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Impact of Paper Board Mill Solid Sludge Biocompost and Treated Effluent Irrigation on Growth and Yield Attributes of Vegetable Cowpea

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Abstract: Field experiment was conducted in Alfisol (red sandy loam) at Balalpur Industrial Packaging Company Limited (BIPCO) model farm, Mettupalayam, Tamil Nadu, to assess the impact of paper board mill sludge biocompost and treated paper board mill effluent irrigation on growth and yield of vegetable cowpea, (CO 2). Application of sludge biocompost by mixing sludge, fly ash, coir pith @ 2:1:1 ratio along with recommended level of NPK (20:20:60 kg NPK ha^{-1}) under treated effluent irrigation produced the highest vegetable cowpea yield of 6500 kg ha^{-1} as against 5325 kg ha^{-1} in FYM + 100% NPK. There were no adverse effect on soil physical and biochemical properties due to sludge biocompost application. The quality of the vegetable cowpea *viz.* protein and fibre content were not affected due to sludge biocompost application along with effluent irrigation. The treated effluent which complies the state pollution control board norms can be used for raising vegetable cowpea along with sludge biocompost @ 6 t ha^{-1} with out any adverse effect on soil and crop quality.

Key words: Paper board sludge biocompost - treated effluent - vegetable cowpea.

Introduction

In order to meet the production needs in agriculture, the Government of India's working group on fertilizer has estimated that more than 25 mt of NPK may be required by 2010 A.D. On no account, fertilizers or any single input can provide such large quantities of plant nutrients. So all available nutrient sources have to be tapped to meet the target.

Since 1950s, benefits associated with the land application of paper mill effluent and sludges have been recognized from spray irrigation studies. Subsequent research on paper sludge utilization in agriculture and forestry have shown numerous benefits like increased plant growth, yield and improved soil moisture and soil moisture retention etc. (Bellary *et al.* 1995; Udayasoorian *et al.* 1991).

In addition, integrated use of mineral, organics and usable waste is necessary for sustaining high crop yield. A field experiment was conducted to assess the impact of paper mill sludge biocompost and treated effluent irrigation on growth, yield and quality of vegetable cowpea.

Materials and Methods

The solid sludge obtained from the paper board mill was mixed with different solid wastes *viz.* Effluent Treatment Plant Sludge (ETPS + FA + CP + Farm Yard Manure (FYM) @ 2:1, 2:1:1, 2:1:1:1 ratios respectively and composted in heaps under shade using *Bacillus* sp. and *Pleurotus sajor-caju* @ 5 L per tonne and 5 packets per tonne of raw materials (each pack weigh about 500 gm). The nutrient status of sludge biocompost is given in Table 3. Three composts were selected based on nutrient status for land application.

Treated effluent samples were obtained from the outlet at BIPCO model farm Thekkampatti, Mettupalayam, Tamil Nadu. The samples collected were analysed for physical and biochemical properties as per the methods detailed in standard methods for the examination of water and waste water (APHA, 1985).

The biocomposts obtained were applied @ 6 t ha^{-1} along with 50% and 100% level of recommended NPK (20:60:60 kg NPK ha^{-1}) and the performance of these biocomposts was evaluated along with FYM @ 12.5 t ha^{-1} + 100% NPK and control (100% NPK

