Impact of treated papermill effluent on yield and quality of Bhendi

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Abstract
An attempt has been made to use the treated paperboard mill effluent and well water with STCR recommended NPK, MLSS (Mixed Liquor Suspended Solids) and pressmud compost as nutrient source for cultivating Bhendi crop to assess their impact on yield and fruit quality. Application of MLSS, Presssmud compost had increased the available nutrients (N, P, K) and organic carbon content in the soil. The treatment combination of 50% STCR recommended NPK + 50% MLSS (Mixed Liquor Suspended Solids) + effluent irrigation performed better compared to other treatments. The experimental results revealed that yield of Bhendi under treated effluent irrigation was higher than well water irrigation. The yield increase was recorded as 31.20 percent over the control (100% STCR NPK + well water). The quality parameters viz., crude fibre and total protein were higher under effluent irrigation.

Keywords: Treated papermill effluent, Bhendi, MLSS, STCR NPK, quality parameters

Introduction
Declining freshwater sources for the expanding population is a major concern in the world. To deal with the situations of fresh water shortages it is necessary to focus on the recycling and reuse of the wastewaters generated from various industries. The treated industrial wastewaters can be used for secondary purposes such as agricultural needs for irrigating the crops. (Kansal, 1994) [1] The organic carbon content and available NPK in the soil were found to be increased in the waste water irrigated soils (Singh et al., 2013) [2] and improve the soil fertility. The pulp and paper industry being one of the largest consumers of fresh water releases a huge quantity of effluent which when used to irrigate crops can be an alternative source of plant nutrients. The paper mill effluent irrigation has improved the soil nutrient status (Kumar et al., 2010) [3] and thereby improve the nutrient availability to the crops. Also effluents from some industries have the potential to improve the crop productivity (Sheela and Peethambaram, 2007) [4] without any deterioration of crop quality. (Palaniswami and Ramulu, 1994) [5] Such effective management would bring economic benefits and also prevent environment degradation. The vegetable consumption per capita per day in India is 135 g which is much lower than the requirement of 285 g per day. It shows the necessity to raise the vegetable production by increasing the area for cultivation and also increasing productivity of the crops. Abelmoschus esculentus (L.) is an economically valuable vegetable crop grown widely in tropical and subtropical countries of the world including India. (Kumar and Chopra, 2013) [6]. To combat the struggles of water scarcity and increasing the vegetable production in an effective way, the present investigation was carried out to study the impacts of treated paper mill effluent on Bhendi crop productivity.

Materials and Methods
The experiment was carried out at Seshasayee Papers and Boards Pvt. Ltd., Pallipalayam, Namakkal district of Tamil Nadu during 2019-2020. Bhendi hybrid Co 4 was used in this study and the experiment was laid out in split plot design. The main plot factors was the irrigation source viz., well water (M1) and treated effluent (M2) and the sub plot factors are: 100% STCR recommended NPK (S1), 50% STCR recommended NPK + 50% pressmud compost (S2), 50% STCR recommended NPK + 50% MLSS (S3) and 50% pressmud compost + 50% MLSS (S4). The STCR based NPK recommendation for the soil are: 135 g which is much lower than the recommendation of 285 g per day.
Based on the nutrient status of the soil the STCR (Soil Test Crop Response) recommended NPK was 100:60:98 kg ha$^{-1}$. The growth attributes, plant height was measured from the ground level to the tip of the main stem at interval of 30, 60 and 90 DAS (Days after Sowing). The yield attributes viz., fruit weight, fruit length and girth were recorded. The crude fibre content and total protein was estimated adopting the procedures given by (Chopra and Kanwar, 1976) (Lowry et al., 1951) [7, 8].

Statistical analysis
The statistical tool SPSS (Statistical Package for Social Sciences) was used to compute the ANOVA and determine any significant difference ($P<0.05$) among the factors. The treatment differences that are not significant were noted as Non-Significant (NS).

