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IMPACT OF DISTILLERY SPENTWASH ON GROWTH AND YIELD OF TAPIOCA

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ABSTRACT
Field experiment was conducted to study the effect of application of spentwash as a nutrient source on crop growth and yield of tapioca. Results indicated that the spent wash application increase the yield of tapioca. However, the starch content of tubers was high in the plots that received spentwash as one time application (100 KL ha^{-1}). Piezometer studies revealed that the pH, conductivity, cations and anions in the leachate were within the critical limits, and that the ground water quality was not affected. Hence, spentwash can be applied as the fertilizer source at recommended doses in agriculture fields.

KEYWORDS: Spent wash, Groundwater quality, Growth parameters, Yield attributes, Tuber yield.

INTRODUCTION
India ranks first in sugar production in the world. At present, there are 579 sugar mills producing 28.5 metric tonnes of sugar by crushing 281.57 metric tonnes of sugarcane annually (Ravindra *et al*., 2016). These sugar mills expel large volume of bagasse, press mud and molasses as byproducts during sugar manufacture. Among different by-products, molasses is fermented by yeast (*Saccharomyces cerevisiae)* and this is subsequently distilled for extracting alcohol and the liquid left over after distillation is generally known as spent wash. About 12-15 litres of spent wash is being produced during production of 1litre of alcohol. The spent wash causes concern of environmental pollution and safe disposal of spent wash is a major problem for most of the sugar industries due to its very high organic load and total solids. In order to decrease its BOD and COD levels, it is made to pass through the biomethanation digesters and the effluent obtained is known as biomethanated distillery spentwash (BMDSW).

PBMDSW is rich in organic matter, major and micronutrients especially nitrogen and potassium (Mahamod Haron and Subhash Chandra Bose, 2004). Its application to soil has been reported to be beneficial to increase sugarcane (Zalawadia *et al*., 1997), rice (Devarajan and Oblisami, 1995) wheat and rice yield (Pathak *et al*., 1998), quality of groundnut (Amar *et al*., 2003) and physiological response of soybean (Ramana *et al*., 2000). Diluted spentwash could be used for irrigation purpose without adversely affecting soil fertility (Kuntal *et al*., 2004), seed germination and crop productivity (Raverkar *et al*., 2000). However, non-judicious use of DSW adversely affected crop growth and increased soil salinity (Joshi *et al*., 2000). Chonker*et al.* (2000) observed that use of distillery spentwash should be discontinued intermittently for one to two crop-seasons to avoid the deteriorating effects on soil and groundwater quality. Keeping in view the nutrient content of biomethanated spent wash and its beneficial role in present agriculture, present investigation was carried out with tapioca as test crop.

MATERIALS AND METHODS
The field experiment was carried out with 'YTP 1' tapioca as test crop in randomized block design with 10 treatments and 3 replications. All cultural practices including gap filling, weeding and plant protection measures were carried out as per the TNAU recommendations. The experimental soil and the spent wash used for the field trial was characterised as per the standard methods (Jackson, 1973, Gupta *et al*., 2002, Walkley and Black, 1934, Humphries, 1956, Lindsay and Norvell, 1978). Growth parameters of tapioca such as plant height and stem girth was monitored every 30 days. At the time of harvest, yield attributing characters such as tuber length, number of tubers and tuber yield were recorded. The starch content in the tubers were analysed by anthrone method. For monitoring the groundwater quality, piezometers were installed at 45cm depth in the experimental field. Leachates were collected at 30 days interval and analysed for pH, EC, cations (Ca, Mg, Na and K) and anions (Cl^- and SO_4^{2-}) by adopting standard methods.

RESULTS AND DISCUSSION
The experimental soil was characterised with soil pH (7.06), EC (0.25 dSm^{-1}), medium in organic carbon (0.53%), available nitrogen (338.8 kg ha^{-1}), Available phosphorus (21.4 kg ha^{-1})and available potassium (197.3 kg ha^{-1}) respectively at the initiation of the experiment. The spent wash used was dark brown colour with a pH of 4.72. The total solid was 84000mg $L^{-1}$with and EC of 45.60 (dSm^{-1}). The potassium content was very high (12100mg L^-1) with a chloride content of 24620mg L^{-1}.

