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Research Paper

Influence of distillery spentwash ferti-irrigation on productivity, economics and nutrient uptake in banana (*Musa paradisiaca*)

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ABSTRACT

A field experiment was carried out in a loamy soil to study the effect of distillery spentwash ferti-irrigation under different combinations in banana (*Musa paradisiaca L.*) cv. Grand Naine from 2008 to 2010 at the Shanthi farm of the M/s Gemini Distilleries Pvt. Ltd., Nanjangud, Mysore. The experiment consisted of nine treatments, of which five treatments were based on nitrogen supply, three treatments on potassium supply through distillery spentwash irrigation and one recommended dose of fertilizer to banana. Application of 25% N through fertilizers plus 75% N through distillery spentwash irrigation recorded higher bunch yield (74.6 and 67.9 t/ha of main and ratoon crop, respectively), growth parameters, yield components, nutrients uptake and B:C ratio (4.79 and 8.07, respectively) as compared to other treatments.

Key words: Banana, Distillery spentwash, Ferti-irrigation, Nutrient uptake, Yield

Banana, an antique fruit crop of the world, is known as 'Apple of the Paradise'. It is the cheapest and plentiful fruit. Banana occupies an area of 4.88 million hectares globally with a production of 93.71 million tonnes and the average productivity is 19.20 tonnes/ha. India leads in global production next to China. Among the fruits grown in India, banana has 38.3% share in production (26.22 million tonnes annually) from an area of 0.71 million hectares, at an average productivity of 36.93 tonnes/ha (NHB, 2009). In Karnataka, banana is grown in an area of 75,400 ha with an annual production of 1.92 million tonnes and the average productivity is 25.46 tonnes/ha (NHB, 2009). Banana productivity in Karnataka is low due to improper management of irrigation and fertilizers which otherwise needs to be managed judiciously.

The primary treated distillery spentwash can be utilized for irrigation of long duration horticultural fruit crop like banana. Thus saving the irrigation water and solve the problem of waste disposal as well as source of nutrients for crop production finally saving the chemical fertilizer required for banana as it requires large quantity of plant nutrients. Hence it reduces environmental (air, water and soil) pollution from both effluent and chemical fertilizers and to know the effective utilization of distillery spentwash as a nutrient source, the present investigation was carried out in the premises of distillery.

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MATERIALS AND METHODS

A field experiments was carried out in a loamy soil to study the effect of distillery spentwash ferti-irrigation under different combinations in banana 'Grand Naine' on the availability of nutrients in soil at the Shanthi farm of the M/s Gemini Distilleries Pvt. Ltd., Nanjangud, Mysore district located in Southern Dry Zone of Karnataka and situated at 12° 11' North latitude 76° 69' East longitude with an altitude of 610 meters above mean sea level during the years from 2008 to 2010. The sandy loam soil of the experimental field had 0.57% organic carbon, 398.6, 39.4 and 265.8 kg/ha of available N, P_2O_5, K_2O_5 respectively with pH of 8.10 and EC 0.30 dS/m. The samples were also analyzed for nitrogen, phosphorus and potassium 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%, respectively. The experiment consisted of nine treatments, of which five treatments were based on nitrogen supply, three treatments on potassium supply through distillery spentwash irrigation and one recommended dose of fertilizer to banana crop *viz.* T_1 - Recommended dose of fertilizer, T_2 - 100 % N through distillery spentwash

(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, K based treatments were also included. The experiment was laid out in randomized complete block design (RCBD) with three replications.

Bio-compost, again a byproduct of distillery produced using pressmud and DSW in 1:3 ratio, at 6 kg/plant was incorporated in to pits two weeks before planting. Banana crop was planted at a spacing of 2 m × 2 m. The size of each plot was 8 m × 6 m surrounded by bunds of sufficient height. Spentwash and fertilizers were applied as basal dose at 15 days before planting for 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 and for other treatments in five splits at 35, 70, 105, 140, and 175 days after planting. Distillery spentwash was applied to the basin along with irrigation 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 were given. The crop was supplied with 15 t/ha or 6 kg/plant of bio-compost plus 405:245:507 kg N, P_2O_5 and K_2O/ ha and 250:270:500 kg N, P_2O_5 and K_2O/ha, respectively for main and ratoon crops. Recommended packages of practices were adopted for crop production. The banana suckers were planted on August 31, 2008 and main crop was harvested on September 8, 2009. For ratoon crop, suckers from the main crop were left on one day after 100% flowering i.e. on May 16, 2009 and ratoon crop was harvested on June 25, 2010. The concentration of N, P_2O_5, K_2O, Ca, Mg, S, Fe, Mn, Zn and Cu was multiplied by total dry matter of leaves, pseudo-stem and fruit yield at harvest to obtain uptake of N, P_2O_5, K_2O, Ca, Mg, S and expressed as kg/ha by following standard methods. All the data were analyzed statistically.

