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Agro-Potentiality of Treated Paperboard Mill Effluent Along with Organic Amendments on Growth and Yield Characteristics of Okra

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Authors' contributions

This work was carried out in collaboration between both authors. Author KV designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CU managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Field experiment was conducted in Indian Tobacco Company - Paperboards and Specialty Papers Division (ITC-PSPD) model farm, Thekkampatti, Mettupalayam, Coimbatore District, Tamil Nadu to assess the impact of ITC treated effluent and solid wastes on crop growth, yield and quality of okra and soil. The experiment was a 7x2 factorial arranged in a randomized complete block design (RCBD) and replicated three times. The treatment combinations consisted of seven amendments and two sources of irrigation water *(*well water and effluent water). The seven amendments were T_1-Control 100% NPK, T_2-FYM 25 t ha^{-1}+NPK, T_3-ETP Sludge 5 t ha^{-1}+NPK, T_4-Biochar 2.5 t ha^{-1}+NPK, T_5-Vermicompost 3.5 t ha^{-1}+NPK, T_6-Pressmud 6 t ha^{-1}+NPK and T_7-Fly ash 5 t ha^{-1}+NPK. Plant spacing used was 45 x 30 cm and irrigated at weekly intervals. The treated paperboard mill effluent and solid wastes generated from ITC (PSPD), Unit: Kovai for cultivating okra resulted in

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increased yield (37.8 per cent) and growth characteristics along with the application of vermicompost. This is because of the nutrients present in the treated paperboard mill effluent. The scientific ways and means of recycling this wastewater in an integrated, eco friendly manner is the main objective of this study.

Keywords: Effluent irrigation; okra; paper and pulp industry; vermicompost.

1. INTRODUCTION

Paper and pulp industry is categorized under 17 most polluting industries due to discharge of large volumes of black coloured liquor with high nutrients. It ranks third in the world in terms of utilization of fresh water for processing. The paper mills generating appreciable quantities of solid wastes and effluent every day. The average quantity of water consumed for each tonne of paper produced is about 300 m^3 and this significant amount recur as effluent causing wide spread of environmental pollution [1]. Utilization of this wastewater for irrigation purpose makes the soil healthier due to the presence of plant nutrients [2]. Some researchers had reported that the nutrient status of soil like N, P and K has been increased with proper application of paper mill wastewater [3]. The crop yield and growth also showed positive correlation with the increasing dose of irrigating paper mill waste water and application of sludge compost up to certain limits [4].

Udayasoorian and Ponmani [5] revealed that the yield of chillies and brinjal under treated paperboard mill effluent irrigation was higher than well water irrigation. The pH, electrical conductivity, organic carbon, cation exchange capacity and exchangeable cationic activities were improved in effluent irrigated soils over the years, without any deterioration on crop quality [6]. The paper mill effluent at 25 per cent concentration showed maximum growth performance in *Trigonella foenum-graecum* (fenugreek) [7]. The effluent from Nilakotai paper mill exceeds the parameters fixed by World Health organisation (WHO) in terms of pH, colour, odour, temperature electrical conductivity, total dissolved solids, biological oxygen demand, chemical oxygen demand, sodium, calcium and magnesium [8]. Manika et al. [9] reported that the paper industry effluent of Nagaon paper mill in Assam contains 3.11±2.2 parts per million (ppm) of phosphorus and 46.88±10.3 ppm of potassium. The paper industry effluent also contains 278.5±4.1 ppm of sodium, 262.8±14.0 ppm of calcium and 15.2±11.77 ppm of magnesium.

India is the second largest producer of vegetables in the world next to China and accounts for about 15 per cent of the world's production of vegetables. The current production level is over 71 million tonnes and the total area under vegetable cultivation is around 6.2 million hectares which is about 3 per cent of the total area under cultivation in the country. *Abelmoschus esculentus* (L.) commonly known as okra is an economically important crop grown in tropical and sub tropical regions in the world including India. Globally, India ranks first in the production of okra with 5.78 million tonnes annually [10]. The major states in the production of okra in India are Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh, Karnataka and Assam. There has been a continuous increment in the production trend of okra in India for the past ten years [11].