Growth parameters

Plant height - The data revealed significant differences in plant height among various treatments at all the stages of crop growth. In T2 (one time application of spent wash @ 100 KL ha^{-1}), there was a steady increase in the plant height. Highest value recorded was in T8 (425 cm) followed by T10 (422 cm) and T2 (420 cm) (Table 1). A regular pattern of growth was obtained in T1 (absolute control). The plant heights in all the treatments except T1 and T2 were increased rapidly after application of spent wash on 180 DAP. The increase in plant height was may be attributed to promotion of metabolic activity and cell division.

TABLE 1: Growth parameters of tapioca under spent wash irrigation – Plant height

Treatments	Plant height (cm)								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
T1	33.00	63.00	93.00	123.00	153.00	182.30	250.60	275.00	296.60
T2	59.60	99.60	149.60	199.60	279.60	313.00	385.60	398.30	420.00
T3	34.00	64.00	94.00	124.00	154.00	181.10	312.60	330.20	350.80
T4	42.30	72.30	102.30	132.30	162.30	195.00	354.00	368.60	390.20
T5	57.00	87.00	117.00	147.00	177.00	185.00	344.30	360.00	382.30
T6	49.00	79.00	109.00	139.00	169.00	228.00	362.00	385.20	403.30
T7	50.00	80.00	112.00	146.00	197.00	234.00	336.60	355.60	390.20
T8	48.60	88.60	118.60	168.60	198.60	241.00	388.30	407.50	425.00
T9	48.60	78.60	108.60	138.60	188.60	215.00	336.00	353.00	371.60
T10	44.60	74.60	124.60	164.60	184.60	212.00	383.60	395.60	422.30
SE(d)	0.43	0.56	0.83	1.20	1.87	2.03	2.12	2.00	2.00
CD	1.57	2.04	3.00	4.30	6.69	7.26	7.59	7.15	7.15
S1-30 DAP	S2-60 DAP	S3-90 DAP	S4-120 DAP	S5-150 DAP	S6-180 DAP	S7-210 DAP	S8-240 DAP	S9-270 DAP	

*Values represent mean average of three replications

T1	Absolute Control	T5	100 % NP + 100 % K as SW	T8	T6+10KLha^{-1} on 90, 150, 180 DAP
T2	Spent wash OTA @100KL ha^{-1}	T6	T3 + SW OTA @100KL ha^{-1}	T9	T6+15KLha^{-1} on 90, 150, 180 DAP
T3	Control(90:90:240Kg ha^{-1} NPK)	T7	T6 +5KLha^{-1} on 90,150,180 DAP	T10	T6 +20KLha^{-1}on 90, 150, 180 DAP
T4	100%NP+50%K +50 %Kas SW				

Stem girth–The results showed that there is significant difference in the stem girth due to the treatments imposed. In T2 and T7, there was an increase in stem girth. But,gradual and steady increase was observed in T8. Decrease in stem girth was shown in T9 (T6 + 30 KL ha^{-1} on 90, 120, 150 DAP). Here, the highest value was recorded in T8 (40.16 mm) and the least value in T1 (33.10 mm) on 270 DAP (Table 2).