RESULTS AND DISCUSSION

Yield and yield attributes

Bunch yield of banana differed significantly with respect to application of distillery spentwash irrigation. Application of 25% N through fertilizers plus 75% N through distillery spentwash irrigation recorded maximum 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

Table 1. Effect of distillery spentwash ferti-irrigation on plant height, leaf area index at 10 months after planting and ratooning, pseudo–stem girth and dry matter accumulation of banana at harvest

Treatment	Plant height (cm)		Leaf area index		Pseudo-stem girth (cm)		Dry matter accumulation (kg/plant)	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Recommended dose of fertilizer	204.3	195.9	2.83	2.49	61.3	61.3	8.76	8.50
100% N through distillery spentwash irrigation	221.7	212.0	3.15	2.70	67.1	67.0	10.51	9.27
50% N through distillery spentwash 15 days before planting + 50% N through fertilizers	218.8	207.9	3.11	2.64	66.5	66.1	10.20	9.08
25% N through distillery spentwash 15 days before planting + 75% N through fertilizers	213.7	206.9	3.04	2.62	64.9	64.6	9.66	9.01
50% N through fertilizers + 50% N through distillery spentwash irrigation	221.0	209.9	3.14	2.67	66.4	66.8	10.43	9.17
25% N through fertilizers + 75% N through distillery spentwash irrigation	227.7	220.6	3.17	2.82	69.1	68.7	11.01	9.64
100% K through distillery spentwash irrigation	202.1	193.9	2.73	2.46	60.7	60.3	8.67	8.45
150% K through distillery spentwash irrigation	207.7	204.9	2.87	2.61	63.1	62.8	9.12	8.92
200% K through distillery spentwash irrigation	217.1	207.8	3.09	2.64	66.0	65.6	10.04	9.06
SEm±	5.06	5.00	0.09	0.06	1.38	1.46	0.48	0.22
CD (P=0.05)	15.16	15.00	0.26	0.19	4.12	4.37	1.45	0.65

spentwash irrigation (66.5 and 59.7 t/ha, respectively). Higher bunch yields were recorded with 25% N through fertilizers plus 75% N through distillery spentwash irrigation (12.18 and 13.74%, respectively) followed by 100% N through distillery spentwash irrigation (8.72 and 9.88%, respectively) over 100% K through distillery spentwash irrigation (Table 3).

The reduction in bunch yield of banana in both main and ratoon crops with 100% K through distillery spentwash irrigation, recommended dose of fertilizers (66.5 and 60.0 t/ha, respectively) and 150% K through distillery spentwash irrigation (67.7 and 62.9 t/ha, respectively) were attributed to decreased individual plant performance characters in terms of plant height, pseudo-stem girth, leaf area index and dry matter accumulation (Table 1), length of fruits, girth of fruit, fruit volume, mean fruit weight, number of hands per bunch , number of fingers per bunch and total dry matter accumulation at harvest and at different stages of crop growth. The yield is final expression of growth attained by individual plant parts during course of its development. Therefore, the poor growth components recorded in this particular treatment had contributed for lower yields.

Higher yield recorded with 25% N through fertilizers plus 75% N through distillery spentwash irrigation was attributed to better availability of nutrients and root development with the integrated use of organic and inorganic manures besides possessing better growth components. These results are in agreement with the findings of Devarajan and Oblisami (1994), who observed that higher yield of banana with 50 and 40 times dilution of distillery spentwash. Increased yield due to 75 and 100% N through spentwash application could also be attributed to the significant improvement in yield parameters like number of hands/bunch, (10.3 and 10.2), number of fingers/hand (15.0 and 14.5) number of fingers/plant (154.3 and 147.9), length (22.6 and 21.9 cm), circumference (14.6 and 14.1 cm), volume (143.6 and 137.8 cc) and fresh weight of fruit (224.5 and 220.4 g) of main and ratoon crop, respectively (Tables 2 and 3).

Nutrient uptake

Nitrogen

Maximum nitrogen uptake (364.3 and 325.5 kg/ha, respectively during main and ratoon crops) was recorded with 25% N through fertilizers plus 75% N through distillery spentwash irrigation (Table 4). The least uptake by banana was recorded with 100% K equivalent through distillery spentwash irrigation (254.3 kg/ha in main crop) and during ratoon crop, the least uptake 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 plant forming and the highest proportion being found in the leaves (Thangaselvabai *et al*.,2009).

