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Response of distillery spentwash through fertigation on dry matter accumulation and concentration of nutrients in banana

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ABSTRACT

Field experiments were carried out in a loamy soil (pH = 8.10, EC = 0.30 dSm^{-1} and organic carbon = 0.57%) to study the response of distillery spentwash fertigation under different combinations on the nutrient content of banana cv. Grand Naine from 2008 to 2010 at the Shanthi Farm of the M/s Gemini Distilleries Pvt. Ltd., Nanjangud, Mysore located in Southern Dry Zone of Karnataka and situated at 12°11' North latitude, 76° 69' East longitude with an altitude of 610 m above mean sea level. Significantly higher nitrogen content in leaf, pseudostem and fruit (2.95, 1.20 and 0.96%, respectively) was observed in 25% N through fertilizers plus 75% N through distillery spentwash irrigation followed by 100% N through distillery spentwash irrigation. Similar trend was also observed in phosphorus content. Potassium content was significantly higher in treatment 100 percent N through distillery spentwash irrigation which recorded significantly higher potassium content (1.36, 3.72 and 0.68%, respectively) during main crop. Whereas, in ratoon crop, it was higher with 25% N through fertilizers plus 75% N through distillery spentwash irrigation. Higher calcium, magnesium and sulphur contents were noticed with 100% N through distillery spentwash irrigation.

Key words: Banana, distillery spentwash, fertigation, nutrient content.

INTRODUCTION

Majority of the industries in India are agro-based and utilize large volume of fresh water and turn almost this entire quantity in to an effluent. The unscientific disposal of this wastewater on soil and in to water bodies may create serious problems of pollution. Thus, there is a need to develop eco-friendly measures to utilize these liquid wastes profitably. Distillery is one such industry which uses molasses, a byproduct from sugar industry, as a raw material and generates large quantities of liquid waste in the form of spentwash. Karnataka has 29 working distilleries with a production of 126 million litres of rectified spirit generating 1,600 million litres of spent wash (Anon, 1). On an average, 13 m^3 of spentwash is generated kl^{-1} of rectified spirit produced. The safe disposal of such voluminous effluent is a challenge. Distillery spent wash is a plant extract (sugarcane) containing many plant nutrients that makes it a potential substitute for irrigation and nutrients. This study will also help in curbing its unscientific use by some farmers and its unhygienic dumping near the distillery sites. Need to ascertain the effective utilization of distillery spentwash, as a nutrient source arises the necessary to conduct present investigation.

MATERIALS AND METHODS

Field experiments were carried out in a loamy soil (pH = 8.10, EC = 0.30 dSm^{-1} and organic carbon = 0.57%) to study the response of distillery spentwash fertigation on concentration of nutrients in banana cv. Grand Naine at the Shanthi Farm of the M/s Gemini Distilleries Pvt. Ltd., Nanjangud, Mysore located in Southern Dry Zone of Karnataka during the year 2008 to 2010. The experiment consisted of nine treatments of which five were based on nitrogen supply, three treatments were based on potassium supply and one recommended dose of fertilizer to banana crop through distillery spentwash (DSW) irrigation, *viz.*, T_1 = Recommended dose of fertilizer, T_2 = 100 % N through DSW irrigation, T_3= 50% N through DSW 15 days before planting + 50% N through fertilizers, T_4 = 25% N through DSW 15 days before planting + 75% N through fertilizers, T_5 = 50% N through fertilizers + 50% N through DSW irrigation, T_6 = 25% N through fertilizers + 75% N through DSW irrigation, T_7 = 100% K through DSW irrigation, T_8 = 150% K through DSW irrigation and T_9 = 200% K through DSW irrigation. When treatments were fixed on N-basis enormous amount of K was incidentally added to soil due to its high content in spentwash, to examine the effect of excessive K, such treatments were also included. The samples were analyzed for pH, BOD, COD, total solids, suspended solids, total dissolved solids, total nitrogen, phosphorus, potassium, chlorides, sodium, calcium, magnesium, sulfur and micronutrients (Zn, Cu, Fe & Mn) using standard procedures (Table 1). The experiment was

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Table 1. Physico-chemical properties primary treated distillery spentwash.

