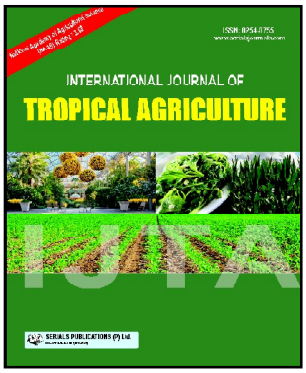

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Effect of Coffee Pulp Effluent Irrigation and Nutrient Levels on Yield, Yield Attributing Characters and Quality of Banana (*Musa paradisiaca. L.*)

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Abstract:: To study the effect of coffee pulp effluent irrigation on yield and yield attributing characters of banana, a field investigation was carried out during 2006 to 2009 at Kollibylu, Mudigere, Chikmagalur District. Alternate irrigation with lime treated coffee pulp effluent and fresh water recorded maximum mean bunch weight (69.3 t ha^{-1}) which was on par with 1:1 ratio irrigation with coffee pulp effluent and fresh water irrigation (68.4 t ha^{-1}). Significantly lower mean bunch yield was recorded in lime treated effluent irrigation (58.3 t ha^{-1}). Application of 50 per cent of nitrogen recorded significantly maximum bunch yield (67.7 t ha^{-1}) which was superior over the treatment without nitrogen.

Key words: Effluent, BOD, COD, TSS, Reducing sugar, Non-reducing sugar.

INTRODUCTION

Improving productivity with use of high yielding varieties and hybrids to meet the burgeoning population's demand is greatly limited by the availability of water and nutrients. Water is one of the most valuable natural resource available to man for his domestic, agricultural and industrial uses. Growth of population, massive urbanization, rapid rate of industrialization and availability of modern technology in agriculture have accelerated water pollution and led to the gradual deterioration of its

quality. India is the seventh largest nation in terms of industries. Majority of the industries are agro-based and utilize large volumes of good quality water and other raw materials and generate almost entire quantity of water as effluent and appreciable quantities of solid wastes. Demand by these industries for water is expected to increase from 5 per cent in 2000 to 11.5 per cent by 2010 and 23 per cent by 2025. Generation of large volume of effluent due to the phenomenal growth of industries and huge quantities of sewage effluent due to population explosion pose a serious threat to environment and water resources (Rani Perumal and Singram, 1996). The changing scenario of both issues had researchers to develop strategies for effective utilization of waste water resources in food production having dual advantage of waste recycling with minimizing environmental pollution.

It has been estimated that about 75,000 to 80,000 litres of waste water is generated for curing one ton coffee beans (Damodaran, 1998) and to process 2.23 lakh tons of coffee through wet processing, 8.4 million cubic metres of waste water is generated (Anand Alwar, 1998). The issue of water pollution became very serious when the Karnataka State Pollution Control Board passed strictures to close the pulping units in Chikmagalur district during 1995-96. The by-products of coffee processing are mainly coffee pulp, pulp effluent, parchment husks and coffee husk. Due to contribution of these by-products to environmental pollution, effective environmentally friendly disposal methods are very essential (Mburu and Mwaura, 1996). Presently, neutralization of effluent with lime and storing in pits is being adopted for treatment of wastewater, which may not effectively protect the water environment (Anand Alwar, 1998). Hence, there is a great need to conduct studies to suggest safe ways of waste disposal for better purposes like irrigation in agriculture in the locales where the effluent is generated. Therefore the study was conducted to find out the effect of coffee pulp effluent irrigation and nutrient levels on growth, yield and quality of banana.

MATERIAL AND METHODS

The experiment was carried out during 2006 to 2009 on farmer's field at Kollibylu, Mudigere, Chikmagalur District, Karnataka, India. The coffee pulp effluent was used as source of irrigation and it was applied as per the crop water requirement during pulping season (December to April). The preliminary analysis of raw and treated coffee pulp effluents was given in the Table 1.

The pH of raw effluent (3.94) and microbial treated effluent (4.27) was acidic in nature, whereas lime treated effluent (7.16) and microbial and lime treated effluent (7.59) are near to neutral in range. The electrical conductivity ranged from 1.091 to 1.366 dSm^{-1}. Higher total solids (suspended solids and dissolved solids) were recorded in raw effluent (16.108 g l^{-1}) followed by lime treated effluent (12.338 g l^{-1}), microbial treated effluent (9.466 g l^{-1}) and microbial and lime treated effluent (8.403 g l^{-1}). The concentration of BOD and COD varied with the treatment of effluent. Raw effluent recorded

Table 1
Chemical composition of raw and lime treated coffee pulp effluent.