TABLE 2: Growth parameters of tapioca under spent wash irrigation – Stem girth

Treatments	Stem girth (mm)								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
T1	9.10	13.20	15.30	19.20	22.10	25.79	28.90	30.80	33.10
T2	12.80	14.30	16.20	20.20	25.10	29.70	35.20	38.20	40.00
T3	9.80	15.20	18.80	22.30	24.60	28.13	30.00	31.90	33.28
T4	11.50	14.30	16.20	20.20	25.10	29.87	34.32	36.13	38.73
T5	13.00	16.20	19.20	23.40	27.30	31.42	35.40	37.76	39.94
T6	11.90	14.30	16.20	20.20	25.10	28.12	33.95	35.83	38.12
T7	11.30	16.40	19.60	24.10	26.10	31.09	36.40	38.23	40.13
T8	11.00	14.30	16.20	20.20	25.10	29.43	35.26	37.96	40.16
T9	11.50	13.30	15.60	19.60	22.20	25.42	31.76	33.41	37.26
T10	10.60	15.40	18.20	22.40	24.80	27.77	32.65	35.83	39.20
SE(d)	0.06	0.05	0.08	0.08	0.08	0.10	0.12	0.13	0.13
CD	0.22	0.19	0.29	0.32	0.29	0.36	0.45	0.49	0.49
S1-30 DAP	S2-60 DAP	S3-90 DAP	S4-120 DAP	S5-150 DAP	S6-180 DAP	S7-210 DAP	S8-240 DAP	S9-270 DAP	

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T3	Control(90:90:240Kg ha^{-1} NPK)	T7	T6 +5KLha^{-1} on 90,150,180 DAP	T10	T6 +20KLha^{-1}on 90, 150, 180 DAP
T4	100%NP+50%K +50 %Kas SW				

Yield attributes

Tuber length: Length of the tuber in Tapioca crop is an important parameter to be measured after harvest. The treatment T5 has recorded maximum tuber length of 27.66 cm followed by T4 (23.22 cm) and T9 (23.22cm). Minimum length was observed in T6 (18.22 cm) (Table 5).

Number of tubers: More number of tubers per plant was found in T8 (11.00) followed by T2 (10.00). Least number of tubers was observed in T5 (7.00) (Table 3).

Yield (Kg ha^{-1})

The results revealed that maximum yield was recorded in T8 (70830 Kg ha^{-1}) followed by T7 (70000 Kg ha^{-1}) and T2 (66330 Kg ha^{-1}). Minimum yield was obtained in T1 (43310 Kg ha^{-1}) (Table 5). It showed that the additional application of spentwash at the rate of 10 KL ha^{-1} with actual recommendation of 100 KL ha^{-1} increased the tuber yield. But the concentration higher (T9 and T10) than 110KL ha^{-1}decreased the tuber yield. Anandha krishnan *et al.* (2007) studied that the long term impact of postmethanated distillery effluent (PMDE) revealed that the application of PMDE at1.25 lakh litres ha^{-1}increased the yield of sugarcane. Monica, 2007 also observed that the application of post methanated distillery spentwash (PMDSW) @ 60 KL ac^{-1} recorded highest yields of grain (5430kg ha^{-1}) in maize.

Starch content in tubers: The starch content was more in T2 (17.78 %) followed by T3 (16.68 %). Though the yield was high in T8, the higher starch content was recorded in the tubers harvested from the T2 plots. The more nutrients in spentwash may increase the starch content in tuber. Less amount of starch was found in T9 (7.01 %) and T10 (9.78 %).

TABLE 3: Tuber length and number of tubers/plant

Treatments	Length of the tubers (cm)	No. of tubers/plant	Yield (Kg ha^{-1})	Starch content (%)
T_1	19.00	9.60	43310.00	10.34
T_2	21.00	10.00	66330.00	17.78
T_3	21.00	8.30	53525.00	16.68
T_4	23.22	9.30	65485.00	13.86
T_5	27.66	7.00	66050.00	14.19
T_6	18.22	8.60	65090.00	13.22
T_7	21.22	8.30	70000.00	11.36
T_8	19.66	11.00	70830.00	12.24
T_9	23.22	8.60	61430.00	7.01
T_{10}	20.55	9.00	60295.00	9.78
SE(d)	0.13	0.05	424.11	0.23
CD	0.49	0.19	1520.61	0.83

*Values represent mean average of three replications

Impact of spent wash on groundwater quality

pH and electrical conductivity

The pH of the leachate collected from DSW applied soils was relatively higher compared to control (figure 1). Corroborative results were reported by Sridharan (2007) who stated that application of distillery spent wash to pearl millet gradually increased the pH of the leachate as the number of leaching increased. Saliha (2003) also reported that the increase in pH with increase in leaching events in the sodic soil treated with organics and distillery spent wash.

