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Effect of Treated Effluent Irrigation on Yield and Biominerals of Banana

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***Abstract*- To assess the effect of treated paper board mill effluent irrigation on yield and biofortification of banana a field trial was conducted during 2002- 2003in Mettupalayam taluk of Coimbatore District where ITC Paper board mill effluents were treated and irrigated for agricultural crops. Split plot design was adopted and replicated twice. Main plot treatments consisted of irrigations treatments and amendments were added in subplots. Treated board mill effluent after filtration was fertigated through drip irrigation with 75 and 50 per cent NK for banana while basin irrigation was done with 100 and 75 per cent NK. Surface irrigation with river water along with 100 per cent NK (farmer's practice) was used as control for comparison. In the subplots amendments *viz.*, fly ash, biocompost, fly ash + biocompost + green manure were applied. Banana variety Robusta was raised and observations were recorded on biofortificationof banana fruits with mineral constituents and vitamins. The result indicated that fruit mineral constituents *viz.*, Ca and Fe increased due to effluent irrigation sources and it was maximum under basin irrigation of treated board mill effluent with 100 per cent NK whereas Cu and Zn were increased under effluent fertigation with 75 per cent NK. Similarly, mineral constituents and vitamins were increased due to the application of fly ash + biocompost + green manure over fly ash alone.**

Key words:Fertigation, treated board mill effluent, biofortification

I. INTRODUCTION

Industrialization is believed to cause inevitable problem of pollution of water, soil and air. Pulp and paper industries use large volume of water, the bulk of which is released as effluent requiring proper treatment and disposal. Since, these effluent fall in borderline as saline water, they can be considered as potential source for irrigation (Gomathi and Oblisami, 1992) [1]. Trickle irrigation has the greatest potential in increasing yields of crops with significant savings in water and nutrients as compared to other conventional methods (Mohamedharoon, 1991) [2]. Brackish water could effectively be used in drip irrigation. When brackish water is applied frequently under drip irrigation the salinity and sodicity of the soil especially in the root zone of the crop is maintained at low level. Fertigation is a technique that combines irrigation with fertilization through any micro irrigation system especially through drip irrigation. Fertigation could bring an accurate control of water and nutrients in the immediate vicinity of the root system. Slow and frequent watering eliminates wide fluctuation of soil moisture under drip irrigation resulting in better growth and yield (Baryosef, 1999) [3]. Among the fruit crops, banana is well known for its high water requirement, high evaporative demand, high transpiration, shallow root system, poor ability to draw water from soil beneath field capacity and high sensitivity to soil water deficiency. Thus, it requires liberal supplies of irrigation water throughout its life cycle, emphasizing the importance of correct irrigation scheduling. Fertigation has been proved to be of great success in banana in terms of water and labour saving with increased water use efficiency culminating in early cropping and heavy yield (Santhanabosu *et al.,* 1995) [4] and it is an environmentally safer technology which prevents ground water contamination (Mahalakshmi *et al.,* 2002) [5]. Prabakaran (2017) [6] reported the ground water quality was safe due to effluent drip fertigation.Dietary constituent of over two thirds of world population lack one or more essential mineral elements like Ca, Mg, Fe, Zn, Cu *etc*., The literature regarding biofortification of banana fruits due to effluent fertigation is meagre. Hence this study was proposed.

II. MATERIALS AND METHODS

The investigation on the effect of fertigation of treated paperboard mill effluent and solid amendments on biofortification and yield of banana besides improving soil characteristics, crop growth, quality of crop produce and ground water qualitywere carried out at the Bipco paper board industries Pvt. Ltd, Mettupalayam taluk of Coimbatore district of Tamil Nadu (India). The experiment was conducted in split plot design with two replications and banana (Robusta) was selected as test crop. The treatments were assigned in main plots and sub plots. Irrigation treatments were assigned in main plot that consisted of seven treatments (I_1 – Farmer's practice as control (Surface Irrigation with river water (RW)+ 100% NK), I_2 – RW + Drip irrigation (DI) + 75% NK thro' fertigation, I_3 – RW + DI + 50% NK thro' fertigation, I_4 – Treated effluent (TE) +Basin irrigation (BI)+100% NK thro' soil application I_5 - TE + BI + 75% NK thro' soil application, I_6 - TE + DI + 75% NK thro' fertigation, I_7 - TE + DI + 50% NK thro' fertigation). Amendments were applied in sub-plot. Three types of amendments were applied in the soil (A_1- Fly ash @ 6 t ha^{-1}, A_2 - Biocompost@ 5 t ha^{-1} , A_3- Fly ash @ 6 t ha^{-1} + Biocompost @ 5 t ha^{-1} + Green manure @ 6.25 t ha^{-1} recommended 100% NPK is 110: 35:330 g of NPK $plant^{-1}$ y^{-1}). The drip system was installed as described by Udayasoorian and Prabakaran [7], 2010. The entire P was applied through single super phosphate as basal dressing in the pit before planting the suckers uniformly for all the treatments. The experimental area was irrigated with river water obtained from River Bhavani and treated paperboard mill effluent from Bipco according to the treatments. The treated effluent