The studies on the irrigational effect of paperboard mill effluent on okra is meager and there has not much attention paid on the vegetable crop which render more economy. Keeping the aforementioned points in mind, the study has been designed to assess the influence of paper board mill effluent irrigation on growth and yield of okra.

2. MATERIALS AND METHODS

2.1 Experimental Design

Field experiment was conducted in Indian Tobacco Company - Paperboards and Specialty Papers Division (ITC-PSPD) model farm, Thekkampatti, Mettupalayam, Coimbatore District, Tamil Nadu to assess the impact of ITC treated effluent and solid wastes on crop growth, yield and quality of okra and soil. The experiment was a 7x2 factorial arranged in a randomized complete block design (RCBD) and replicated three times. The treatment combinations consisted of seven amendments *and* two sources of irrigation water (well water (I1) and effluent water (I2)). The seven amendments were T_1-Control (100 % NPK), T_2-FYM 25 t ha^{-1}+NPK, T_3-ETP Sludge 5 t ha^{-1}+NPK, T_4-Biochar 2.5 t ha^{-1}+NPK, T_5-Vermicompost 3.5 t ha^{-1}+NPK, T_6-Pressmud 6 t ha^{-1}+NPK and T_7-Fly ash

5 t ha^{-1}+NPK. Plant spacing used was 45 x 30 cm and irrigated at weekly intervals.

2.2 Plant Biometric Observation

Plant height, number of leaves per plant, number of branches, internodal length, leaf area index were measured at different stages of plant growth. The height of the plant from the ground level to the tip of the main stem was measured at 30 and 60 days after sowing (DAS) and at harvest stage. Total number of fully opened leaves in a plant was recorded at 30, 60 DAS and at harvest stage. The total number of main branches whose origin is in the leaf axils and the main stem was taken from on 10 randomly selected plants at 30, 60 DAS and at harvest stage.

2.3 Yield and Quality Parameters

Individual fruit weight, fruit length, fruit girth, fruit yield and dry matter production (DMP) were recorded at matured stage of the plant. Fruit yield was calculated by weighing of all the fruits in the plants from each plot and expressed in tones per hectare (t ha^{-1}). Five randomly selected plants were cut from the ground level for the estimation of DMP. The plant samples were sun dried for three days followed by oven drying at 70ºC till constant weight was obtained. The dry weight of the plant samples were recorded and expressed in kg ha^{-1}. The leaf sample of 500 mg was taken and total phenol content in the leaves was estimated using Folin-Ciocalteau reagent and expressed as mg 100 g^{-1} of the material [12]. Crude fibre content was estimated by the method [13] and expressed in percentage. The protein content of fruits was estimated by the method suggested by [14] and expressed in per cent.

2.4 Statistical Analysis

The data generated during this investigation for various characters were statistically analysed by the method given by [15]. Results are presented and discussed at five per cent probability level uniformly. Treatment differences that are not significant were noted as non significant (NS).

3. RESULTS AND DISCUSSION

3.1 Plant Biometric Observation

Effluent irrigation produced taller and stronger plant than the well water irrigation. Among the treatments, VC + NPK had a favorable influence on plant growth attributes in okra at all the stages of growth period with effluent irrigation compared to well water irrigation (Fig. 1). This is because the treated effluent supplies appreciable amounts of plant nutrients than well water. Similarly [5] reported that effluent irrigated okra recorded higher plant height and yield than the well water irrigated okra.

In the present study, the vermicompost might have contributed all essential plant nutrients which helped to maintain the soil moisture ultimately resulted in the promotion of the plant height of okra. Najar and Khan [16] reported that the application of vermicompost increased the number of clusters per plant, fruits per cluster, number of fruits per plant, mean fruit weight and yield in tomato. Kumar et al. [7] reported that low concentration of the paper mill effluent increases the agronomical parameters such as seed germination, shoot length, root length, number of roots, root nodule, number of leaves, flowers, pods, pod length, dry weight and chlorophyll content of *T. foenum-graecum* (fenugreek).

