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Ecofriendly utilization of Treated Distillery Effluent (TDE) And Inorganic Fertilizers Management on Microbial Population and Enzymatic Activities

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Abstract- Treated distillery effluent (TDE) generated through biomethanated distillery effluent was applied to arable land for augmenting agricultural production. The TDE contains considerable amount of organic matter and salt besides its high plant nutrients content. With this background, an attempt was made. Field experiments were conducted to study the long term effect of TDE and inorganic fertilizers on soil properties and yield of sugarcane in sandy loam soil during 2010-2011 and 2011-2012. The main plot treatments *viz.,* TDE was applied at the rate of 1.25, 2.5, 3.75 and 5.0 lakh litres ha^{-1} for treatments were compared with control and the sub-plots *viz.,* N, NP, NK, PK, NPK for fertilizer treatments were compared with control (no fertilizer). The results revealed that the application of TDE @ 5.0 lakh liters per ha had significantly increased the microbial population and enzymatic activities and this will indirectly improve the chemical and physical properties.

Index Terms- TDE, Inorganic fertilizers, microbial and enzymatic activities and sugarcane yield

I. INTRODUCTION

Agriculture is the backbone of India. It occupies second position in the sugarcane production in the world. In Tamil Nadu, there are 35 sugar factories and distilleries with a total installed capacity of 2.4 lakh kiloliters of alcohol. Distillery effluent, a liquid waste from the distillery industry is of plant origin contains large quantities of soluble organic matter and plant nutrients. In the distillery industry, for every litre of alcohol produced, about 15 litres of spentwash is released as waste water. So there is a possibility of getting 48 billion litres of spentwash (Distillery spentwash) from distillery industries in India. The sugarcane crop irrigated with Treated distillery effluent (TDE) did not contain any toxic elements/compounds. The estimated potential of 48 billion liters of spentwash will be 1,44,000 tonnes of K, 12,200 tonnes of N and 2000 tonnes of P per annum. The proper use of TDE application could produce 85,000 tonnes of biomass annually. Different doses of TDE have been tried in combination with different fertilizers in agricultural fields by Joshi et al. (1996) and they had recommended post sown irrigation with 50% NPK treatment for better performance in sugarcane. Under sugarcane cultivation, the soils are getting depleted of nutrients. So, replenishment of soil nutrients and maintenance of soil health by organic source are required. The TDE can play a prime role in bridging the wide gap of depletion and repletion of nutrients. The present study was carried out in sandy loam soil to assess the nutrient supplying potential of TDE to sugarcane crop with different combination of fertilizers. The effect of such application on the cane yield and physico-chemical properties were also assessed.

II. MATERIALS AND METHODS

The field experiment was undertaken up to study the long term effect of TDE and fertilizers on sugarcane yield at cane farm, EID Parry (India) Ltd., Cuddalore district, Tamil Nadu. The TDE was obtained from EID Parry (India) Ltd., Distillery, Nellikuppam and was characterized for its various physico-chemical properties (Table 1). The initial soil (0-15 cm depth) was low in organic carbon (0.37 per cent) and alkaline $KMnO_4$-N (123 kg/ha) and medium in Olsens's P (15.1 kg/ha) and Neutral normal ammonium acetate-K (212 kg/ha), having pH (8.38) and EC of 0.10 dSm^{-1} (Table 1).

Experimental details

The experiments were laid out in split-plot design with graded doses of TDE as main-plots and nutrient combinations as sub-plots with three replications. The main-plot treatments viz., TDE was applied @ 1.25, 2.5, 3.75 and 5 lakh litres per ha for M_2, M_3, M_4, M_5 treatments and were compared with control and the sub-plots *viz.*, N, NP, NK, PK, NPK for S_2,S_3,S_4,S_5,S_6 fertilizer treatments and were compared with control (no fertilizer). The TDE was applied as pre-planting dose in the fallow land as per the treatments and allowed for natural oxidation. The natural oxidation was to narrow down the BOD and COD of the TDE. The soil was then thoroughly mixed and sugarcane planting (Variety CO 86032) was taken up after 45 days of TDE application. The N, P and K fertilizers were applied at 75 per cent of the recommended doses *viz.*, 206, 45 and 84 kg of N, P_2O_5 and K_2O per ha.