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was neutral in reaction with high salinity, contained appreciable amounts of nutrient cations viz., Na, Ca, Mg and anions viz., Cl, SO_4 and HCO_3 with less sodium hazard (SAR <10). The percent sodium was well below the tolerance limit of 60 and the parameters recorded were well within the range of permissible limit prescribed by the Tamil Nadu State Pollution Control Board norms (TNSPCB). The effluent was rich in microbial load with the dominance of bacteria over fungi and actinomycetes.

The drip system consisted mainly of control head system (filter, dosatron) and distribution network system (main, sub-main, lateral and dripper). The equipment used for fertigation i.e., for injection of fertilizer solution into the drip system was dosatron (doser pump). The fertilizer stock solution was sucked from the tank installed below the dosatron by a suction tube of 1.2 m long. The injection rate was regulated by adjusting the graduated scale provided in the injector body of the dosatron. The unit was connected to the main water line on a bypass 20 mm PVC pipe fitted with 50 mm ball valve in the upstream and a non-return valve in the downstream. A 63 mm ball valve was provided in the main PVC which was closed, allowed water to flow through the dosatron to create vacuum. Fully matures fruit samples were collected at harvest and analysed for mineral constituents ascorbic acid and β carotene as per standard procedures.

The data on the observation recorded and the characters studied were statistically analyzed by the procedure described by Gomez and Gomez (1984) using AGRES software. Wherever the results are significant, the critical difference at 5 per cent level was presented

III. RESULTS AND DISCUSSION

Ca and Fe are an important component of a healthy diet and a mineral necessary for life..The changes on Ca and Fe content of the banana fruits ranged from 18 to 58 and 1.3 to 4.2 mg 100 g^{-1} pulp, respectively (Table 1). Higher Ca content was recorded due to basin irrigation of effluent with 100 and 75 per cent NK (I_4 , I_5), whereas lower Ca content was recorded due to farmer’s practice (I_1). The Ca content was not significantly influenced due to amendments.

Table 1. Effect of effluent irrigation and amendments on Ca, (mg 100 g^{-1} pulp) content of fruits

Irrigation(I)/ Amendments(A)	A_1	A_2	A_3	Mean
I_1	24.0	18.0	22.0	**21.3**
I_2	28.0	26.0	26.0	**26.7**
I_3	29.0	26.0	33.0	**29.3**
I_4	58.0	49.0	50.0	**52.3**
I_5	56.0	50.0	51.0	**52.3**
I_6	33.0	32.0	35.0	**33.3**
I_7	31.0	32.0	36.0	**33.5**
Mean	**37.0**	**33.3**	**36.1**	**35.5**
	I	**A**	**I at A**	**A at I**
SEd	2.9	2.0	5.2	5.3
CD (0.05)	7.2	NS	NS	NS

Table 2. Effect of effluent irrigation and amendments on Fe (mg 100 g^{-1} pulp) content of fruits

Irrigation(I)/ Amendments(A)	A_1	A_2	A_3	Mean
I_1	1.80	1.30	1.60	**1.57**
I_2	2.00	1.90	1.90	**1.93**
I_3	2.10	1.90	2.40	**2.13**
I_4	4.20	3.60	3.70	**3.83**
I_5	4.20	3.70	3.30	**3.73**
I_6	2.40	2.40	2.50	**2.43**
I_7	2.30	2.30	2.60	**2.40**
Mean	**2.71**	**2.44**	**2.57**	**2.58**
	I	**A**	**I at A**	**A at I**
SEd	0.13	0.07	0.2	0.19
CD (0.05)	0.32	0.16	0.5	0.42

Higher Fe content was recorded due to basin irrigation of effluent with 100 per cent NK (I_4). Among the amendments, addition of fly ash (A_1) increased the Fe content (Table 2).