Parameter	Range	Average
pH	7.39 - 7.58	7.48
EC (dSm^{-1})	14.26 - 15.20	14.67
Total solids (%)	3.94 - 4.17	4.02
Suspended solids (%)	1.06 - 1.27	1.17
COD (mg l^{-1})	24656 - 27123	25674
BOD (mg l^{-1})	14258 - 17258	15630
Cl (mg l^{-1})	6392 - 6532	6501
Total N (%)	0.08 - 0.12	0.11
Total P_2O_5 (%)	0.019 - 0.025	0.02
Total K_2O (%)	0.89 - 1.20	1.01
Ca (mg l^{-1})	1384 - 1832	1626
Mg (mg l^{-1})	1280 - 1456	1341
SO_4 (mg l^{-1})	372 - 536	475
Na (mg l^{-1})	1234 - 1642	1440
Fe (mg l^{-1})	10.10 - 12.50	10.82
Mn (mg l^{-1})	4.50 - 5.80	5.11
Zn (mg l^{-1})	6.56 - 8.21	7.24
Cu (mg l^{-1})	3.02 - 3.64	3.22

laid out in randomized complete block design with three replications.

Bio-compost (six kg $plant^{-1}$) was incorporated in to pits two weeks before planting. Banana crop was planted at a spacing of 2 m x 2 m. The size of each plot was 8 m x 6 m surrounded by bunds of sufficient height. Spentwash and fertilizers were applied in five splits at 35, 70, 105, 140, and 175 days after planting and one more split of potassium fertilizer at the time of flowering and balance nitrogen and phosphorus were supplied through urea and single super phosphate, respectively in main crop. In ratoon crop, two equal splits at 60 days interval from two days after harvesting of main crop. The crop was supplied with 405:245:507 kg N, P_2O_5 and K_2O ha^{-1} kg and 250:270:500 kg N, P_2O_5 and K_2O ha^{-1}N: P_2O_5:K_2O ha^{-1}, respectively for main and ratoon crop and the recommended packages of practices were adopted for crop production. Nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content on dry weight basis were determined by following standard methods. All the data were analyzed statistically as outlined by Panse and Sukhatme (5).

RESULTS AND DISCUSSION

Representative primary treated distillery spentwash samples collected from M/s Gemini Distilleries Pvt. Ltd., Nanjangud, Mysore at 30 days interval during spentwash application to both main and ratoon crop were analyzed for different parameters and results are presented in Table 1. The pH ranged from 7.39 to 7.58 with an average value of 7.48. The electrical conductivity ranged from 14.26 to 15.20 dS m^{-1} with an average value of 14.67 dS m^{-1}. Total suspended solids (SS) and total dissolved solids (TDS) contents varied from 1.06 to 1.27% and 2.77 to 2.96%, respectively. The chemical oxygen demand (COD) and biological oxygen demand (BOD) also varied at each time of collection and the average values were 25, 674 and 15,630 mg l^{-1}, respectively.

The samples were also analyzed for major and micronutrient contents. The concentration of nitrogen, phosphorus and potassium which varied from 0.08 to 0.12, 0.019 to 0.025 and 0.89 to 1.20%, respectively with average value of 0.11, 0.02 and 1.01%. Spentwash also contained good amount of calcium, magnesium and sulphur, which ranged from 1384-1832, 1280-1456 and 372-536 ppm, respectively. The average concentration of iron, manganese, zinc and copper were 10.82, 5.11, 7.24 and 3.22 mg l^{-1}, respectively. The values for different parameters varied slightly in samples collected during different months. However, considerable variation was observed with respect to BOD, COD, magnesium and calcium. Spentwash contains almost all the essential nutrients required by plants. Thus, it could be treated as liquid organic fertilizer (Kulkarni *et al*., 4). Since it is purely from plant origin, it can be used as nutrient source to banana and other crops without any adverse effects on their growth. Banana is known to absorb large quantity of nutrients particularly N and K. High water and nutrient requirement of banana makes it suitable crop for utilization of spentwash without polluting the environment.

Bunch yield, dry matter accumulation and its distribution in leaves, pseudo-stem and fruits varied significantly due to distillery spentwash irrigation at harvest (Table 2). Increase in dry matter production per unit area is a first step in achieving higher yield. Dry matter production and its accumulation in different parts of plants during various growth phases of life cycle of any crop is an important pre-requisite for higher yields as it signifies photosynthetic ability of the crop and also indicates other synthetic processes during developmental sequences. Maintenance of higher total dry matter was established with 25% N through fertilizers plus 75% N through distillery spentwash irrigation (11.01 and 9.64 g $plant^{-1}$, respectively during main and ratoon crop) followed by 100% N through distillery spentwash irrigation (10.51 and 9.27 g $plant^{-1}$, respectively), over 100%

Table 2. Quantity of distillery spentwash applied and its effect of fertigation on dry matter accumulation (kg plant^{-1}) and bunch yield (t ha^{-1}) of banana at harvest.