Cane yield and collection of soil samples

The crop was managed by adopting standard package of practices. Cane yield data were recorded at the age of 12 months from the plots and were converted to yield ha^{-1}. The initial and post harvest soil samples were collected from 10 spots at random from each experimental plot (0-30 cm depth) and a composite sample of each plot was used for estimation of soil physico-chemical properties by standard procedures. The data were statistically scrutinized (Gomez and Gomez, 1984).

III. RESULTS AND DISCUSSIONS

Biological properties

Bacteria (Table 3)

The bacterial population was changed due to different levels of TDE and fertilizers. It ranged from 53.33 to 74.17 x 10^{-6} CFU g^{-1} of post harvest soil. The highest population was recorded due to application of 5.0 lakh litres ha^{-1} (M_5) and control (M_1) recorded the lowest. Among the subplot treatments, the NPK (S_6) found to be higher than rest of the treatments and this was followed by PK (S_5), NK (S_4), NP (S_3) and control (S_1) and which in turn on a par. The colony count was low in N alone (S_2). Though, the interaction effect of TDE and fertilizer on bacterial population was not significant. However, the graded doses of TDE and NPK (S_6) fertilizers had recorded the highest population among the rest of the treatments.

Fungi (Table 3)

It varied from 6.27 to 10.85 x 10^{-3} CFU g^{-1} of post harvest soil. The application of graded doses of TDE increased the fungal population. The fungal population was highest in the treatment which received 5.0 lakh litres ha^{-1} (M_5) whereas, control (M_1) recorded the lowest. Among the subplot treatments, NPK (S_6) found to be highest colony count, followed by NP (S_3), PK (S_5), NK (S_4) and N alone (S_2) which were comparable among themselves but had higher values than control. Though the interaction effect was not significant, the fungal population was found to be enhanced at high levels of TDE application.

Actinomycetes (Table 3)

The actinomycetes population of the soil monitored at post harvest stage of sugarcane crop indicated that the application of TDE @ 5.0 lakh litres ha^{-1} (M_5) increased over control. This was followed by 3.75 (M_4), 2.5 (M_3) and 1.25 lakh litres ha^{-1} (M_2) which in turn being on a par and control (M_1) recorded the lowest. Among the subplot treatments, the application of NP (S_3) fertilizers recorded the highest and being comparable with NPK (S_6) fertilizers. This was followed by PK (S_5) and NK (S_4) which had similar effect and control (S_1) recorded the lowest. The interaction of main X subplot treatments were found to be non-significant.

The microbial populations were remarkably increased due to application of graded doses of TDE. The per cent increase of 27.63, 57.32 and 48.87 of bacteria, fungi and actinomycetes were observed in the TDE received plots @ 5.0 lakh litres ha^{-1} (M_5) respectively over control (M_1). Since, TDE contains high amount of organic matter with high content of dissolved salts of essential plant nutrients, its application improves the soil biological health. The stimulation of higher microbial activity and secretion of microbial polysaccharides due to application of TDE might be the reason for higher microbial population of post harvest soil. This is inline with the findings of Maheswari, 2011.

Dehydrogenase (Table 4)

The dehydrogenase content was found to vary between 2.67 µg TPF g^{-1} soil h^{-1} (M_1) in control plot and 6.59 µg TPF g^{-1} soil h^{-1} in 5.0 lakh litres ha^{-1} (M_5) applied plots at post harvest soil. The main plot treatment had significant effect on dehydrogenase activity. The subplot treatment, NPK received plots found to be high value (4.89 µg TPF g^{-1} soil h^{-1}), followed by NP (S_3) (4.85 µg TPF g^{-1} soil h^{-1}), NK (S_4) (4.82 µg TPF g^{-1} soil h^{-1}), PK (S_5) (4.80 µg TPF g^{-1} soil h^{-1}), N alone (S_2) (4.74 µg TPF g^{-1} soil h^{-1}) and control (S_1) recorded the lowest (4.34 µg TPF g^{-1} soil h^{-1}).The interaction effect of TDE and fertilizers application on dehydrogenase activity was significant.