Table 1. Characteristics of treated effluent and well water

Sl. No	Characteristics	Unit effluent	Treated BIPCO	Well water
1.	Colour		Colourless	Colourless
2.	Odour		Slight phenolic	Odourless
3.	TDS	mg L^{-1}	780.80	46.00
4.	Suspended solids	mg L^{-1}	84.00	-
5.	Total solids	mg L^{-1}	864.80	46.00
6.	pH		7.95	7.50
7.	EC	dSm^{-1}	1.22	0.62
8.	Dissolved oxygen	mg L^{-1}	4.10	8.75
9.	Biological oxygen demand	mg L^{-1}	10.60	7.50
10.	Chemical oxygen demand	mg L^{-1}	148.00	18.95
11.	Total organic carbon	%	0.65	0.22
12.	Exchangeable Ca	cmol L^{-1}	7.68	2.12
13.	Exchangeable Mg	cmol L^{-1}	0.47	0.13
14..	Exchangeable Na	cmol L^{-1}	31.97	13.11
15.	Exchangeable K	cmol L^{-1}	0.17	0.11
16.	Per cent Na		17.81	-
17.	CO_3	mg L^{-1}	Trace	-
18.	HCO_3	mg L^{-1}	95.20	-
19.	SO_4	mg L^{-1}	105.00	9.00
20.	Cl	mg L^{-1}	313.00	15.00
21.	SAR		15.83	-
22.	Bacteria	x 10^5 cfu ml^{-1}	19.20	7.4
23.	Fungi	x 10^4 cfu ml^{-1}	7.50	2.2
24.	Actinomycetes	x 10^3 cfu ml^{-1}	9.10	2.1

alone).The impact of biocomposts and effluent irrigation on yield and quality of vegetable cowpea was studied by conducting a field experiment in FRBD and replicated thrice. Vegetable cowpea seeds were sown on either side of the ridges at a spacing of 15 cm between plants during the second week of March 2001 and harvested during the month of May 2001. After cultivation operations were carried out as recommended by TNAU crop production guide (1999). All the recorded data were subjected to statistical scrutiny following the method, described by Panse and Sukhatme, 1985.

Results and Discussion

Characteristics of treated board mill effluent

The paperboard mill treated effluent was colourless with slight phenolic odour in nature. The phenolic odour of the effluent might be due to the presence of hydrogen sulphides. The effluent contained considerable amount of total and suspended solids, which are considered as important parameters in evaluating the suitability of effluent for irrigation since these solids may clog the soil pores and components of water distribution system (Feign *et al.* 1991), The treated paperboard mill effluent contains higher amount of total dissolved solids and suspended solids. The pH of the effluent was neutral with the EC value of 1.22 dSm^{-1}. The effluent had appreciable amount of Ca, Mg, Na, K, carbonates, bicarbonates, sulphates and chlorides (Table 2). The effluent was used for irrigating vegetable cowpea crop because of the concentration of all the above said parameters were well within the limits as prescribed by the State Pollution Control Board.

Table 2. Initial charcteristics of experimental soil

Sl.No.	Parameters	Unit	Values
1	Bulk density	Mg m^{-3}	1.06
2	Particle density	Mg m^{-3}	2.04
3	Pore spare	per cent	18.98
4	pH		7.40
5	EC	dSm^{-1}	0.32
6	Total organic carbon	%	0.36
7	Available nitrogen	kg ha^{-1}	142
8	Available phosphorus	kg ha^{-1}	13.2
9	Available potassium	kg ha^{-1}	190
10	Exchangeable calcium	c mol (p+) kg^{-1}	1.18
11	Exchangeable magnesium	c mol (p+) kg^{-1}	2.86
12	Exchangeable sodium	c mol (p+) kg^{-1}	1.30
13	DTPA Fe	mg L^{-1}	7.20
14	DTPA Zn	mg L^{-1}	4.10
15	DTPA Cu	mg L^{-1}	1.80
16	DTPA Mn	mg L^{-1}	2.40
17	Bacteria	x 10^5 cfu g^{-1} of dry soil	15.21
18	Fungi	x 10^4 cfu g^{-1} of dry soil	8.20
19	Actnomycetes	x 10^3 cfu g^{-1} of dry soil	12.10

Table 3. Nutritional status of paperboard mill biocompost

Sl.No.	Biocompost	N (%)	P (%)	K (%)	Organic carbon (%)	C/N ratio
1.	ETPS + FA	0.82	0.19	0.55	19.80	24.15
2.	ETPS + FA + CP	0.79	0.19	0.56	20.10	25.44
3.	ETPS + FA + CP + FYM	0.80	0.19	0.56	20.10	20.10

ETPS - Effluent Treatment Plant Sludge; FA - Fly ash; CP - Coir pith ; FYM - Farmyard manure

Characteristics of well water

The well water used for irrigation was colourless with neutral pH and the EC was well below that of treated effluent. The dissolved oxygen was higher than that of effluent. The well water showed very low level of nutrients, anions and cations. The microbial load also was found to be very low.