The effect of treatments on the EC was found to be significant. The EC values of piezometer samples was high during initial stages in tapioca plots under various irrigation regimes but did not exceed the critical limit of 4.0 dSm^{-1} fixed for any water system. Leachates collected from spent wash applied treatments had high EC, which however, gradually decreased during later stages. Increase in EC values were seen after the application of spent wash on 45,90, 180 and 275 DAP in T7, T8, T9 and T10 (figure 2).A significant reduction in EC of subsequent leachate was due to the removal of huge amount of soil cations and anions added through DSW in the first instance itself. This is in line with the findings of Banuelos and Lin (2006) who reported that the salt content was reduced to safe limit after progressive leaching. So, the possibility of increasing the salinity of ground water is very limited under field situation when DSW is applied. Valliappan (1998) also pointed out that increase in the salt content of groundwater was only possible where there was not sufficient leaching of soil solution. Malathi (2002) also observed zero pollution of well water in nearby spent wash applied field in Theni District of Tamil Nadu.

Analysis of the leachates over fortnight intervals indicated that there is significant difference in the pH due to effect of treatments. With respect to various treatments, T10 recorded the highest mean pH (7.33) and the lowest pH (7.06) was recorded by T2. There is no remarkable change in pH of the leachates collected from the field.

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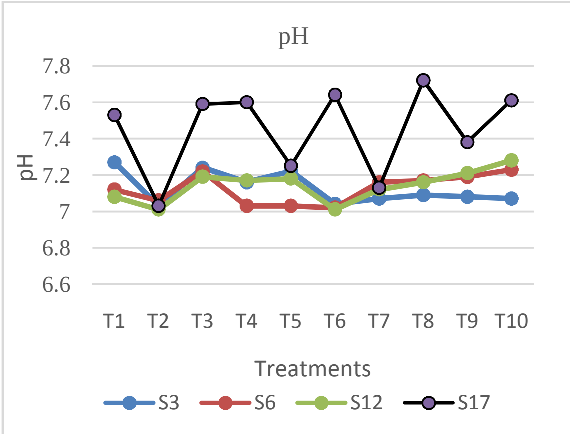