The application of TDE @ 3.75 (M_4) and 5.0 lakh litres ha^{-1} (M_5) had similar effect, but superior over the rest of the treatment in increasing the phosphatase activity.The subplot treatments effect on soil phosphatase activity was also significant. Irrespective of doses of TDE application, PK (S_5) received plots found to be higher and control recorded the lowest (20.06 µg nitrophenol g^{-1} soil h^{-1}) which was followed by 22.60, 22.18, 21.77 and 21.22 µg nitrophenol g^{-1} soil h^{-1} in NPK (S_6), NP (S_3), NK (S_4) and N alone (S_2) respectively. The interaction effect of TDE and fertilizer application on soil phosphatase activity was significant. The graded doses of TDE and fertilizer plots had increased the phosphatase activity. The control recorded lowest value (8.54 µg nitrophenol g^{-1} soil h^{-1}) in M_1S_1.

The urease activity was found to vary between 12.62 µg NH_4-N g^{-1} soil h^{-1} in 5.0 lakh litres ha^{-1} (M_5) and 3.50 µg NH_4-N g^{-1} soil h^{-1} in control (M_1) at post harvest soil. Irrespective of fertilizer application, the graded doses of TDE had significantly increasing the urease activity. The subplot treatments effect on soil urease activity was also significant. Irrespective of doses of TDE application, the urease activity was higher in NPK (S_6) and NP (S_3). The graded doses of TDE and fertilizers had increased the urease activity. The interaction effect of TDE and fertilizer application on urease activity was significant.

Dehydrogenase is considered as important enzymes for oxidative process in the soil. The enzyme activity is important for nutrient cycling and transformation. Application of TDE enhanced the activities of enzymes in the post harvest soils especially at higher levels. Addition of organic matter through TDE which inturn reflected on organic carbon. Increased enzyme activity over periods might be due to increased microbial activity which would have enhanced the organic matter degradation and mineralization. Similar results were also reported by Saliha *et al.* (2005). Application of NPK fertilizer also showed significant positive effect on dehydrogenase activities. Similar increase in soil phosphatase activity with the application of biomethanated distillery effluent was also reported by Kalaiselvi and Mahimairaja (2009).

IV. CONCLUSION

Based on the above discussion, it can be concluded that the application of TDE @ 5.0 lakh liters per ha along with NP fertilizer will be the best suitable combination for getting the highest microbial population and enzymatic activities in sandy loam soil. Besides it will indirectly improve the chemical properties of soil.

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Table 1.Physico-chemical properties and chemical composition of the treated distillery effluent

Parameters	Content	Parameters	Content
Colour	Dark brown	Nitrogen (ppm)	1,350
pH	7.3	Phosphorus (ppm)	550
EC (dS m^{-1})	29.5	Potassium (ppm)	9,500
BOD	4,500	Zinc (ppm)	11
COD	48,000	Copper (ppm)	65
Total solids	85,000	Iron (ppm)	4.3
Organic carbon (per cent)	27.4	Manganese (ppm)	5.4

Table 2. Characteristics of experimental soil

S No	Parameter	Values
1.	Soil Series	**Vadalapakkam**
2.	Soil taxonomy	***Typic Haplustalf***
3.	Texture	Sandy loam
4.	Bulk density (Mg m^{-3})	1.32
5.	Particle density (Mg m^{-3})	2.33
6.	Pore space (%)	30.2
7.	Water holding capacity (%)	36.4
8.	pH	8.38
9.	EC (dS m^{-1})	0.10
10.	CEC (cmol p(+) kg^{-1}	15.6
11.	Organic carbon (per cent)	0.37
12.	Available N (kg ha^{-1})	123
13.	Available P (kg ha^{-1})	15.1
14.	Available K (kg ha^{-1})	212
15.	Exchangeable Calcium (cmol (p+) kg^{-1})	7.40
16.	Exchangeable Magnesium (cmol (p+) kg^{-1})	3.50
17.	Exchangeable Sodium (cmol (p+) kg^{-1})	1.52
18.	Exchangeable Potassium (cmol (p+) kg^{-1})	0.25
19.	ESP (%)	12.0

Table 3. Effect of TDE and fertilizers on microbial population of post harvest soil (pooled data of 2 crop cycles)

