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Research Article

YIELD AND ECONOMICS OF BANANA AS INFLUENCE BY COFFEE PULP EFFLUENT IRRIGATION AND MICROBIAL CULTURE

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Abstract: To study the effect of coffee pulp effluent irrigation and microbial culture on yield and yield attributing characters of banana, a field investigation was carried out during 2006 and 2007 at Kollibylu, Mudigere, Chikmagalur District. Alternate irrigation with lime treated coffee pulp effluent and fresh water with microbial culture recorded maximum bunch yield, net returns and B:C ratio (75.1t ha^{-1}, 286830 Rs ha^{-1} and 3.24, respectively) which was on par with alternate irrigation with lime treated coffee pulp effluent and fresh water without microbial culture (71.0 t ha^{-1}, 266449 Rs ha^{-1} and 3.02, respectively) followed by fresh water irrigation (70.7 t ha^{-1}, 265290 Rs ha^{-1} and 3.01, respectively), 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water with microbial culture (70.5 t ha^{-1}, 263997 Rs ha^{-1} and 2.98, respectively) and 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water without microbial culture (70.1 t ha^{-1}, 262324 Rs ha^{-1} and 2.97, respectively). The lowest bunch yield, net returns and B:C ratio was recorded in raw coffee pulp effluent irrigation without microbial culture (38.6 t ha^{-1},105012 Rs ha^{-1} and 1.19, respectively) which was significantly inferior to all the other treatments.

Keywords: *Crop productivity, BOD, COD*

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Introduction

Improving the crop productivity with use of high yielding varieties and hybrids to meet the burgeoning population 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 percent in 2000 to 11.5 percent by 2010 and 23 percent 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 [1]. The changing scenario of both issues had researchers to develop strategies for effective utilization of water resources in food production. One among them is recycling of industrial and sewage effluent for crop production, which is having dual advantage of waste recycling with minimizing environmental pollution. Coffee is being cultivated on an area of 3 lakh hectares in India, out of which 2 lakh hectares is in Karnataka. Coffee requires large quantities of water for post harvesting processing, which inturn discharged as effluent to natural water bodies posing serious environmental problems. It has been estimated that about 75,000 to 80,000 litres of waste water is generated for curing one tonne coffee beans [2] and to process 2.23 lakh tons of coffee through wet processing, 8.4 million cubic metres of waste water is generated [3]. 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. Hence there is a great need to conduct studies to overcome the problems of pollution and to suggest the ways of waste water disposal for better purpose like irrigation and manuring. There is a great potential in trapping nutritive values these effluents, which is known to have considerable quantities of major and minor plant nutrients. Keeping above points in view a study was conducted during 2007 to 2009 to find out the effect of coffee pulp effluent irrigation and microbial culture on growth and yield of banana.

Material and Methods

The experiment was carried out during 2006 and 2007 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 to1.366 dSm^{-1}. Higher total solids (suspended solids and dissolved solids) were recorded in raw

Table-1 *Chemical composition of raw and treated coffee pulp effluent*

Parameters	Raw effluent	Microbial treated effluent	Lime treated effluent	Microbial and lime treated effluent
pH	3.94	4.27	7.16	7.59
EC (dSm^{-1})	1.366	1.091	1.343	1.112
Suspended solids (g l^{-1})	7.843	4.512	5.766	3.614
Dissolved solids (g l^{-1})	8.265	4.954	6.572	4.789
Total solids (g l^{-1})	16.108	9.466	12.338	8.403
BOD (mg l^{-1})	16500	10200	13600	7800
COD (mg l^{-1})	27700	20400	24200	14900
Chlorides (meq l^{-1})	5.84	5.21	4.63	5.42
Bicarbonates (meq l^{-1})	6.72	7.04	6.37	6.82
Total nitrogen (%)	0.105	0.094	0.099	0.112
Total phosphorus (%)	0.0023	0.0028	0.0037	0.0032
Total potassium (%)	0.058	0.0583	0.0613	0.0501
Iron (ppm)	24.49	25.02	23.17	23.33
Zinc (ppm)	0.696	0.762	0.667	0.621
Copper (ppm)	1.793	1.833	2.162	1.81
Manganese (ppm)	0.586	0.531	0.494	0.511

Table-2 *Effect of coffee pulp effluent irrigation and microbial culture on yield and fruit characters of banana plant crop*