FIGURE 1. Assessment of mobility of salts upon irrigation with spent wash – pH

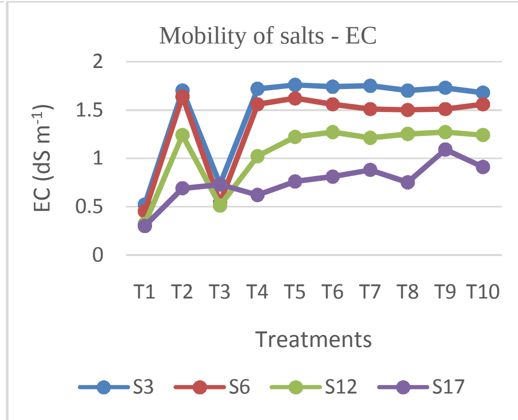

FIGURE 2. Assessment of mobility of salts upon irrigation with spent wash - EC

Cations

Cation values have been increased slightly whenever spent wash was applied to the respective treatments *i.e.* after 90, 150 and 180 DAP (Table 8-11). The cations viz., Ca, Mg, Na and K were high in the DSW applied soils than the control plot. This could be due to large amount of these cations present in the spentwash. However, the amount of cations leached was decreased in the later stages of the crop.There was a steady decline in the levels of potassium till 45 DAP and remained in more or less same levels unless fertilizer or distillery effluent was applied to the field. This was supported by the research done by Malathi(2002). Piezometer study found that the leachate collected on every month was having the pH, EC, cations and anions within the permissible limit and there was no threat to the groundwater quality (Anandakrishnan*et al.*, 2007). Cation values have been lightly increased whenever spent wash was applied to the respective treatments i.e. after 90, 150 and 180 DAP. But there is no notable difference in the initial and final values of cations except in some treatment plots. There is 44.2 % decrease of Mg in T6 and no remarkable decrease in calcium and sodium values. There was a steady decline in the levels of potassium till 45 DAP and remained in more or less same levels unless fertilizer or distillery effluent was applied to the field.