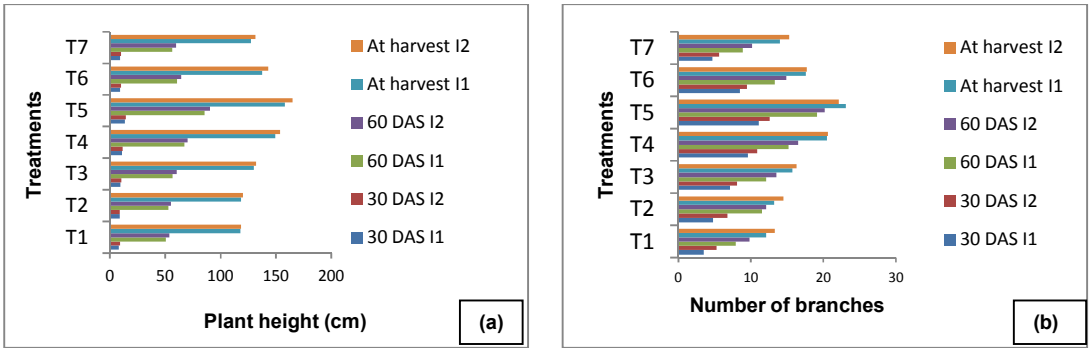

Fig. 1. Effect of treated paperboard mill effluent irrigation and solid waste on plant height (a) and number of branches (b) of okra

Treatment deatils:T_1 - Control (100 % NPK), T_2 - FYM + NPK, T_3 - ETP sludge + NPK, T_4 - BC + NPK, T_5 - VC + NPK, T_6 - PM + NPK, T_7 - FA + NPK

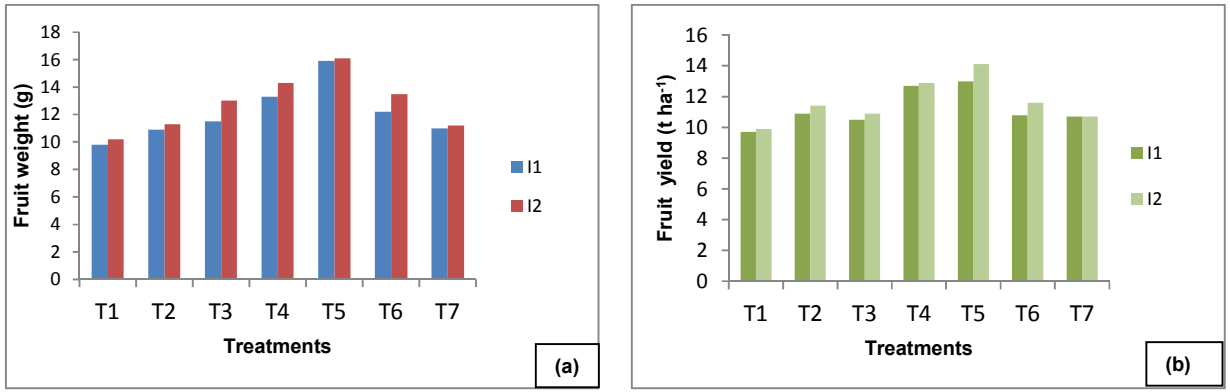

Fig. 2. Effect of treated paperboard mill effluent irrigation and solid waste on fruit weight (a) and yield (b) of okra

Treatment deatils:T_1 - Control (100 % NPK), T_2 - FYM + NPK, T_3 - ETP sludge + NPK, T_4 - BC + NPK, T_5 - VC + NPK, T_6 - PM + NPK, T_7 - FA + NPK