Results and Discussion
The soil from the experimental field was characterized and found to have 180, 14.1 and 261 kg ha$^{-1}$ of available N, P and K. The pH, EC and organic carbon were 7.79, 0.26 dSm$^{-1}$ and 0.56% respectively. Also, the pressmud compost and MLSS (Mixed Liquor Suspended Solids) were characterized. The pH, EC, organic carbon was 6.89, 1.93 dSm$^{-1}$, 38.10% and 7.63, 1.62 dSm$^{-1}$, 24.10% for pressmud compost and MLSS respectively. The total NPK were 1.53, 0.45 and 1.43, 0.93, 0.89% for pressmud compost and MLSS respectively.

Plant biometric observation
The plant height of bhendi measured on different stages during the growth period influenced by the different treatments is given in Table 1. At the harvest stage highest yield and the organic load present in the pressmud compost + effluent (9.9 t ha$^{-1}$) which received 50% STCR NPK +50% MLSS + effluent. The lowest yield was recorded in M$_1$S$_1$ – 100% STCR NPK +Well water (9.7 t ha$^{-1}$) followed by M$_3$S$_1$ – 100% STCR NPK + effluent (9.9 t ha$^{-1}$). The nutrients present in the treated effluent and the organic load present in the pressmud compost and MLSS have improved the yield of Bhendi crop. Similar results were obtained for different crops like cowpea, (Prasanthrajan et al., 2004) [10] chillies and brinjal (Udayasoorian and Ponmani, 2014 and 2009) [11, 12] when treated effluent combined with organic manures.

Table 1: Effect of treated papermill effluent irrigation on plant height (cm) of Bhendi

| Treatments | 30 DAS | 60 DAS | At harvest |
|------------|--------|--------|------------|
| M$_1$ | 11.87 | 14.07 | 12.87 |
| M$_2$ | 12.87 | 20.37 | 27.17 |
| Mean | 13.87 | 18.07 | 22.07 |

| S$_1$ | 10.75 | 14.07 | 11.87 |
| S$_2$ | 13.87 | 24.37 | 31.27 |
| S$_3$ | 12.87 | 20.77 | 27.57 |
| S$_4$ | 11.87 | 13.27 | 12.54 |
| Mean | 12.07 | 13.62 | 12.24 |

| SEd | CD (0.05) | SEd | CD (0.05) |
|-----|---------|-----|---------|
| M | 2.566 | 5.787 | 0.763 | 1.662 |
| S | 1.533 | NS | 0.933 | 2.032 |
| MS | 1.564 | 3.400 | 1.564 | 3.400 |

M$_1$ – well water; M$_2$ – treated effluent
S$_1$ – 100% STCR NPK, S$_2$ – 50% STCR NPK + 50% Pressmud compost, S$_3$ – 50% STCR NPK +50% MLSS, S$_4$ – 50% Pressmud compost +50% MLSS.

Yield of Bhendi
The treatments received effluent irrigation recorded higher yield than the well water irrigated treatments. The maximum yield of Bhendi was recorded in M$_3$S$_1$ (14.1 t ha$^{-1}$) which received 50% STCR NPK +50% MLSS + effluent. The lowest yield was recorded in M$_1$S$_1$ – 100% STCR NPK +Well water (9.7 t ha$^{-1}$) followed by M$_3$S$_1$ – 100% STCR NPK + effluent (9.9 t ha$^{-1}$). The nutrients present in the treated effluent and the organic load present in the pressmud compost and MLSS have improved the yield of Bhendi crop. Similar results were obtained for different crops like cowpea, (Prasanthrajan et al., 2004) [10] chillies and brinjal (Udayasoorian and Ponmani, 2014 and 2009) [11, 12] when treated effluent combined with organic manures.