Increased nitrogen uptake 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. Similar observations were made by Kulkarni *et al*. (1987), who opined that spentwash containing N chiefly in organic colloidal form behaved as slow releasing fertilizer upon application to soil.

Table 2. Effect of distillery spentwash ferti-irrigation on bunch characters of banana at harvest

Treatment	Number of hands/bunch		Number of fingers/hand		Number of fingers/bunch		Fruit length (cm)	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Recommended dose of fertilizer	9.3	9.1	13.3	12.8	124.3	116.9	20.2	19.4
100% N through distillery spentwash irrigation	10.1	9.9	14.7	14.0	148.0	138.3	22.0	21.2
50% N through distillery spentwash 15 days before planting + 50% N through fertilizers	9.9	9.7	14.5	13.6	144.1	132.0	21.6	20.7
25% N through distillery spentwash 15 days before planting + 75% N through fertilizers	9.7	9.6	14.2	13.5	137.4	129.9	21.2	20.5
50% N through fertilizers + 50% N through distillery spentwash irrigation	10.0	9.8	14.6	13.8	147.1	134.8	21.9	21.0
25% N through fertilizers + 75% N through distillery spentwash irrigation	10.3	10.2	15.0	14.5	154.3	147.9	22.6	21.9
100% K through distillery spentwash irrigation	9.3	9.0	13.3	12.7	123.8	115.0	20.1	19.3
150% K through distillery spentwash irrigation	9.4	9.4	13.8	13.4	129.7	126.3	20.6	20.3
200% K through distillery spentwash irrigation	9.9	9.6	14.4	13.6	142.0	131.0	21.5	20.6
SEm±	0.22	0.23	0.37	0.33	6.53	6.07	0.51	0.49
CD (P=0.05)	0.66	0.69	1.09	0.99	19.57	18.21	1.53	1.46

Phosphorus

Increased phosphorus uptake (Table 4) 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 organic acids released during decomposition of spentwash and consequent improvement in the available P in soil. The results corroborate with the findings of Zalawadia and Raman (1994) and Zalawadia *et al*. (1997), who also found that higher organic carbon, available N, P and K with the usage of effluent application and thus improves the uptake of nutrients.

Potassium

Highest potassium uptake 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 was 3037.5 and 4050 kg/ha, respectively during main crop

Table 3. Fruit volume, fresh weight of fruit, mean bunch weight and yield of banana as influenced by distillery spentwash ferti-irrigation at harvest

Treatment	Fruit volume (cc)		Fresh weight (g/fruit)		Mean bunch weight (kg)		Total bunch yield (t/ha)	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Recommended dose of fertilizer	128.6	121.9	200.1	194.8	26.7	24.0	66.8	60.0
100% N through distillery spentwash irrigation	139.4	133.1	218.6	212.5	28.9	26.2	72.3	65.6
50% N through distillery spentwash 15 days before planting + 50% N through fertilizers	137.6	130.0	215.7	207.6	28.5	25.6	71.3	64.1
25% N through distillery spentwash 15 days before planting + 75% N through fertilizers	134.4	129.0	210.7	206.0	27.9	25.4	69.7	63.6
50% N through fertilizers + 50% N through distillery spentwash irrigation	139.0	131.3	217.9	209.6	28.8	25.9	72.1	64.7
25% N through fertilizers + 75% N through distillery spentwash irrigation	143.6	137.8	224.5	220.4	29.8	27.2	74.6	67.9
100% K through distillery spentwash irrigation	128.3	121.2	199.2	193.6	26.6	23.9	66.5	59.7
150% K through distillery spentwash irrigation	130.5	127.7	204.8	203.9	27.1	25.2	67.7	62.9
200% K through distillery spentwash irrigation	136.6	129.5	214.1	206.8	28.3	25.5	70.8	63.8
SEm±	3.20	3.10	4.95	5.00	0.67	0.62	1.67	1.54
CD (P=0.05)	9.58	9.29	14.85	15.00	2.00	1.85	5.01	4.62

Table 4. Nitrogen, phosphorus, potassium and sulphur uptake (kg/ha) by banana as influenced by distillery spentwash ferti-irrigation at harvest