	Bacteria (x10^{-6} CFU g^{-1})							Fungi (x10^{-3} CFU g^{-1})							Actinomycetes (x10^{-5} CFU g^{-1})						
Treatments	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
	55.33	53.33	55.97	54.30	53.43	62.10	55.74	6.27	6.45	6.50	6.77	6.61	6.78	6.56	3.82	3.98	4.08	3.94	3.99	4.11	3.99
M_2	59.30	59.00	61.53	60.27	62.17	60.67	60.49	8.09	8.08	8.46	8.01	8.18	8.34	8.19	5.06	5.33	5.38	5.49	5.32	5.47	5.34
M_3	65.07	62.87	62.90	64.10	63.43	63.43	63.63	8.48	8.68	8.48	8.60	8.45	8.74	8.57	5.34	5.48	5.68	5.50	5.46	5.56	5.51
M_4	67.80	65.07	67.03	69.00	69.00	70.43	67.40	8.75	8.87	9.29	8.96	9.25	9.30	9.07	5.43	5.51	5.71	5.69	5.65	5.74	5.62
M_5	68.40	68.83	72.27	72.30	72.30	74.17	71.14	9.89	10.29	10.35	10.30	10.25	10.85	10.32	5.69	5.66	6.43	5.63	5.93	6.29	5.94
Mean	63.18	61.82	63.94	64.07	64.07	66.16		8.30	8.47	8.62	8.53	8.55	8.80		5.07	5.19	5.46	5.25	5.27	5.44	
	M	S	M x S	S x M				M	S	M x S	S x M				M	S	M x S	S x M			
SE d	0.85	1.06	2.33	2.38				0.11	0.10	0.23	0.23				0.05	0.09	0.20	0.21	0.05		
CD (0.05)	1.97	2.14	NS	NS				0.26	0.20	NS	NS				0.12	0.19	NS	NS	0.12		

M1-control, M2- 1.25, M3- 2.5, M4-3.75, M- 5.0 lakh liters per ha (TDE)

S1- control, S2- N, S3- NP, S4-NK, S5-PK and S6-NPK

Table 4. Effect of TDE and fertilizers on enzymatic activities of post harvest soil (pooled data of 2 crop cycles)

	Dehydrogenase µg TPF g^{-1} soil h^{-1}							**Phosphatase (**µg nitrophenol g^{-1} soil h^{-1}							**Urease** µg NH_4-N g^{-1} soil h^{-1}						
Treatments	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
	55.33	53.33	55.97	54.30	53.43	62.10	55.74	6.27	6.45	6.50	6.77	6.61	6.78	6.56	3.82	3.98	4.08	3.94	3.99	4.11	3.99
M_2	59.30	59.00	61.53	60.27	62.17	60.67	60.49	8.09	8.08	8.46	8.01	8.18	8.34	8.19	5.06	5.33	5.38	5.49	5.32	5.47	5.34
M_3	65.07	62.87	62.90	64.10	63.43	63.43	63.63	8.48	8.68	8.48	8.60	8.45	8.74	8.57	5.34	5.48	5.68	5.50	5.46	5.56	5.51
M_4	67.80	65.07	67.03	69.00	69.00	70.43	67.40	8.75	8.87	9.29	8.96	9.25	9.30	9.07	5.43	5.51	5.71	5.69	5.65	5.74	5.62
M_5	68.40	68.83	72.27	72.30	72.30	74.17	71.14	9.89	10.29	10.35	10.30	10.25	10.85	10.32	5.69	5.66	6.43	5.63	5.93	6.29	5.94
Mean	63.18	61.82	63.94	64.07	64.07	66.16		8.30	8.47	8.62	8.53	8.55	8.80		5.07	5.19	5.46	5.25	5.27	5.44	
	M	S	M x S	S x M				M	S	M x S	S x M				M	S	M x S	S x M			
SE d	0.85	1.06	2.33	2.38				0.11	0.10	0.23	0.23				0.05	0.09	0.20	0.21	0.05		
CD (0.05)	1.97	2.14	NS	NS				0.26	0.20	NS	NS				0.12	0.19	NS	NS	0.12		

M1-control, M2- 1.25, M3- 2.5, M4-3.75, M- 5.0 lakh liters per ha (TDE)

S1- control, S2- N, S3- NP, S4-NK, S5-PK and S6-NPK