Parameters	*Raw effluent*	*Lime treated effluent*
pH	3.94	7.16
EC (dSm^{-1})	1.366	1.343
Suspended solids (g l^{-1})	7.843	5.766
Dissolved solids (g l^{-1})	8.265	6.572
Total solids (g l^{-1})	16.108	12.338
BOD (mg l^{-1})	16500	13600
COD (mg l^{-1})	27700	24200
Chlorides (meq l^{-1})	5.84	4.63
Bicarbonates (meq l^{-1})	6.72	6.37
Total nitrogen (%)	0.105	0.099
Total phosphorus (%)	0.0023	0.0037
Total potassium (%)	0.058	0.0613
Iron (ppm)	24.49	23.17
Zinc (ppm)	0.696	0.667
Copper (ppm)	1.793	2.162
Manganese (ppm)	0.586	0.494

maximum values (16500 and 27700 mg l^{-1}, respectively) and microbial and lime treated effluent (7800 and 14900 mg l^{-1}, respectively) recorded minimum values. The samples were also analyzed for major and micronutrient contents. There is no much difference with respect to the major and micronutrient contents of treated and raw effluent. The experiment was laid out in Factorial RCBD design with 4 replications includes 6 treatments. T_1-Lime treated effluent irrigation without Nitrogen, T_2 -Lime treated effluent irrigation with 50% Nitrogen, T_3-Alternate irrigation with lime treated effluent and fresh water without Nitrogen, T_4-Alternate irrigation with lime treated effluent and fresh water with 50% Nitrogen, T_5-1:1 ratio of lime treated effluent and fresh water irrigation without Nitrogen, T_6 -1:1 ratio of lime treated effluent and fresh water irrigation with 50% Nitrogen. Banana tissue culture variety Grand naine was used as test crop and was planted in first week of September 2006 at a spacing of 2 m × 2 m. A fertilizer dose of 200:100:300 g N: P_2O_5:K_2O per plant were applied to the crop at different growth stages. FYM (10 kg pit^{-1}) was supplied and mixed thoroughly in to the top soil 15 days prior to planting. Growth and yield observation were recorded and statistically analyzed by adapting the procedure outlined by Panes and Sukatme (1967).

RESULTS AND DISCUSSION

Alternate irrigation with lime treated coffee pulp effluent and fresh water recorded maximum mean bunch weight (69.3 t ha^{-1}) which was on par with 1:1 ratio irrigation with coffee pulp effluent and fresh water irrigation (68.4 t ha^{-1}). Significantly lower mean bunch yield was recorded in lime treated effluent irrigation (58.3 t ha^{-1}). Application of 50 per cent of nitrogen recorded significantly maximum bunch yield (67.7 t ha^{-1}) which was superior over the treatment without nitrogen.

The reduction in bunch yield of banana crop in treatments receiving lime treated coffee pulp effluent irrigation could be due to decreased individual plant performance characters in terms of length of fruits, girth of fruit, fruit weight, number of hands per bunch, number of fingers per bunch (Table 2), fruit length, fruit girth, fruit weight, pulp weight, peel weight and pulp to peel ratio (Table 3)

Table 2
Effect of lime treated coffee pulp effluent irrigation and nitrogen levels on dry bunch characters and yield of banana plant crop at harvest.

	Number of hands per bunch			*Number of fingers per hand*			*Number of fingers per bunch*			*Bunch weight (kg)*			*Bunch yield (t ha^{-1})*		
Treatments	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*
I_1	8.5	9.3	8.9	96.6	104.2	100.4	11.4	11.3	11.4	21.9	24.8	23.3	54.6	61.9	58.3
I_2	10.3	10.8	10.5	123.1	133.7	128.4	11.9	12.5	12.2	26.7	28.7	27.7	66.8	71.8	69.3
I_3	10.3	10.6	10.4	125.7	129.6	127.6	12.3	12.3	12.3	26.9	27.8	27.4	67.3	69.5	68.4
Mean	9.7	10.2		115.1	122.5		11.9	12.1		25.2	27.1		62.9	67.7	
	I	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*
S.Em+	0.22	0.18	0.31	1.21	0.99	1.71	0.28	0.23	0.4	0.62	0.5	0.87	1.54	1.26	2.18
CD at 5%	0.66	0.54	0.93	3.64	2.97	NS	NS	NS	NS	1.85	1.51	NS	4.64	3.79	NS

Sources of irrigation
I_1-Lime treated effluent irrigation
I_2-Alternate irrigation with lime treated effluent and fresh water
I_3-1:1 ratio lime treated effluent and fresh water irrigation

Nitrogen levels
N_0-No Nitrogen.
N_1-50% Nitrogen.

Note: Recommended dose of FYM, P&K and microbial culture is common for all the treatments.

Table 3

Effect of lime treated coffee pulp effluent irrigation and nitrogen levels on fruit characters of banana plant crop.

