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Impact of Paper Mill Treated Effluent Irrigation and Solid Wastes Amendment on the Productivity of Cumbu Napier (CO- 3) -A Field Study

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Abstract : In this investigation productivity of Cumbu Napier (CO- 3) fodder grass under effluent irrigation and solid waste application was evaluated. The field experiment with solid waste incorporation coupled with effluent irrigation for Cumbu Napier grass revealed that effluent irrigation increased the biomass yield of the grass by 7.35 % in the second harvest and 10.35 % in the third harvests over well water irrigation, even though, lower yield was obtained in the first harvest due to initial establishment problem under effluent irrigation. This suggests that growing Cumbu Napier grass under treated paper mill effluent for enhanced fodder production to support dairy units is a viable option which needs a positive consideration. The increase in grass biomass yield under I_2T_4 (Effluent irrigation coupled with Fly ash 10 t ha^{-1}+ Bio sludge 6 t ha^-1 + 75% NPK over I_1T_1(100% NPK) was 44.7 percent during II cutting and 52.6 percent in III cutting. The soil available N, and organic carbon were also significantly the highest under Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK treatment as compared to 100% NPK alone.

Key words : Paper mill effluent, Cumbu Napier , Fly ash, Bio sludge, Lime sludge, vermiculite.

Introduction

The paper mills are generating appreciable quantities of solid wastes and effluent everyday. The scientific ways and means of recycling these wastes in an integrated, eco friendly manner had been the main objective of this study. In India, a tropical country, drought conditions and depletion of ground water sources necessitate alternate irrigation sources. The scarce irrigation water sources can be augmented by the waste water from pulp and paper industry (Oblisami and Palanisami,1991).

In the paper mill, the production of bleached kraft pulp normally generates several inorganic residues including ashes, fly ashes, dregs and grits as well as organic residues including primary clarifier sludge and brown stock screening rejects (Springer,1993 and Sherman,1995). Regarding the disposal of solid wastes, probably the most sound approach from the economic and ecologic stand points over the long run would be the disposal of such organic wastes on land amendments for crop production. To confirm such possibilities present study was undertaken.

Materials and Methods

The field experiment was laid out in split plot design with three replications. The treatment details are given below:

Treatment details

I. Main plot treatments – Irrigation sources

I 1 – Well water Irrigation

I 2 - Treated effluent irrigation

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II Sub plot treatments – Solid wastes

T1 - Control (100% NPK)

T2 - Bio sludge 12 t ha-1 + 75% NPK

T3 - Limesludge 12 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK

T4 - Fly ash 10 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK

T5 - Vermiculite 5 t ha-1 + 75%NPK

Cumbu Napier (CO3) was used as the test crop. Rooted slips of Cumbu Napier grass wee plated at the rate of one slip per bill at a spacing of 75 x 60 cms. The area of each plot was 18 m2. The net plots were harvested and treatment wise yield was recorded by cutting stalks close to the ground level. Soil samples were collected periodically and analysed for PH,EC,OC and available N.

Results

The Characteristics of the treated paper mill effluent, mill water and solid wastes used in the field experiment are tabulated in Tables 1-3. The initial characteristics of the experimental field soil is tabulated in Table 4.

Biomass yield (Table 5)

In the first harvest, well water irrigation (I1) recorded significantly higher yield of 171.3 kg/plot than effluent irrigation (I2) of 93.1 kg/ plot. In the second harvest, effluent irrigation (I2) and well water irrigation performed equally good and there was no significant difference between them. But at the third harvest, the highest mean yield of 132.3 kg/plot was observed under effluent irrigation (I2).

In the third harvest, the interactions between irrigation sources and solid waste treatments revealed that the biomass yield ranged from 97kg/plot (I1T4) to 148.0 kg/ plot (I2T4). The highest biomass yield was recorded in the treatment T4 which received 10 t ha-1 of Fly ash + 6 t ha-1 of Bio sludge + 15%NPK under both irrigations I1T4 (135.3 kg/plot) and I2T4(148.0kg/plot)

Soil pH(Table 6)

It was observed that the pH increased with the advancement in crop growth. Regarding irrigation sources, the highest pH of 7.63 was observed under well water irrigation (I1) on the 30^{th} day after planting. Solid waste treatment T3 (Lime sludge 10 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK) recorded the highest pH under both irrigations. PH was not influenced by the interaction between irrigation sources and solid waste application.