Treatment	Nitrogen		Phosphorus (P_2O_5)		Potassium (K_2O)		Sulphur	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Recommended dose of fertilizer	271.7	259.3	83.6	80.5	390.6	361.0	15.72	14.95
100% N through distillery spentwash irrigation	344.3	310.1	117.8	105.1	512.3	464.1	22.57	20.15
50% N through distillery spentwash 15 days before planting + 50% N through fertilizers	330.7	299.7	111.1	99.6	483.2	432.8	21.26	18.86
25% N through distillery spentwash 15 days before planting + 75% N through fertilizers	307.4	289.0	99.9	93.2	443.7	410.9	19.03	17.48
50% N through fertilizers + 50% N through distillery spentwash irrigation	340.7	305.9	116.2	102.7	498.2	443.3	22.31	19.49
25% N through fertilizers + 75% N through distillery spentwash irrigation	364.3	325.5	126.6	110.1	525.1	477.3	25.09	21.55
100% K through distillery spentwash irrigation	268.5	260.5	82.6	79.6	378.5	355.8	15.53	14.86
150% K through distillery spentwash irrigation	284.4	278.7	89.7	87.8	416.6	393.9	16.98	16.50
200% K through distillery spentwash irrigation	323.7	297.3	107.9	97.9	471.9	426.3	20.61	18.52
SEm±	20.1	12.1	9.33	5.75	27.58	19.05	1.99	1.22
CD (P=0.05)	60.3	36.2	27.96	17.22	82.68	57.13	5.97	3.65

Table 5. Economics of banana cultivation as influenced by distillery spentwash ferti-irrigation

Treatment	Cost of cultivation (× 10^3 ₹/ha)		Net returns (× 10^3₹/ha)		Benefit: cost ratio	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Recommended dose of fertilizer	110.2	58.8	324.2	331.2	3.94	6.64
100% N through distillery spentwash irrigation	100.7	53.0	369.3	373.4	4.67	8.05
50% N through distillery spentwash 15 days before planting + 50% N through fertilizers	103.5	53.6	360.3	363.0	4.48	7.77
25% N through distillery spentwash 15 days before planting + 75% N through fertilizers	101.2	55.8	351.6	357.6	4.47	7.40
50% N through fertilizers + 50% N through distillery spentwash irrigation	101.3	54.6	367.1	365.9	4.62	7.70
25% N through fertilizers + 75% N through distillery spentwash irrigation	101.2	54.7	383.6	386.7	4.79	8.07
100% K through distillery spentwash irrigation	101.4	55.0	331.1	333.1	4.27	7.06
150% K through distillery spentwash irrigation	101.5	54.8	338.6	354.1	4.34	7.47
200% K through distillery spentwash irrigation	101.5	54.8	358.8	359.9	4.54	7.57

Note: Urea @ ₹4.80/kg, SSP@ ₹3.70/kg, MOP @ ₹4.50/kg, Bio–compost @ ₹1,250/t, Cost of banana suckers @ ₹4 .00/ sucker and Price of banana fruit @ ₹6.50/kg

plus 1875.0 and 2500 kg/ha, respectively in ratoon crop. 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, accumulated higher concentration due to increased availability of K in soil (Shinde *et al.,* 1993 and Zalawadia *et al.,* 1997). In addition, where in potassium supply is abundant, large amounts of potassium is absorbed during the later half of the vegetative phase.

Sulphur

Sulphur content and uptake increased with the application of distillery spentwash, which may be attributed to more sulphur added to the soil. Maximum uptake was due to its higher content and higher dry matter production (Table 4).

Economics

Application of 25% N through fertilizers plus 75% N through distillery spentwash irrigation recorded maximum gross returns (₹4,84,770 and 4,41,350/ha), net returns (₹3,83,577 and 3,86,682/ha) and benefit: cost ratio (4.79 and 8.07) as compared to other treatments. This was due to higher bunch yield indicating favourable nutrient supply to banana besides reduced cost of fertilizers as compared to recommended dose of fertilizers. The lowest net returns (₹3,24, 233 and 3,31,221/ha) and benefit: cost ratio (3.94 and 6.64) was recorded with the application of recommended dose of fertilizers and this was due to lower bunch yield in addition to highest cost of cultivation (Table 5).

It was concluded that application of bio-compost (15 t/ha) with 25% N through fertilizers plus 75% N through distillery spentwash irrigation (3.04 and 1.88 lakh litres/ha respectively for main and ratoon crop) in five equal splits at 35, 70, 105, 140, and 175 days after planting during main crop and in two equal splits at 2 and 60 days after harvest of main crop in ratoon crop and balance phosphorus was supplied through single super phosphate significantly improved the productivity, quality, nutrient uptake and monetary returns.

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