1,000 kg gypsum/ha. Hence with the above points in view the present investigations were carried out to find out the influence of treated tannery effluent along with domestic wastewater on yield attributes, yield and nutrient uptake of cotton.

MATERIAL and METHODS

Field experiment was conducted during rainy season 2013 at the common effluent treatment plant (CETP), Dindigul, Tamil Nadu to study the effect of treated tannery effluent (TTE) along with domestic wastewater (DWW) on yield attributes, yield and nutrient uptake of cotton. The geographical location of the experiment site is 11°N latitude and 77°E longitude with an altitude of 426.7 m amsl. The soil of the experimental site was well-drained and clay loam in texture (27.3% clay, 23.5% silt, 26.7% fine and 22.4% course) with low in available nitrogen, medium in available phosphorus and high in available potassium. The soil had 207, 12.6 and 282 kg/ha of $KMno_4$-N, Olsen P and NH_4OAc-K respectively with EC of 0.57 ds/m, pH of 7.34 and organic carbon of 0.43 per cent. The soil of the field was red sandy loam in texture.

Field experiment was laid out in randomized block design replicated thrice. Treatments comprised six levels of irrigation sources viz 25 per cent TTE + 75 per cent DWW, 50 per cent TTE + 50 per cent DWW, 75 per cent TTE + 25 per cent DWW, 100 per cent TTE, 100 per cent DWW and control (normal water) under factor A and three amendments viz control (without amendment), gypsum and arbuscular mycorrhiza (AM) under factor B. The recommended dose of 120:60:60 kg of NPK/ha was applied to all plots. Cotton hybrid Bt Bunny was used as test hybrid for cultivation. Cotton was cultivated with a spacing of 90 x 60 cm. AM was applied at the rate of 100 kg/ha and gypsum as basal at the rate of 4 tonnes/ha. 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. Yield components were recorded and nutrient uptake (nitrogen, phosphorus and potash) was estimated.

RESULTS and DISCUSSION

Yield attributes

Application of normal water recorded higher number of sympodial branches/plant (11.6), number of bolls/plant (15.3) and cotton wool weight (4.12 g/boll) (Table 1). This was followed by the treatment 100 per cent DWW and 25 per cent TTE with 75 per cent DWW. The least yield parameters were recorded under 100 per cent treated tannery effluent. Better yield attributes due to application of normal water 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 per cent TTE + 75 per cent 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 as reflected in yield attributes. Similar findings in maize were reported by Nath (2009).

Yield

Higher seed cotton yield (1,053 kg/ha) was obtained under normal water irrigation followed by 100 per cent DWW (1,003 kg/ha) (Table 2). Under combined use 25 per cent treated tannery effluent with 75 per cent DWW recorded highest yield (975 kg/ha) and the least seed cotton yield (590 kg/ha) was obtained under 100 per cent treated tannery effluent. The seed cotton yield was higher under application of normal water due to better performance of various growth and yield components which in turn might have increased the seed cotton yield as reported by Kalibavi (2006). Regarding amendments application of gypsum registered higher yield than AM and control. Makhdum et al (2001) also reported that gypsum application promoted plant growth through an adequate supply of sulphur and other nutrients imperative for cotton growth and yield.

Nutrient uptake (NPK)

Irrigation of normal water recorded higher NPK uptake (Table 3). This was followed by 100 per cent DWW and 25 per cent TTE + 75 per cent DWW. The least nitrogen uptake was observed under 100 per cent TTE. With respect to amendments gypsum addition recorded higher NPK uptake compared to AM and control.

This might be due to salinity induced nutritional disorders by competitive uptake, transport or partitioning within the plant like higher reducing K uptake and Cl reducing NO_3 uptake as reported by Grattan and Grieve (1999). Even accumulation of calcium ions at root surfaces might precipitate phosphate and thereby hinder uptake of not only phosphate but also

Table 1. Effect of treated tannery effluent (TTE) and domestic wastewater (DWW) on yield parameters and yield of cotton

Treatment	Number of sympodial branches/plant	Number of bolls/plant	Kapas weight (g/boll)	Seed cotton yield (kg/ha)
TTE/DWW				
T_1 (25% TTE + 75% DWW)	11.1	13.4	3.32	975
T_2 (50% TTE + 50% DWW)	10.0	10.2	3.14	706
T_3 (75% TTE + 25% DWW)	9.6	10.0	2.82	644
T_4 (100% TTE)	9.3	8.2	2.63	590
T_5 (100% DWW)	11.3	14.2	3.65	1003
T_6 (Control: normal water)	11.6	15.3	4.12	1053
SEd	0.1	0.2	0.04	34
$CD_{0.05}$	0.2	0.3	0.10	71
Amendments				
A_0 (Control)	10.3	11.4	3.02	747
A_1 (Gypsum)	10.5	12.3	3.43	946
A_2 (AM)	10.6	11.9	3.44	792
SEd	0.1	0.1	0.02	26
$CD_{0.05}$	0.2	0.3	0.04	55

AM: Arbuscular mycorrhiza

Table 2. Effect of treated tannery effluent (TTE) and domestic wastewater (DWW) on the yield of cotton

Treatment	Amendments			
	A_0	A_1	A_2	Mean
T_1 (25% TTE + 75% DWW)	851	1127	946	975
T_2 (50% TTE + 50% DWW)	621	802	694	706
T_3 (75% TTE + 25% DWW)	563	782	588	644
T_4 (100% TTE)	513	727	530	590
T_5 (100% DWW)	913	1,108	987	1,003
T_6 (Control: normal water)	1,020	1,132	1,008	1,053
Mean	747	946	792	-

A_0: Control (without amendment), A_1: Gypsum, A_2: Arbuscular mycorrhiza (AM)

	SEd	CD
T	34	71
A	26	55
T x A	60	126

Table 3. Effect of treated tannery effluent (TTE) and domestic wastewater (DWW) on nutrient uptake of cotton

Treatment	Nutrient uptake (kg/ha)		
	N	P	K
Irrigation water			
T_1 (25% TTE + 75% DWW)	46.08	10.49	40.88
T_2 (50% TTE + 50% DWW)	31.76	7.66	29.97
T_3 (75% TTE + 25% DWW)	25.51	7.27	24.36
T_4 (100% TTE)	24.07	6.18	19.82
T_5 (100% DWW)	47.87	13.46	43.65
T_6 (Control: normal water)	59.0	17.48	51.88
SEd	2.56	0.61	1.80
$CD_{0.05}$	5.32	1.30	3.92
Amendments			
A_0 (Control)	37.15	8.97	33.64
A_1 (Gypsum)	40.72	11.41	36.03
A_2 (Arbuscular mycorrhiza)	39.21	10.88	35.59
SEd	1.63	0.43	1.38
$CD_{0.05}$	3.80	0.89	2.80

calcium for a short time. This is in conformity with earlier findings of Savvas and Lenz (1994) in brinjal and Perez-Alfocea et al (1996) in tomato.

Among the amendments application of gypsum recorded higher nutrient uptake which was comparable with AM. Addition of gypsum reduced the sodicity which might have helped for better uptake of water and nutrients. Regarding AM, application of AM might have enhanced permeability of root cells resulting in increased water and nutrient uptake. Similar findings were also reported by Artursson et al (2006) which support the present results.

CONCLUSION

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

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