	Fruit length (cm)			*Fruit mid circumference (cm)*			*Fruitweight (g)*			*Pulpweight (g)*			*Peelweight (g)*			*Pulp to peel ratio*		
Treatments	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*
I_1	18.2	18.6	18.4	13.6	14.1	13.8	171.2	184.5	177.8	126.0	136.8	131.4	45.2	47.7	46.4	2.79	2.88	2.84
I_2	21	22.4	21.7	15.1	15.5	15.3	198.2	202.4	200.3	148.8	153.0	150.9	49.4	49.4	49.4	3.01	3.1	3.06
I_3	21.0	21.3	21.2	15.0	15.2	15.1	195.3	198.9	197.1	145.6	149.0	147.3	49.7	49.9	49.8	2.93	2.99	2.96
Mean	20.1	20.8		14.5	14.9		188.2	195.2		140.1	146.3		48.1	49.0		2.91	2.99	
	I	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*
S.Em+	0.31	0.25	0.44	0.1	0.08	0.14	1.64	1.34	2.32	1.33	1.09	1.88	0.61	0.50	0.86	0.04	0.03	0.05
CD at 5%	0.94	NS	NS	0.30	0.25	NS	4.95	4.04	NS	4.02	3.28	NS	1.84	NS	NS	0.12	NS	NS

Sources of irrigation

I_1-Lime treated effluent irrigation

I_2-Alternate irrigation with lime treated effluent and fresh water

I_3-1:1 ratio lime treated effluent and fresh water irrigation

Nitrogen levels

N_0-No Nitrogen.

N_1-50% Nitrogen.

Note: Recommended dose of FYM, P&K and microbial culture is common for all the treatments.

at harvest and at different stages of crop growth. The results clearly show that only lime treated coffee pulp effluent has deleterious effect on the growth of banana plant and resulted in its stunted growth and lower yields of banana crop.

Alternate and 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water recorded higher yield as compared to the other treatments (Table 2). This might be due to dilution effect in case of alternate and 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water and also due to greater reduction in BOD and COD as compared to lime treated coffee pulp effluent irrigation. Further BOD and COD load was reduced to 18 to 13 per cent in lime treated coffee pulp effluent, respectively. Similar results have been obtained by Singh and Raj Bahadur (1997), Sukanya and Meli (2004) and even though coffee pulp effluent is rich in organic matter and high BOD and COD, it will undergo mineralization at faster rate releasing plant nutrients over it is added to soil. Application of coffee pulp effluent was known to increase the nutrient status of soil indicating better mineralization.

This might be attributed to the presence of high humic substances which facilitate the timely availability of NPK to the plants through gradual release of nutrients in to the soil and thus contributing for higher yield parameters. Greater absorption of nutrients in turn aids in conversion of vegetative phase in to reproductive phase of the plant. Rapid differentiation of the meristem into various floral primordial structures that determine the future bunch size and also contribute for earlier completion of flower primordial differentiation in the span of four and eight months. Yield attributing characters like fruit length, fruit girth, fruit weight pulp to peel ratio (Table 3), number of fingers per hand, number of hands per bunch and number of finger per bunch contributed for final yield of banana main crop and ratoon crop. The entire processes of fruit growth and development in banana which are mediated by the interplay of endogenous growth substances and particularly, fruit length and girth have been associated with endogenous levels of IAA and gibberellins in development parthenocarpic fruit like banana.

The quality parameters of banana fruit like, total soluble solids (TSS), titrable acidity, reducing sugar, non-reducing sugar, total sugar and sugar to acid ratio were increased significantly in the treatments received

Table 4

Effect of lime treated coffee pulp effluent irrigation and nitrogen levels on fruit quality of banana plant crop at harvest.

	TSS (%)			*Titrable acidity per cent of citric acid*			*Reducing sugar (%)*			*Non-reducing sugar (%)*			*Total sugar (%)*			*Sugar to acid ratio*		
Treatments	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*	N_0	N_1	*Mean*
I_1	25.1	24.9	25.0	0.094	0.096	0.095	22.39	21.23	21.81	3.10	3.14	3.12	25.49	24.37	24.93	271.4	255.3	263.4
I_2	23.3	23.3	23.3	0.086	0.086	0.086	19.50	21.12	20.31	2.51	2.69	2.60	22.01	23.81	22.91	255.2	278.5	266.9
I_3	23.5	23.9	23.7	0.084	0.085	0.085	18.87	20.41	19.64	2.34	2.77	2.55	21.21	23.18	22.19	251.8	273.5	262.6
Mean	24.0	24.0		0.088	0.089		20.25	20.92		2.65	2.87		22.90	23.79		259.5	269.1	
	I	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*	*I*	*N*	*IXN*
S.Em+	0.43	0.35	0.60	0.001	0.001	0.001	0.24	0.19	0.33	0.05	0.04	0.06	0.229	0.187	0.324	4.09	3.34	5.78
CD at 5%	1.29	NS	NS	0.003	NS	NS	0.71	0.58	1.01	0.14	0.11	0.19	0.690	0.564	0.976	NS	NS	17.43

Sources of irrigation

I_1-Lime treated effluent irrigation

I_2-Alternate irrigation with lime treated effluent and fresh water

I_3-1:1 ratio lime treated effluent and fresh water irrigation

Nitrogen levels

N_0-No Nitrogen.

N_1-50% Nitrogen.

Note: Recommended dose of FYM, P&K and microbial culture is common for all the treatments.

50 per cent nitrogen, alternate and 1:1 ratio irrigation with coffee pulp effluent and fresh water irrigation Vaughan and Linehan (1976) found that humic acids released from organic matter have stimulatory effect on cell elongation in both roots and shoots indicating the possibility of triggering the endogenous production of growth hormones. Similar results were observed by several workers (Ushakamari *et al*., 1997 and Tirkey *et al*., 2002).

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