Soil electrical conductivity: (Table 7)

It was observed that as the stages of crop growth advanced, the electrical conductivity (dSm-1) increased with respect to irrigation sources. Effluent irrigation recorded the highest EC at the state of first harvest, while well water irrigation recorded the lowest EC on the 30^{th} day of planting.

The interaction I2T4 (effluent irrigation together with Fly ash 10 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK) recorded the highest EC of 1.70 dS m-1.

Soil Organic Carbon (Figure-1)

The order of soil organic carbon content at different stages of crop growth was as follows: 30 D < 60 D <90 D < I cut < 30 D after I cut < II cut < 30 D after II cut < III cut. All the stages were significantly different from each other. In all the stages of crop growth, the treatments receiving effluent irrigation (I2) registered higher OC content than under well water irrigation (I1). Among the solid wastes, T3 (Lime sludge 10 t ha-1 + Bio sludge 6t ha-1 + 75%NPK) recorded the highest OC present under both effluent irrigation and well water irrigation.

Available Solid nitrogen

The trend of soil available nitrogen during the crop growth period is depicted in Figure 2. It was observed that as the crop growth stages progressed the available nitrogen content decreased. After each harvest, nitrogen was supplemented in the form of urea and there was increase in the N content at 30 days after each cut.

The highest N content of 195.6kg ha-1 was observed under effluent irrigation (I2) on the 30th day after planting. While considering solid wastes application, T4 (Fly ash 10 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK) recorded the highest soil N content of 187.8kg ha-1 under effluent irrigation (I2).

Discussion

The yield of Cumbu Napier was higher under effluent irrigation in the II and III cutting, but, well water irrigation enhanced yield even during the I harvest. The decrease in yield during the I harvest, under effluent irrigation was probably due to initial shock in the establishment of the slips, since the slips of Cumbu Napier grass procured from TNAU are normally cultivated under fresh water. Use of the treated paper mill effluent could have delayed the rooting and initial establishment of the slips. The increase in biomass yield under I2 T4 (Effluent irrigation together with Fly ash 10 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK) over I1T1 (100%NPK) was 44.71% during II cutting and 52.57% in III cutting. This might be due to increased available nutrient content which could have led to greater utilization of nutrients by the crops resulting in higher yields. The same is corroborated by the similar findings of Sathish kumar (2002)

The soil pH increased progressively with both, well water and effluent irrigation, because of their slightly alkaline nature. PH also increased with the application of solid wastes which corroborated with the findings of Olaniya *et al.*, 1991. Among the treatments T3 (Limesludge 10 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK) registered the highest pH in all the stages because of the very high alkaline nature (11.31) of the limesludge.

The EC of the soil increased at all stages of crop growth due to continuous effluent irrigation and incorporation of solid wastes, the increase being 0.46 units during an year of effluent irrigation and 0.72 units under Fly ash + Bio sludge over I1T1. The soluble salts present in the effluent and solid wastes contributed to the increase in EC of the soil.

There was a gradual increase in organic carbon content of soil irrigated with effluent irrespective of the solid wastes incorporation. The increase in organic carbon content of the treated effluent irrigated soil might be due to higher concentration of suspended solids in the effluent, which could contribute to the build up of organic matter. This is in agreement with the findings of several workers (Someshekar *et al.*, 1984: Jawarkar and Subrahmanyam,1987: Kannan and Oblisami,1990: Hameed Sulaiman,1997). The build up of organic matter under effluent irrigation would sustain soil health and enhance soil productivity. Among the treatments, Fly ash and Bio sludge combination increased the organic carbon content by 52.6% and Bio sludge alone by 33.3% over I1T1. In recent days, the recycling of organic solid wastes are recommended for the build up of soil organic carbon.

The soil available nitrogen in the treatment T4 (Fly ash 10 t ha-1 + Bio sludge 6 t ha-1 + 75%NPK) irrigated with effluent recorded significantly higher available N content of 5.32% over the control (100%NPK) under well water irrigation. This could be due to the mineralization of nitrogen from Bio sludge and the suspended solids of the effluent leading to an increase in available nitrogen content. Observed high available nitrogen in Fly ash applied plots were also in corroboration with earlier workers(Camphell *et al.*, 1983, Warambhe *et al.*, 1992, Gupta and Chowdhary 1995).

Conclusion

Productivity of Cumbu Napier (CO 3) fodder grass under effluent irrigation and solid waste application was evaluated. Solid waste incorporation coupled with effluent irrigation for Cumbu Napier grass revealed that effluent irrigation increased the biomass yield of the grass by 7.35 % in the second harvest and 10.35 % in the third harvests over well water irrigation, however, lower yield was obtained in the first harvest. due to. This suggests that growing Cumbu Napier grass under treated paper mill effluent for enhanced fodder production to support dairy units is a viable option which needs a positive consideration.