Characteristics of paper board mill solid wastes

The pH of ETPS and fly ash were 7.97 and 8.01 respectively. The EC of fly ash was higher (2.38 dSm^{-1}) and the EC value for sludge (0.036 dSm^{-1}) found to be lower. The initial organic carbon content of the sludge was higher (28.28%) and found to be rich in total N and Ca where as fly ash recorded the highest value of total P, K and Mg. The ETPS had higher micronutrients status for Zn, Fe, Mn whereas fly ash showed higher value for Cu.

Vegetable cowpea is an important pulse crop grown in south India. Vegetable cowpea crop was selected for the present investigation because of the season and it is one of the important crops grown by farmers in the adjacent area where BIPCO effluent is used for land application. Application of composted paperboard mill biomanure and treated effluent irrigation clearly produced taller and stronger plants than well water irrigation. Among the treatments biomanure sludge + fly ash + coir pith with 100% NPK had a marked influence on growth

Table 4. Influence of paper board mill sludge biocompost and treated effluent irrigation on growth attributes of vegetable cowpea.

Treatments	Plant height (cm)		Root length (cm)		No. of branches plant^{-1}		Leaf area (cm^2)		No. of nodules plant^{-1}	
	WW	TE	WW	TE	WW	TE	WW	TE	WW	TE
T_1	58.60	59.20	19.00	20.10	10	10	559.2	624.1	13	13
T_2	60.20	60.10	20.10	22.50	11	10	576.5	725.2	14	15
T_3	57.20	58.10	20.10	22.30	10	10	547.1	652.2	16	16
T_4	56.00	57.20	22.10	22.10	9	9	732.1	734.2	17	17
T_5	54.30	55.10	22.10	24.30	9	9	676.1	680.2	16	17
T_6	63.30	65.40	24.30	26.20	12	13	832.1	840.2	23	25
T_7	55.30	56.30	20.40	22.50	9	10	785.2	790.2	19	19
T_8	56.40	57.10	20.50	22.50	9	9	819.4	823.2	20	20
	SEd	CD	SEd	CD	SEd	CD	SEd	CD	SEd	CD
I - Irrigation sources	0.293	0.597	0.074	0.152	2.888	0.588	0.175	0.357	0.449	0.919
T - Treatments	0.585	1.975	0.148	0.303	0.576	1.177	0.349	0.714	0.899	1.838
I x T	0.828	1.690	0.209	0.429	0.815	1.664	0.494	1.000	1.273	2.599

T_1 - NPK alone (Control)
T_2 - FYM - 100% NPK
T_3 - Biocompost (ETPS + FA) + 50% NPK
T_4 - Biocompost (ETPS + FA) + 100% NPK
T_5 - Biocompost (ETPS + FA+CP) + 50% NPK
T_6 - Biocompost (ETPS + FA+CP) + 100% NPK
T_7 - Biocompost (ETPS + FA+CP+FYM)+50% NPK
T_8 - Biocompost (ETPS + FA+CP+FYM)+100% NPK

ETPS - Effluent Treatment Plant Sludge; FA - Fly ash; CP - Coir pith; FYM - Farm yard manure; WW - Well water; TE - Treated effluent

Table 5. Effect of paper board mill solid sludge biocompost and irrigation sources on yield attributes of vegetable cowpea.