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Table 3. Effect of effluent irrigation and amendments on Mn (mg 100 g $^{-1}$ pulp) of fruits

Irrigation(I)/ Amendments(A)	A_1	A_2	A_3	Mean
I_1	4.20	4.10	4.40	**4.23**
I_2	4.30	4.10	4.50	**4.30**
I_3	4.30	4.20	4.50	**4.33**
I_4	3.60	3.50	3.80	**3.63**
I_5	3.50	3.40	3.30	**3.40**
I_6	4.30	4.20	4.50	**4.33**
I_7	4.40	4.30	4.50	**4.40**
Mean	**4.09**	**3.97**	**4.21**	**4.09**
	I	**A**	**I at A**	**A at I**
SEd	0.41	0.11	0.29	0.29
CD (0.05)	NS	NS	NS	NS

Manganese is an important metal for human health, being absolutely necessary for development, metabolism, and the antioxidant system. The Mn content of the fruits varied from 3.4 to 4.5 mg 100 g^{-1} pulp (Table 3). There was no significant difference observed in Mn content due to fertigation treatments, amendments and interaction effects.

Table 4. Effect of effluent irrigation and amendments on Cu (mg 100 g $^{-1}$ pulp) content of fruits

Irrigation(I)/Amendments(A)	A_1	A_2	A_3	Mean
I_1	0.42	0.41	0.44	**0.42**
I_2	0.41	0.40	0.46	**0.42**
I_3	0.4	0.38	0.46	**0.41**
I_4	0.41	0.36	0.39	**0.39**
I_5	0.41	0.36	0.34	**0.37**
I_6	0.46	0.43	0.47	**0.45**
I_7	0.44	0.40	0.46	**0.43**
Mean	**0.42**	**0.39**	**0.43**	**0.41**
	I	**A**	**I at A**	**A at I**
SEd	0.01	0.01	0.03	0.03
CD (0.05)	0.04	0.02	NS	NS

The Cu content of the fruits varied from 0.34 to 0.47 mg 100 g^{-1} pulp, respectively (Table 4). The Cu content of the fruit was increased due to effluent fertigation with 75 per cent NK (I_7), whereas it was decreased due to basin irrigation of effluent with 75 per cent NK (I_5). Among the amendments, addition of fly ash + compost + green manure (A_3) increased the Cu content, while incorporation of biocompost(A_2) reduced it.

Table 5. Effect of effluent irrigation and amendments on Zn (mg 100 g $^{-1}$ pulp) content of fruits

Irrigation (I)/ Amendments (A)	A_1	A_2	A_3	Mean
I_1	0.36	0.36	0.46	**0.39**
I_2	0.32	0.30	0.40	**0.34**
I_3	0.30	0.30	0.38	**0.33**
I_4	0.36	0.38	0.46	**0.40**
I_5	0.38	0.36	0.48	**0.39**
I_6	0.39	0.41	0.48	**0.43**
I_7	0.38	0.38	0.46	**0.41**
Mean	**0.36**	**0.35**	**0.44**	**0.38**
	I	**A**	**I at A**	**A at I**
SEd	0.01	0.01	0.03	0.03
CD (0.05)	0.04	0.02	NS	NS

Zinc is an essential trace element for humans and other animals.Nearly two billion people in the developing world are deficient in zinc. In children it causes an increase in infection and diarrhea, contributing to the death of about 800,000 children worldwide per year. The World Health Organization advocates zinc supplementation for severe malnutrition and diarrhea.. In this present study. The Zn content of the fruits varied from 0.30 to 0.48 mg 100 g^{-1} pulp, respectively (Table 5). Among the irrigation treatments, Zn content of the fruits were increased due to effluent fertigation with 75 per cent NK (I_6) and among the amendments, Zn content of the fruit was increased due to addition of fly ash + compost + green manure(A_3). Interaction effects between irrigation and amendment on Zn were not significant.