Treatment	Quantity of spentwash applied (m^3 ha^{-1})		Main crop					Ratoon crop				
			Dry matter accumulation				Bunch yield	Dry matter accumulation				Bunch yield
	Main crop	Ratoon crop	Leaf	Pseudo-stem	Fruit	Total	(t ha^{-1})	Leaf	Pseudo-stem	Fruit	Total	(t ha^{-1})
T_1	0.0	0.0	1.47	2.65	4.64	8.76	66.8	1.44	2.40	4.66	8.50	60.0
T_2	405.0	250.0	1.63	2.90	5.97	10.51	72.3	1.56	2.63	5.08	9.27	65.6
T_3	202.5	125.0	1.60	2.87	5.74	10.20	71.3	1.54	2.57	4.98	9.08	64.1
T_4	101.3	62.5	1.54	2.77	5.34	9.66	69.7	1.53	2.54	4.95	9.01	63.6
T_5	202.5	125.0	1.61	2.90	5.92	10.43	72.1	1.55	2.59	5.03	9.17	64.7
T_6	303.7	187.5	1.64	2.93	6.44	11.01	74.6	1.64	2.71	5.30	9.64	67.9
T_7	50.7	50.0	1.46	2.59	4.61	8.67	66.5	1.43	2.39	4.63	8.45	59.7
T_8	76.1	71.3	1.49	2.73	4.90	9.12	67.7	1.51	2.51	4.89	8.92	62.9
T_9	101.4	96.3	1.58	2.84	5.61	10.04	70.8	1.54	2.56	4.96	9.06	63.8
CD (P = 0.05)	-	-	0.12	0.19	1.15	1.45	5.01	0.11	0.18	0.36	0.65	4.62
CV (%)	-	-	4.63	4.01	12.19	8.51	4.12	4.09	4.11	4.23	4.17	4.22

T_1 = Recommended dose of fertilizer
T_3 = 50 % N through distillery spentwash 15 days before planting + 50 % N through fertilizers
T_4 = 25 % N through distillery spentwash 15 days before planting + 75 % N through fertilizers
T_5 = 50 % N through fertilizers + 50 % N through distillery spentwash irrigation
T_6 = 25 % N through fertilizers + 75 % N through distillery spentwash irrigation
T_7 = 100% K through distillery spentwash irrigation
T_8 = 150% K through distillery spentwash irrigation
T_9 = 200% K through distillery spentwash irrigation
Recommended dose of fertilizer: Main crop: 405:245:507 kg N, P_2O_5 and K_2O ha^{-1}
Bio-compost = 15 t ha^{-1} or 6 kg plant^{-1} was common for all the treatments
Ratoon crop = 250:270:500 kg N, P_2O_5 and K_2O ha^{-1}

K through distillery spentwash irrigation (8.67 and 8.45 g plant^{-1}, respectively) and recommended dose of fertilizers (8.76 and 8.50 g plant^{-1}, respectively). Application of 25% N through fertilizers plus 75% N through distillery spentwash irrigation recorded higher bunch yield (74.6 and 67.9 t/ha, respectively in main and ratoon crops) followed by 100% N through distillery spentwash irrigation (72.3 and 65.6 t/ha, respectively), 50% N through fertilizers plus 50% N through distillery spentwash irrigation (72.1 and 64.7 t/ha, respectively). The lowest yield was recorded with 100% K through distillery spentwash irrigation (66.5 and 59.7 t/ha, respectively).

Significantly higher nitrogen content (2.95 and 2.91, 1.20 and 1.19, 0.96 and 0.95% in leaf, pseudostem and fruit, respectively during main and ratoon crop) was recorded with 25% N through fertilizers plus 75% N through distillery spentwash irrigation (Table 3). Thus, the present results are directly corroborated with higher nitrogen content in DSW (Table 1). The least concentration of nitrogen in leaf, pseudostem, fruit and total uptake by banana was recorded with 100% K equivalent through distillery spentwash irrigation (2.68, 1.08 and 0.86%, respectively in main crop) and during ratoon crop, the least content was recorded with recommended dose of fertilizers. This may be due to increase in the availability of nutrients to the crop from spentwash, accumulating more nitrogen in the leaves and nitrogen is evenly distributed throughout the growth period and the highest proportion being found in the leaves (Thangaselvabai *et al*., 8). Increased plant tissue nitrogen content in distillery spentwash applied treatments might be due to slow release of N from spentwash which resulted in decreased loss of N from soil and maintained higher N potential throughout the plant growth period. Many researchers reported improved availability of N in soil with application of distillery spentwash (Zalawadia and Raman, 10; Joshi *et al*., 2; Sukanya and Meli, 7).