Treatments	Bunch yield (t ha^{-1})	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Pulp weight (g)	Pulp to peel ratio
T_1	70.7	21.47	15.30	204.6	154	3.05
T_2	38.6	12.4	12.07	135.3	96.2	2.46
T_3	51.3	14.03	12.53	149.7	109.6	2.74
T_4	61.8	15.23	13.37	169.1	137.7	2.81
T_5	66.6	17.2	14.20	185.8	137.8	2.88
T_6	71.0	21.67	15.37	206.2	155.4	3.07
T_7	75.1	22.27	15.57	211.3	160.4	3.16
T_8	70.1	21.13	15.17	200.2	149.8	2.97
T_9	70.5	21.23	15.30	202.3	152.1	3.03
S.Em±	2.44	0.57	0.44	5.90	4.79	0.09
CD at 5%	7.30	1.70	1.32	17.79	14.37	0.26

T1-Fresh water irrigation; T2-Raw CPE irrigation without microbial culture; T3-Raw CPE irrigation with microbial culture
T4-Lime treated CPE irrigation without microbial culture; T5-Lime treated CPE irrigation with microbial culture;
T6-Alternate irrigation with lime treated CPE and fresh water without microbial culture; T7-Alternate irrigation with lime treated CPE and fresh water with microbial culture
T8-1:1 ratio irrigation with lime treated CPE and fresh water without microbial culture; T9-1:1 ratio irrigation with lime treated CPE and fresh water with microbial culture
Note: Recommended dose of fertilizer and FYM is common for all the treatments

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 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 RCBD design with 3 replications includes 9 treatments. T1 - Fresh water irrigation, T2 - Raw effluent irrigation without microbial culture, T3- Raw effluent irrigation with microbial culture, T4 - Lime treated effluent irrigation without microbial culture, T5 - Lime treated effluent irrigation with microbial culture, T6 - Alternate irrigation with lime treated effluent and fresh water without microbial culture,T7 - Alternate irrigation with lime treated effluent and fresh water with microbial culture, T8- 1:1 ratio irrigation with lime treated effluent and fresh water without microbial culture, T9- 1:1 ratio irrigation with lime treated effluent and fresh water with microbial culture. 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 X 2 m. A fertilizer dose of 200:100:300 g N: P_2O_5:K_2O per plant where was 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 [4].

Results and Discussion

Bunch yield of banana plant crop differed significantly due to coffee pulp effluent irrigation and microbial culture [Table-2]. Alternate irrigation with lime treated coffee pulp effluent and fresh water with microbial culture recorded maximum bunch yield (75.1t ha^{-1}) which was on par with alternate irrigation with lime treated coffee pulp effluent and fresh water without microbial culture (71.0 t ha^{-1}) followed by fresh water irrigation (70.7 t ha^{-1}), 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water with microbial culture (70.5 t ha^{-1}) and 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water without microbial culture (70.1 t ha^{-1}). The lowest bunch yield was recorded in raw coffee pulp effluent irrigation without microbial culture (38.6 t ha^{-1}) which was significantly inferior to all the other treatments. The reduction in bunch yield of banana in treatments receiving raw coffee pulp effluent irrigation and lime treated coffee pulp effluent without nitrogen could be due to decreased individual plant performance characters in terms of plant height, pseudostem girth, number of leaves, leaf area, total dry matter accumulation, length of fruits, girth of fruit, fruit weight, number of hands per bunch, number of fingers per bunch fruit length, fruit girth, fruit weight, pulp weight, peel weight and pulp to peel ratio [Table-2] at harvest and at different stages of crop growth. The results clearly show that either undiluted coffee pulp effluent or continuous irrigation with only lime treated coffee pulp effluent has deleterious effect on the growth of banana plant and resulted in its stunted growth. The yield is final expression of growth attained by individual plant during course of its development. Therefore, the poor growth components recorded in these treatments had positively contributed for lower yields. Alternate and 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water with and without microbial culture 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 load by treating the effluent with lime and microbial culture which resulted in 38 to 26 % reduction in microbial treated coffee pulp effluent, 18 to 13 % reduction in lime treated coffee pulp effluent and 53 to 46 % reduction in lime treated coffee pulp effluent with microbial culture (BOD and COD respectively). The lime treatment enables to raise the soil pH to neutrality and under neutral pH conditions, the inoculated microbial culture grows optimally and then contributing for further reduction of BOD and COD. 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. Hence it is safer to irrigate standing crop than flooding fallow fields [5-7]. 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 and quality parameters [8]. 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. In the present investigation also the treatments which favoured the early growth were found to possess greater number of yield components. Yield attributing characters like fruit length, fruit girth, fruit weight pulp to peel ratio. The entire processes of fruit growth and development in banana which are mediated by the interplay of endogenous growth substances and particularly, fruit length, fruit girth have been associated with endogenous levels of IAA and gibberellins in development parthenocarpic fruit like banana[9].It was 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 [10-12]. The economics of cultivation of banana plant crop as influenced by coffee pulp effluent irrigation with microbial culture are presented in [Table-3].