Table 1 : Physico chemical characteristics of the secondary treated paper mill effluent

S.No.	Parameters	Units	Range of values
1	Color	CU	150
2	pH	-	7.1-7.6
3	EC	dSm^{-1}	0.9-1.3
4	TSS	$mg\ L^{-1}$	20-30
5	TDS	$mg\ L^{-1}$	680-710
6	BOD	$mg\ L^{-1}$	Oct-14
7	Calcium	$mg\ L^{-1}$	196-216
8	Magnesium	$mg\ L^{-1}$	90-146
9	Sodium	$mg\ L^{-1}$	123-137
10	Potassium	$mg\ L^{-1}$	18-19
11	Chloride	$mg\ L^{-1}$	170.4
12	Sulphate	$mg\ L^{-1}$	124-132
13	Carbonate	$mg\ L^{-1}$	0
14	Bicarbonate	$mg\ L^{-1}$	98-146
15	Soluble sodium	%	19-24
16	Ammoniacal nitrogen	$mg\ L^{-1}$	28-30

Table 2 : Characteristics of well water used in the field experiments

S.No.	Parameters	Units	Range of values
1	Color	-	colorless
2	pH	-	7.4-7.8
3	EC	dSm^{-1}	0.7-0.8
4	Total alkalinity	$mg\ L^{-1}$	140-170
5	Total hardness	$mg\ L^{-1}$	220-240
6	Dissolved oxygen	$mg\ L^{-1}$	6.4-8.4
7	BOD	$mg\ L^{-1}$	0.6-2.4

8	Calcium	mg L^{-1}	40-70
9	Magnesium	mg L^{-1}	24-33
10	Chloride	mg L^{-1}	177-350
11	Sulphate	mg L^{-1}	26.5-31.5
12	Carbonate	mg L^{-1}	24-72
13	Bicarbonate	mg L^{-1}	98-146
14	Sodium	mg L^{-1}	83-95
15	Potassium	mg L^{-1}	4.5-5.5
16	Ammoniacal nitrogen	mg L^{-1}	25-28

Table 3 : Characteristics of the solid wastes from paper mill used in the experiments

S.No.	Characteristics	Press mud	Fly ash	Bio sludge	Lime sludge
1	pH	7.11	8.32	7.24	11.31
2	EC (dS m^{-1})	1.53	3.03	2.14	4.01
3	Organic Carbon (%)	23.5	4.17	20.64	0.97
4	Total N (%)	1.03	0.48	1.41	0.01
5	Total P (%)	2.2	0.28	0.74	0.02
6	Total K (%)	0.87	0.93	1.21	0.79
7	Calcium (%)	1.61	1.54	2.98	12.75
8	Magnesium (%)	0.39	0.39	1.12	2.28
9	Sodium (%)	0.035	0.041	0.13	0.21
10	C:N ratio	22.8	8.69	14.6	97

Table 4 : Initial characteristics of experimental field soil (Cumbu Napier grass)

S.No	Parameters	Value
1	pH	7.83
2	EC (dS m^{-1})	0.7
3	Total N (%)	0.03
4	Total P (%)	0.54
5	Available N (kg ha^{-1})	191
6	Available P (kg ha^{-1})	10.1
7	Organic C (%)	0.503
8	Ex. Ca [c mol (p+) kg^{-1}]	7.52
9	Ex. Mg [c mol (p+) kg^{-1}]	3.24
10	Ex. Na [c mol (p+) kg^{-1}]	1.78
11	Ex. K [c mol (p+) kg^{-1}]	1.05

Table 5 : Biomass yield of Cumbu Napier grass as influenced by effluent irrigation and solid wastes application during three cuttings

Treatments	Biomass Yield (kg/plot)		
	I cut	II cut	III cut
I_1 T_1	146.3	108.7	97
T_2	182.7	130	126
T_3	175.6	126	121.7
T_4	188.7	132.3	135.3
T_5	163.3	122	119.3
Mean	**171.3**	**123.8**	**119.9**
I_2 T_1	80.7	116	116.3
T_2	97.3	151	139
T_3	95.7	119	137.7
T_4	109.3	157.3	148
T_5	82.7	121	120.3
Mean	**93.1**	**132.9**	**132.3**