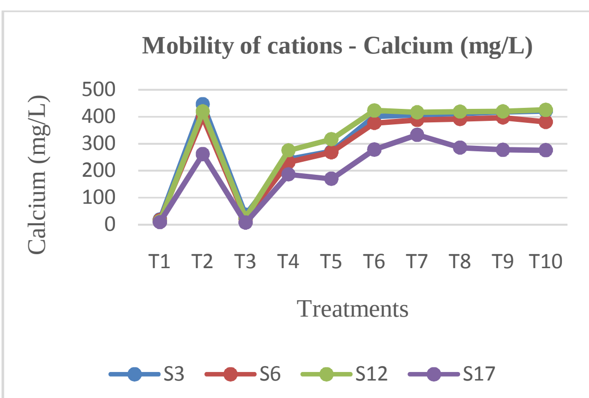

FIGURE 3. Assessment of mobility of cations –Ca

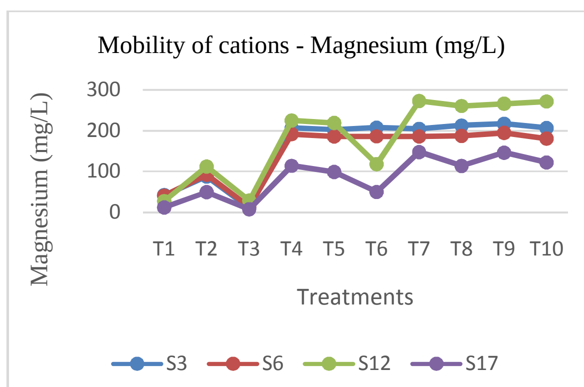

FIGURE 4. Assessment of mobility of cations – Mg

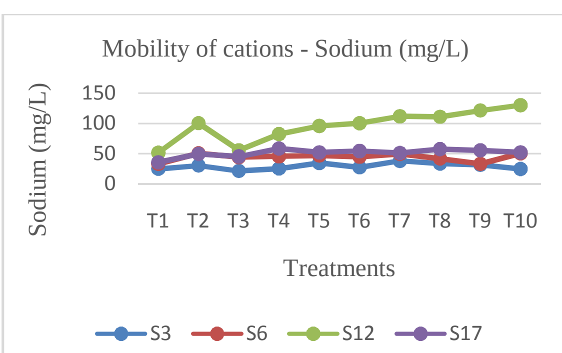

FIGURE 5. Assessment of mobility of cations – Na

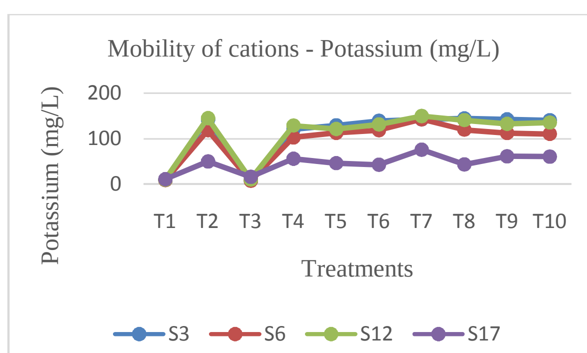

FIGURE 6. Assessment of mobility of cations –K

Anions

Anion values have been slightly increased whenever the spent wash was applied to the respective treatments i.e. after 90, 150 and 180 DAP (Table 12-13). There was a steady decline in the levels of anions till 45 DAP and remained in more or less same levels unless fertilizer or distillery effluent was applied, except in T1 (absolute control) and T3 (control).As the DSW had very high concentration of Cl and SO_4, it would have enriched the soil solution with soluble Cl and SO_4 resulted in greater amount in the leachate. In general, Cl salts are more harmful than SO_4 and these two anions significantly contribute towards the salinity hazard associated with irrigation water (Jain, 2005). However, in most of the treatments, the concentrations of Cl^- and SO_4^{2-} in the leachate were within the safer limits of 600 and 1000 mg L^{-1}, respectively as prescribed by the ISI for the disposal of effluent into inland surface water and land for irrigation.

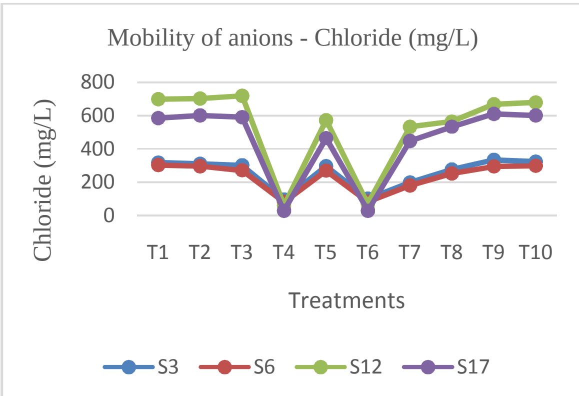

FIGURE 7: Assessment of mobility of anions – Chloride

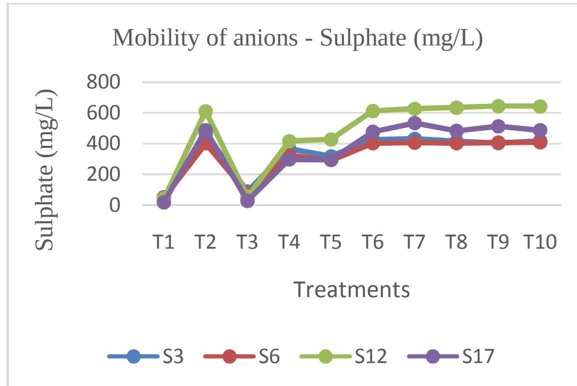

FIGURE 8: Assessment of mobility of anions – Sulphate

Anion values have been slightly increased whenever the spent wash was applied to the respective treatments *i.e.* after 90, 150 and 180 DAP. There was a steady decline in the levels of anions till 45 DAP and remained in more or less same levels unless fertilizer or distillery effluent was applied, except in T1 (absolute control) and T3 (control) (Fig. 7 and 8).

CONCLUSION

It could be concluded that application of spent wash can be effectively and safely utilized as manure in crop production. The spent wash was found to influence the tuber yield and starch content of tapioca through improved growth components and better availability of nutrients. Among all the treatments, T8 (T6 + 10 KL ha^{-1} on 90, 150, 180 DAP) was found to have higher yield and significant over T3 (Control). It can be stated that, yield parameters of tapioca increases when the spent-wash was applied at the rate of 10KL ha^{-1} in addition to the actual recommendation of 100 KL ha^{-1}. The piezometer study also revealed that the pH, conductivity, cations and anions in the leachate were within the limits. Therefore, PBMDSW must be applied judiciously according to crop requirements and soil fertility status which further prevents the environmental pollution of soil and ground water in the vicinity of distilleries.

RECOMMENDATIONS

The use of distillery spent wash with increased rate of application (10 KL ha^{-1}) than the actual recommendation of 100 KL ha^{-1} will increase yield parameters of Tapioca. The piezometer study revealed that the soil health and groundwater quality remain unaffected, because the content of pH, EC, anions and cations in the piezometer water samples were within the permissible limits as per CPCB.

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