Increased phosphorus content in leaf, pseudostem, fruit (Table 2) in 25% N through fertilizers plus 75% N through distillery spentwash irrigation, 100 % N through distillery spentwash irrigation, 50% N through fertilizers plus 50% N through distillery spentwash irrigation and 200% K through distillery spentwash irrigation could be attributed to conversion of fixed phosphorus into readily available form by

Table 3. Nitrogen, phosphorus and potassium content (%) of banana as influenced by distillery spentwash fertigation at harvest.

Treatment	Nitrogen (%)						Phosphorus (%)						Potassium (%)					
	Leaf		Pseudostem		Fruit		Leaf		Pseudostem		Fruit		Leaf		Pseudostem		Fruit	
	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R
T_1	2.69	2.62	1.09	1.08	0.87	0.86	0.283	0.273	0.151	0.149	0.137	0.137	1.18	1.18	3.37	3.32	0.50	0.50
T_2	2.91	2.91	1.17	1.18	0.94	0.94	0.313	0.313	0.166	0.166	0.177	0.179	1.36	1.36	3.72	3.75	0.68	0.69
T_3	2.87	2.87	1.16	1.15	0.92	0.92	0.306	0.306	0.164	0.164	0.170	0.170	1.28	1.28	3.65	3.65	0.62	0.62
T_4	2.80	2.80	1.13	1.13	0.90	0.89	0.296	0.296	0.158	0.158	0.158	0.156	1.24	1.24	3.53	3.53	0.58	0.58
T_5	2.90	2.90	1.17	1.17	0.93	0.93	0.309	0.309	0.165	0.165	0.175	0.175	1.29	1.29	3.68	3.68	0.64	0.64
T_6	2.95	2.91	1.20	1.19	0.96	0.95	0.316	0.313	0.167	0.166	0.184	0.180	1.35	1.35	3.72	3.75	0.67	0.67
T_7	2.68	2.68	1.08	1.08	0.86	0.86	0.281	0.276	0.148	0.148	0.137	0.136	1.17	1.17	3.30	3.30	0.50	0.49
T_8	2.72	2.71	1.10	1.10	0.88	0.88	0.287	0.282	0.156	0.155	0.145	0.145	1.20	1.20	3.47	3.48	0.53	0.53
T_9	2.85	2.85	1.15	1.15	0.92	0.92	0.303	0.303	0.162	0.162	0.166	0.166	1.27	1.29	3.62	3.60	0.61	0.60
CD (P = 0.05)	0.187	0.175	0.077	0.074	0.062	0.059	0.024	0.023	0.011	0.010	0.032	0.031	0.083	0.082	0.25	0.22	0.103	0.099
CV (%)	3.83	3.61	3.90	3.78	3.91	3.76	4.63	4.41	4.01	3.76	11.36	11.12	3.81	3.78	3.87	3.54	10.05	9.69

organic acids released from the spentwash and consequent improvement in the available P in soil. Zalawadia *et al.* (11) who also found that higher organic carbon, available N, P and K with the usage of effluent application, which improves the uptake of nutrients.

The K concentration in leaf, pseudostem and fruit increased with distillery spentwash irrigation (Table 3). The highest potassium content was noticed in 100% N through distillery spentwash irrigation followed by 25% N through fertilizers plus 75% N through distillery spentwash irrigation as addition of K through spentwash varied from 1,014 to 4,050 kg ha^{-1} during main crop and 500 to 2500 kg ha^{-1} in ratoon crop due to varied quantity of application of DSW (Table 2). While treatment, which received recommended dose of fertilizers and 100% K through distillery spentwash irrigation recorded lower K. This is obvious, as very high quantity of K is added to soil with irrigation of distillery spentwash on N basis. Banana being heavy feeder of K (luxury consumption) accumulated higher concentration in different plant parts (Table 3) due to increased availability of K in soil (Shinde *et al.*, 6; Zalawadia *et al.*, 11). In addition, where in potassium supply is abundant, large amounts of potassium is absorbed during the later half of the vegetative phase