	SEd	CD -0.05	SEd	CD -0.05	SEd	CD -0.05
I	0.37	1.61	0.49	2.13	0.52	2.22
T	2.45	5.19	2.08	4.41	2.02	4.28
I x T	3.12	6.71	2.68	5.87	2.61	5.75

I_1-Well water irrigation; I_2 –Effluent irrigation; T_1 - Control (100% NPK); T_2 - Bio sludge 12 t ha^{-1} + 75% NPK; T_3 – Lime sludge 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK; T_4 - Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK; T_5 - Vermiculite 5 t ha^{-1} + 75% NPK

Table 6 : Soil pH as influenced by effluent irrigation and solid wastes application under Cumbu Napier grass at different stages of crop growth

Treatments	30 D	60 D	90 D	I cut	30 D after I cut	II cut	30 D after II cut	III cut	Mean
I_1 T_1	7.85	7.94	7.97	7.98	7.89	7.92	7.93	7.95	**7.93**
T_2	7.94	8.02	8.04	8.09	8.01	8.04	8.06	8.08	**8.04**
T_3	8.3	8.35	8.37	8.39	8.3	8.35	8.37	8.38	**8.35**
T_4	8.09	8.17	8.14	8.21	8.15	8.18	8.2	8.23	**8.17**
T_5	7.99	8.06	8.07	8.09	8.03	8.05	8.06	8.08	**8.05**
Mean	**8.03**	**8.11**	**8.12**	**8.15**	**8.08**	**8.11**	**8.12**	**8.14**	**8.11**
I_2 T_1	7.93	8.04	8.04	8.06	8.02	8.04	8.05	8.05	**8.03**
T_2	8.01	8.07	8.09	8.12	8.03	8.15	8.17	8.19	**8.1**
T_3	8.43	8.48	8.49	8.52	8.44	8.48	8.49	8.52	**8.48**
T_4	8.21	8.27	8.27	8.29	8.23	8.28	8.27	8.28	**8.26**
T_5	8.09	8.15	8.13	8.11	8.04	8.09	8.11	8.14	**8.11**
Mean	**8.13**	**8.2**	**8.2**	**8.22**	**8.15**	**8.21**	**8.22**	**8.24**	**8.2**

	I	T	I x T	D	DxI	DxT
SEd	0.03	0.04	NS	NS	NS	NS
CD (0.05)	0.05	0.09	NS	NS	NS	NS

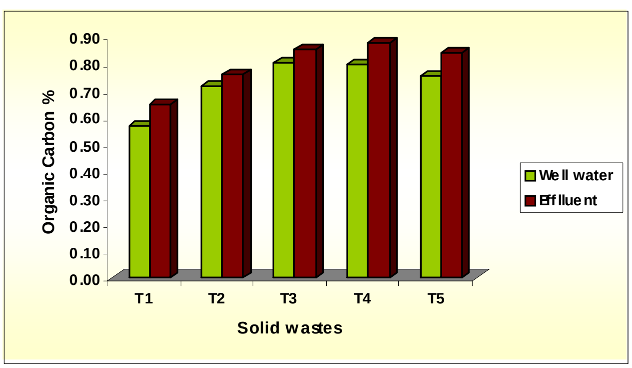
I_1-*Well water irrigation;* ***I_2*** *–Effluent irrigation;* ***T_1*** *- Control (100% NPK);* ***T_2*** *- Bio sludge 12 t ha^{-1} + 75% NPK;* ***T_3*** *– Lime sludge 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_4*** *- Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_5*** *- Vermiculite 5 t ha^{-1} + 75% NPK*

Table 7 : Soil EC (dS m^{-1}) as influenced by effluent irrigation and solid wastes application under Cumbu Napier grass at different stages of crop growth

Treatments	30 D	60 D	90 D	I cut	30 D after I cut	II cut	30 D after II cut	III cut	Mean
I_1 T_1	0.8	0.8	0.9	1	0.9	1.1	1.1	1.2	**0.98**
T_2	0.9	1	1.2	1.3	1.1	1.2	1.1	1.3	**1.14**
T_3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	**1.3**
T_4	1.2	1.4	1.6	1.7	1.5	1.7	1.6	1.8	**1.56**
T_5	1.1	1.1	1.3	1.4	1.2	1.3	1.4	1.5	**1.29**
Mean	**1.06**	**1.12**	**1.26**	**1.34**	**1.2**	**1.32**	**1.3**	**1.42**	**1.25**
I_2 T_1	1	1.2	1.4	1.6	1.3	1.4	1.3	1.4	**1.33**
T_2	1	1.2	1.4	1.5	1.2	1.3	1.4	1.5	**1.31**
T_3	1.5	1.7	1.9	2	1.6	1.9	1.7	1.8	**1.76**
T_4	1.3	1.5	1.7	1.9	1.6	1.8	1.9	1.9	**1.7**
T_5	1.2	1.4	1.6	1.8	1.5	1.7	1.6	1.7	**1.56**
Mean	**1.2**	**1.4**	**1.6**	**1.76**	**1.44**	**1.62**	**1.58**	**1.66**	**1.53**