Treat-ments	No. of pods plant^{-1}		Pod length (cm)		No. of seed pod^{-1}		Seed test weight (gm)		Pod yield kg ha^{-1}	
	WW	TE	WW	TE	WW	TE	WW	TE	WW	TE
T_1	10	10	17	17	13	14	11.9	14.50	4800	5100
T_2	10	11	18	18	15	15	14.2	14.30	4900	5325
T_3	11	11	18	18	14	15	14.2	14.30	4950	5325
T_4	11	12	19	19	16	17	14.7	15.30	5020	5420
T_5	12	11	18	18	15	15	14.3	14.25	5125	5475
T_6	14	16	21	21	17	19	16.2	10.70	6200	6500
T_7	12	12	18	18	16	16	14.7	14.70	5320	5440
T_8	13	14	19	19	16	17	15.9	15.90	4345	5460
	SEd	CD	SEd	CD	SEd	CD	SEd	CD	SEd	CD
I - Irrigation sources	0.289	0.589	0.258	0.527	0.276	0.564	0.122	0.249	6.572	13.42
T - Treatments	0.577	1.179	0.516	1.055	0.553	1.129	0.244	0.499	13.14	26.64
I x T	0.817	1.668	0.730	1.491	0.781	1.597	0.346	0.706	18.59	37.96

T_1 - NPK alone (Control)
T_2 - FYM - 100% NPK
T_3 - Biocompost (ETPS + FA) + 50% NPK
T_4 - Biocompost (ETPS + FA) + 100% NPK
T_5 - Biocompost (ETPS + FA+CP) + 50% NPK
T_6 - Biocompost (ETPS + FA+CP) + 100% NPK
T_7 - Biocompost (ETPS + FA+CP+FYM)+50% NPK
T_8 - Biocompost (ETPS + FA+CP+FYM)+100% NPK

ETPS - Effluent Treatment Plant Sludge; FA - Fly ash; CP - Coir pith; FYM - Farm yard manure; WW - Well water; TE - Treated effluent characters during the early stages, while N mineralized from organic sources would have aided during later stages of the crop growth. The results on biometric observations clearly indicated the role of biomanure and effluent irrigation in increasing the plant height, shoot length, number of branches plant^{-1}, leaf area, number of nodules plant^{-1}, number of seeds pod^{-1}, seed test weight, number of pods plant^{-1} and pod length. The maximum plant height and root length were recorded with the application of biocompost (ETPS + FA + CP) @ 6 t ha^{-1} under effluent irrigation. Biocompost application along with effluent irrigation increased the leaf area and root nodule formation when compared to FYM +100% NPK and control. The biocompost application increased the pod length and number of seeds per pod. Application of biomass from paper mill solid wastes and effluent irrigation positively influenced the pod yield as well as pod formation.

Production of more pods in the present study with biomanure obtained from sludge + fly ash + coir pith and effluent irrigation might be due to the adequate supply of assimilates at the productive stage leading to increased number of pods. This may also be due to the favourable soil biochemical condition provided due to additions of biocompost besides adequate supply of essential nutrients from effluent irrigation. The biocompost (sludge + fly ash + coir pith) with recommended dose of NPK recorded 27.45 per cent increased pod yield over 100 percent NPK alone. The performance of treated effluent irrigation was found to be superior to well water and recorded 8.26 percent increased pod yield over the well water irrigation. Higher pod yield obtained due to the application of biocompost with 100% NPK combined with effluent irrigation might be attributed to favourable changes that might have occurred due to compost application which in turn resulted in loose and friable soil condition enabling better pod formation. Similarly, effluent irrigation also improved physical and biochemical environment favourable for better pod formation. Moreover the positive effect of these biocompost on vegetable cowpea might be due to slow and steady release of nutrients during mineralization of biocompost which ultimately increased the yield of vegetable cowpea.

In general application of biocompost (sludge + fly ash + coir pith) with 100% of recommended NPK under treated irrigation was found to be superior over FYM + 100% NPK and control (Table 4 and 5). The similar results were obtained in groundnut by Udayasoorian *et al* (1999). It was found that there were no reduction in the protein and fibre content of the vegetable cowpea. The favourable growth parameters observed in the present study on vegetable cowpea might be due to the ameliorative effect of biocompost which could alleviate the ill effects of effluent irrigation. Hence paper board mill sludge biocompost and the treated effluent can be used for irrigating cowpea crop with proper care. Also it was found that there were no adverse effect on soil physical and biochemical properties because of the one time application of biocompost and effluent irrigation.

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