Table-3 *Gross returns (Rs. ha^{-1}), net returns(Rs. ha^{-1}) and benefit to cost ratio of banana plant crop as influenced by coffee pulp effluent irrigation with microbial culture*

Treatments	Gross returns (Rs ha^{-1})	Cost of cultivation (Ra ha^{-1})	Net returns (Rs ha^{-1})	B: C ratio
T_1	353347	88057	265290	3.01
T_2	193069	88057	105012	1.19
T_3	256292	88485	167807	1.9
T_4	308750	88525	220225	2.49
T_5	332958	88950	244008	2.74
T_6	354750	88301	266449	3.02
T_7	375333	88503	286830	3.24
T_8	350625	88301	262324	2.97
T_9	352500	88503	263997	2.98

T1-Fresh water irrigation; T2 - Raw CPE irrigation without microbial culture;
T3- Raw CPE irrigation with microbial culture; T4-Lime treated CPE irrigation without microbial culture;
T5-Lime treated CPE irrigation with microbial culture
T6-Alternate irrigation with lime treated CPE and fresh water without microbial culture
T7-Alternate irrigation with lime treated CPE and fresh water with microbial culture
T8-1:1 ratio irrigation with lime treated CPE and fresh water without microbial culture
T9-1:1 ratio irrigation with lime treated CPE and fresh water with microbial culture
Note: Recommended dose of fertilizer and FYM is common for all the treatments

The highest cost of production was recorded in lime treated coffee pulp effluent irrigation with microbial culture (88950 Rs ha^{-1}) and the lowest was recorded in the treatments receiving fresh water irrigation and raw coffee pulp effluent irrigation without microbial culture (88057 Rs ha^{-1}).Alternate irrigation with lime treated coffee pulp effluent and fresh water with microbial culture recorded maximum net returns and B:C ratio (286830 Rs ha^{-1} and 3.24, respectively) which was on par with alternate irrigation with lime treated coffee pulp effluent and fresh water without microbial culture (266449 Rs ha^{-1} and 3.02, respectively) followed by fresh water irrigation (265290 Rs ha^{-1} and 3.01, respectively), 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water with microbial culture (263997 Rs ha^{-1} and 2.98, respectively) and 1:1 ratio irrigation with lime treated coffee pulp effluent and fresh water without microbial culture (262324 Rs ha^{-1} and 2.97, respectively). The lowest net returns and B:C ratio was recorded in raw coffee pulp effluent irrigation without microbial culture (105012 Rs ha^{-1} and 1.19, respectively) which was significantly inferior to all the other treatments. The treatments which receive alternate irrigation and 1:1 ratio of lime and microbial treatments have least adverse effect on growth and development of banana because reduced load of BOD, COD, Total solids and neutral pH of the treated effluent and dilution of coffee pulp effluent. Hence these treatments produce more yield and realises higher gross returns, net returns and B:C ratio [9].

Application of research: Normally, the effluent is discharged indiscriminately in to paddy lands without growing any crop. Under such situations coffee pulp effluent can serve as source of both water and nutrients, besides it contains a higher amount of organic matter, which is helpful in the build-up of organic carbon content and serves as a source of microorganisms in the soil and which, solves the pollution problem and provides additional returns to the farmers.

Research Category: Agronomy.

Abbreviations: BOD-Biological Oxygen Demand, COD-Chemical Oxygen Demand, ha- hactare, l- liter, g- gram, mg- milligram, ppm- parts per million, dSm^{-1}-desi simons per meter, pH- power of Hydrogen, EC- Electric Conductivity, meq- milli equivalent, cm- centimetre, m- meter, S, Em- Standard Error mean, CD- critical Difference, NS- Non-Significant, FYM- Farm Yard Mannure, CPE- Coffee Pulp Effluent, CFU- Colony Forming Unit, TPF- triphenylformazan.

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Study area / Sample Collection: Mudigere

Cultivar / Variety / Breed name: Grand Naine Banana

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