Calcium concentration in leaf, pseudo-stem and fruit differed significantly due to distillery spentwash irrigation during main and ratoon crop (Table 4). Calcium concentration was highest with 100% N through distillery spentwash irrigation followed by 25% N through fertilizers plus 75% N through distillery spentwash irrigation and the least content of calcium was recorded with 100% K through recommended dose of fertilizers. This might be due to the presence of appreciable amount of Ca in spentwash, which enhanced the accumulation. Similar findings were observed by Korndorfer (3) who reported increased availability of Ca to sugarcane crop with application of spentwash. Also sheath potassium had a positive correlation with sheath Ca (Thangavelu *et al.*, 9). Accumulation of higher K in treatments receiving distillery spentwash application might have enhanced the Ca accumulation as account of calcium exchange on clay complex in soil.

Similar trend was observed in magnesium concentration recording highest value in higher amount of distillery spentwash applied treatments (Table 4). Similar reasons can be quoted for increased Mg concentration in leaf sheath, *i.e.*, presence of appreciable quantity of Mg in DSW and greater accumulation of Mg with increased K in leaf sheath (Thangavelu *et al.*, 9). Potassium was found to regulate the transfer of nutrients to

Table 4. Calcium, magnesium and sulphur content (%) of banana as influenced by distillery spentwash fertigation at harvest.

Treatment	Calcium (%)						Magnesium (%)						Sulphur (%)					
	Leaf		Pseudostem		Fruit		Leaf		Pseudostem		Fruit		Leaf		Pseudostem		Fruit	
	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R
T_1	0.90	0.89	1.56	1.55	0.14	0.13	0.13	0.12	1.08	1.08	0.17	0.16	0.075	0.074	0.076	0.074	0.068	0.067
T_2	0.99	0.98	1.73	1.73	0.18	0.18	0.15	0.15	1.19	1.19	0.24	0.24	0.084	0.085	0.084	0.084	0.087	0.089
T_3	0.97	0.97	1.69	1.69	0.17	0.17	0.14	0.14	1.17	1.17	0.21	0.21	0.082	0.082	0.082	0.082	0.084	0.084
T_4	0.94	0.93	1.63	1.62	0.16	0.15	0.14	0.14	1.13	1.12	0.20	0.20	0.079	0.079	0.079	0.078	0.078	0.077
T_5	0.97	0.97	1.71	1.71	0.17	0.17	0.14	0.14	1.18	1.18	0.22	0.22	0.083	0.083	0.083	0.083	0.086	0.086
T_6	0.98	0.98	1.72	1.73	0.18	0.18	0.15	0.15	1.19	1.18	0.23	0.24	0.084	0.085	0.084	0.084	0.094	0.093
T_7	0.89	0.88	1.53	1.52	0.14	0.13	0.13	0.13	1.06	1.06	0.17	0.17	0.075	0.075	0.074	0.074	0.067	0.066
T_8	0.91	0.91	1.61	1.60	0.14	0.14	0.13	0.13	1.11	1.09	0.18	0.18	0.077	0.077	0.077	0.077	0.071	0.071
T_9	0.96	0.96	1.68	1.68	0.16	0.16	0.14	0.14	1.16	1.16	0.21	0.21	0.081	0.081	0.081	0.081	0.082	0.082
CD (P = 0.05)	0.071	0.067	0.11	0.11	0.030	0.029	0.010	0.011	0.09	0.07	0.036	0.034	0.006	0.006	0.006	0.005	0.017	0.017
CV (%)	4.31	4.10	4.01	3.96	10.84	10.67	4.26	4.56	4.01	3.53	10.35	9.69	4.63	4.51	4.01	3.96	12.19	12.54

the xylem. Wherever potassium supply is low, the transfer of nitrogen, phosphorus, calcium and magnesium across the xylem is restricted. Sulphur content (Table 4) increased with the application of distillery spentwash, which may be attributed to more sulphur added to the soil. Pseudostem is the greatest repository for Ca and Mg. Sulphur was evenly distributed in plant.

It is concluded that, the concentration of nitrogen and phosphorus in different parts was highest in 25% N through fertilizers plus 75% N through distillery spentwash irrigation and potassium including secondary nutrients content was higher in 100% N through distillery spentwash irrigation during main crop. Whereas, in ratoon crop, it was higher with 25% N through fertilizers plus 75% N through distillery spentwash irrigation. The highest yield and dry matter accumulation were obtained with 25% N through fertilizers plus 75% N through distillery spentwash irrigation.

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