Table 6. Effect of effluent irrigation and amendments on ascorbic acid (mg 100 g $^{-1}$ of pulp) content of banana fruits

Irrigation(I) /Amendments(A)	A_1	A_2	A_3	Mean
I_1	7.91	7.61	8.22	**7.91**
I_2	8.89	8.43	9.37	**8.90**
I_3	8.78	8.33	9.24	**8.79**
I_4	5.74	5.56	5.91	**5.74**
I_5	5.66	5.49	5.83	**5.47**
I_6	9.40	8.87	9.92	**9.40**
I_7	9.14	8.64	9.63	**9.13**
	7.93	**7.56**	**8.30**	
	I	**A**	**I at A**	**A at I**
SEd	0.37	0.22	0.61	0.59
CD (0.05)	0.90	0.48	NS	NS

Lack of vitamin C may cause scurvy, which may eventually lead to death. In this present study, ascorbic acid content of banana fruits ranged from 7.61 to 9.91 mg 100g^{-1} of fruits (Table 6). Effluent fertigation with 75% NK (I_6) increased ascorbic acid content of banana fruits. Among the amendments tried combined application of fly ash + biocompost + green manure (A_3) recorded higher ascorbic acid content.

Table 7. Effect of effluent irrigation and amendments on β carotene content (Retinol equivalent (RE) µg/100 g) of banana fruits

Irrigation(I) /Amendments(A)	A_1	A_2	A_3	Mean
I_1	81	78	84	**81**
I_2	59	57	60	**59**
I_3	58	56	60	**58**
I_4	91	86	96	**91**
I_5	90	85	94	**90**
I_6	96	91	101	**96**
I_7	93	88	98	**93**
Mean	**81**	**77**	**85**	**81**
	I	**A**	**I at A**	**A at I**
SEd	3.81	2.22	6.13	5.96
CD (0.05)	8.15	4.75	13.5	12.75

The study revealed that β carotene content of banana fruits ranged from 78- 101 (RE) µg 100g^{-1} (Table 7). Irrigation with effluent fertigation with 75 per cent NK (I_6) recorded higher β carotene content of banana fruits. Among the amendments application of green manure along with fly ash and biocompost (A_3) recorded higher values.

Table 8. Effect of effluent irrigation and amendments on fruit yield (t ha^{-1})

Irrigation(I)/Amendments(A)	Yield			
	A_1	A_2	A_3	Mean
I_1	68	61	76	**68**
I_2	116	103	129	**116**
I_3	113	101	126	**113**
I_4	51	45	56	**51**
I_5	48	43	48	**47**
I_6	130	116	144	**130**
I_7	123	109	136	**123**
Mean	**93**	**83**	**102**	
	I	**A**	**I at A**	**A at I**
SEd	5.7	3.0	8.6	7.9
CD (0.05)	14.1	6.4	NS	NS

Fertigation treatments (I_6, I_7, I_2, I_3) recorded higher yield than basin irrigation treatments (I_4, I_5) and farmer's practice (I_1). The amendments also had significant effect on the yield of banana. The yield obtained from the field trial varied from 43 to 144 t ha^{-1} (Table 8). The yield was increased (130 tha^{-1}) due to effluent fertigation with 75 per cent NK (I_6), followed by I_7 (123 t ha^{-1}), whereas it was less due to basin irrigation of effluent with 75 per cent NK (I_5). Among the amendments, addition of fly ash + compost + green manure (A_3) increased the yield, while incorporation of biocompost (A_2)reduced it. Interaction between irrigation (fertigation) and amendments was not effective in producing significant differences in banana yield. However, the highest yield (144 t ha^{-1}) was recorded due to fertigation of effluent with 75 per cent NK with incorporation of fly ash + compost + green manure (I_6A_3) , while the lowest yield (43 tha^{-1}) was recorded due to basin irrigation of effluent with 100 per cent NK with compost (I_4 A_2).

IV. CONCLUSION

The mineral contents *viz.*, Ca, Mg, Fe, Mn, Cu, Zn and vitamins (ascorbic acid and **β** carotene) were higher due to fertigation of effluent with 75 per cent NK. Similarly among the amendments, application of fly ash + biocompost + green manure increased the mineral contents. This might be due to fertigation effect and supply of minerals constantly by the effluent might have increased mineral content. The study indicated that the treated paper board mill effluent can be used for drip fertigation without losing minerals, vitamins and yield of banana fruits.

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