	I	T	I x T	D	DxI	DxT
SEd	0	0.01	0.01	0	0.01	0.02
CD (0.05)	0.01	0.01	0.02	0.01	0.02	0.04

I_1-*Well water irrigation;* ***I_2*** *- Effluent irrigation;* ***T_1*** *- Control (100% NPK);* ***T_2*** *- Bio sludge 12 t ha^{-1} + 75% NPK;* ***T_3*** *– Lime sludge 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_4*** *- Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_5*** *- Vermiculite 5 t ha^{-1} + 75% NPK*



T_1 *- Control (100% NPK);* ***T_2*** *- Bio sludge 12 t ha^{-1} + 75% NPK;* ***T_3*** *– Lime sludge 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_4*** *- Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_5*** *- Vermiculite 5 t ha^{-1} + 75% NPK*

Fig. 1 : Soil Organic carbon as influenced by solid wastes application and sources of irrigation under Cumbu Napier grass

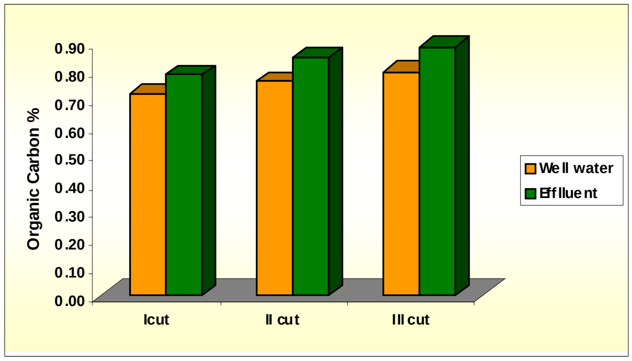
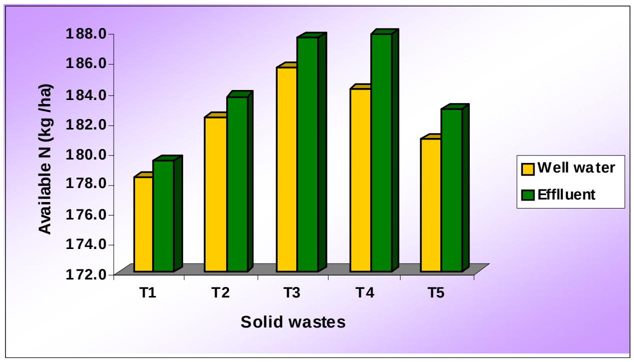


Fig. 2 : Soil Organic Carbon after each cutting of Cumbu Napier grass as influenced by sources of irrigation



T_1 *- Control (100% NPK);* ***T_2*** *- Bio sludge 12 t ha^{-1} + 75% NPK;* ***T_3*** *– Lime sludge 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_4*** *- Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1} + 75% NPK;* ***T_5*** *- Vermiculite 5 t ha^{-1} + 75% NPK*

Fig. 3 : Available Nitrogen o f soil as influenced by solid waste application and sources of irrigation under Cumbu Napier grass

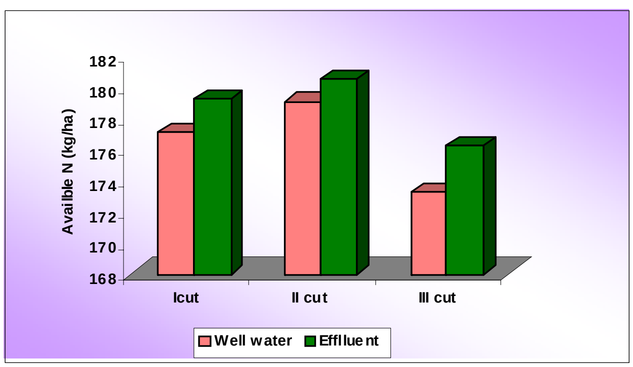


Fig. 4 : Available Nitrogen of soil after each cutting of Cumbu Napier grass as influenced by sources of irrigation

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