Table 2: Effect of treated papermill effluent irrigation and solid waste on bhendi fruit yield (t/ha)

| Treatments | Total yield (t/ha) |
|------------|------------------|
| M$_1$ | 9.7 |
| M$_2$ | 10.5 |
| S$_1$ | 11.6 |
| S$_2$ | 10.7 |
| S$_3$ | 10.7 |
| S$_4$ | 10.7 |
| Mean | 10.63 |

| SEd | CD (0.05) |
|-----|---------|
| M | 0.435 | 0.947 |
| S | 0.468 | 1.020 |
| MS | 0.221 | 0.481 |

M$_1$ – well water; M$_2$ – treated effluent
S$_1$ – 100% STCR NPK, S$_2$ – 50% STCR NPK +50% Pressmud compost, S$_3$ – 50% STCR NPK +50% MLSS, S$_4$ – 50% Pressmud compost +50% MLSS

Fig 1: Effect of treated papermill effluent and solid waste on bhendi fruit yield (t/ha)

| Treatments | Well water | Effluent |
|------------|------------|----------|
| S$_1$ | 10.7 |
| S$_2$ | 10.7 |
| S$_3$ | 10.7 |
| S$_4$ | 10.7 |

Quality parameters
The quality parameters such as crude fibre and total protein were higher in the effluent irrigated treatments compared to well water irrigated treatments which is similar to the results of Kumar and Chopra (2013) [6]. The combination of treated effluent along with organic manures might have provided enough nutrients rich environment and thus improving soil fertility and crop quality of Bhendi. Crops like radish, onion (Prathiba, 2005) [13], ground nut, (Udayasoorian et al., 2004) [14] chillies and brinjal (Udayasoorian and Ponmani, 2009) [11, 12] have also shown similar results when cultivated using treated effluent and organic amendments. The results of fruit weight was higher in effluent irrigated treatments. Similarly in *Allium cepa*, application of organic manure combined with mineral
fertilizers increased bulb qualities like bulb size, total number of bulbs and fresh weight of bulbs (Srivastava et al., 2012).15

Table 3: Effect of treated papermill effluent irrigation and solid waste on Bhendi fruit quality

| Treatments | Crude fibre (%) | Total protein (%) |
|------------|-----------------|------------------|
|            | M1 | M2 | Mean | M1 | M2 | Mean |
| S1         | 12.5 | 12.04 | 12.1 | 1.27 | 1.38 | 1.3 |
| S2         | 12.9 | 13.11 | 13.0 | 1.5 | 1.62 | 1.6 |
| S3         | 13.13 | 13.76 | 13.4 | 1.74 | 1.76 | 1.8 |
| S4         | 13.01 | 13.11 | 13.1 | 1.61 | 1.8 | 1.7 |
| Mean       | 12.8 | 13.0 | 13.0 | 1.5 | 1.6 | 1.6 |

SEd – well water; M1 – treated effluent
S1 - 100% STCR NPK, S2 – 50% STCR NPK + 50% Pressmud compost, S3 – 50% STCR NPK +50% MLSS, S4 – 50% Pressmud compost +50% MLSS.

Table 4: Effect of treated papermill effluent irrigation and solid waste on fruit length and girth (cm) and weight (g) of Bhendi

| Treatments | Length (cm) | Girth (cm) | Weight (g) |
|------------|-------------|------------|------------|
|            | M1 | M2 | Mean | M1 | M2 | Mean | M1 | M2 | Mean |
| S1         | 11.5 | 11.1 | 11.3 | 5.5 | 5.5 | 5.5 | 16.2 | 16 | 16.1 |
| S2         | 11.3 | 9.8 | 10.6 | 5.6 | 5.2 | 5.4 | 14.4 | 14.2 | 14.3 |
| S3         | 11.5 | 11.5 | 11.5 | 5.8 | 5.6 | 5.7 | 13.6 | 15.9 | 14.75 |
| S4         | 10.5 | 11.5 | 11.0 | 5.5 | 5.5 | 5.5 | 15 | 16.7 | 15.85 |
| Mean       | 11.2 | 11.0 | 11.0 | 5.6 | 5.5 | 5.6 | 14.8 | 15.7 | 15.7 |

SEd – well water; M1 – treated effluent
S1 - 100% STCR NPK, S2 – 50% STCR NPK + 50% Pressmud compost, S3 – 50% STCR NPK +50% MLSS, S4 – 50% Pressmud compost +50% MLSS.

Conclusion
Yield and quality of Bhendi under effluent irrigation and solid waste application was evaluated. Solid waste incorporation along with effluent irrigation increased the yield by 31.20%. This suggests that the cultivation of Bhendi with effluent irrigation is a viable option to increase the productivity.

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