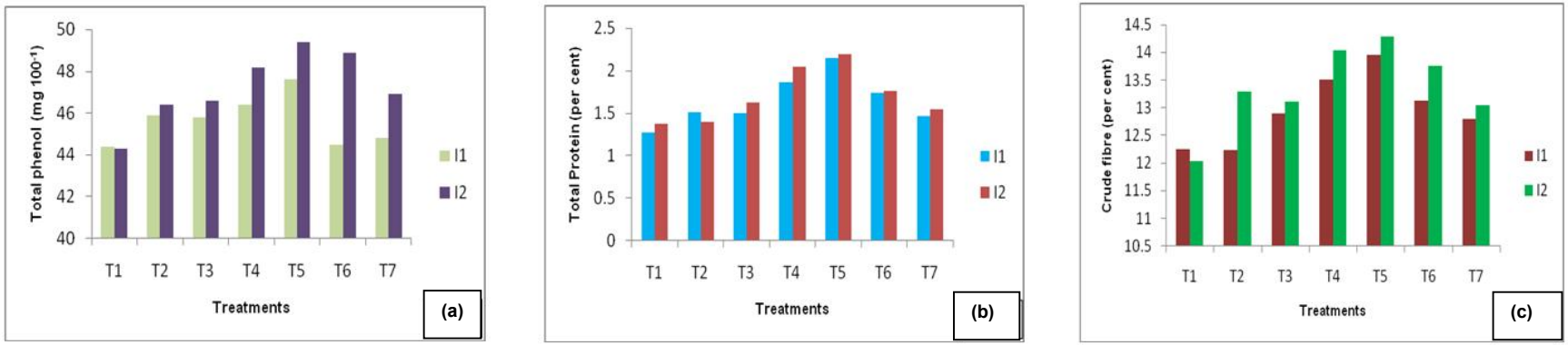

Fig. 3. Effect of treated paperboard mill effluent irrigation and solid waste on total phenol (a), total protein (b) and crude fibre (c) of okra

Roseta and Innocent [17] found that agro industrial effluents and agricultural wastes like poultry manure increased the growth parameters like plant height, number of leaves per plant, stem girth and dry matter of the okra in different combinations.

3.2 Yield Parameters

Application of vermicompost along with NPK had favorable influence on yield attributing characters of okra *viz.,* fruit weight, fruit length and fruit girth with effluent irrigation. The plot receiving vermicompost and NPK and effluent irrigation gave the highest fruit weight and fruit yield compared to other treated plots (Fig. 2). This could be due to increased level of major nutrients in the effluent which might have contributed to higher fruit yield of okra. Similar observations were recorded in cowpea [18]. *Nerium oleander* flowering plant was irrigated with distillery spent wash of different concentrations and found that sprouting, growth and yield of plant was very good (100 per cent) in 1:3 spent wash irrigation, while very poor (25 per cent) in 1:1 spent wash irrigation and moderate (80 per cent) in 1:2 spent wash irrigation [19].

3.3 Quality Parameters

The quality parameters of okra *viz*., total protein, total phenol and crude fibre content were higher in paperboard mill effluent irrigation when compared to well water irrigation. In okra, the quality parameters were better in plots receiving VC + NPK (Fig. 3). This might be due to combined use of treated effluent along with amendments, which might have provided enough nutrients with better physical and microbial environment and thus improving the soil fertility and ultimately resulted in improved quality parameters.

Similar results were also reported in radish and onion [20], chillies and brinjal when these crops were grown in organic amended soil along with paperboard mill effluent irrigation. In *Allium cepa*, application of vermicompost combined with mineral fertilizers increased the bulb qualities like bulb size, total number of bulbs and fresh weight of bulbs [21]. Najar et al. reported similar findings that the application of vermicompost increased the number of marketable fruits and in the same way decreased the non marketable fruits which were infested. Biochemical components of okra like crude proteins, crude fibre and crude carbohydrates were found maximum with 25 per cent paperboard mill effluent fertigation [22].

4. CONCLUSION

Application of vermicompost along with NPK under treated paperboard mill effluent irrigation had a favourable effect on the growth of okra. The yield attributes *viz*., fruit length, fruit girth and individual fruit weight were significantly increased in VC + NPK under treated paperboard mill effluent irrigation. The yield increase was 37.8 per cent in okra under VC + NPK treatment than that of control 100% NPK. The quality parameters of okra *viz.,* total phenol, crude fibre and total protein were not affected due to effluent irrigation along with solid waste application. But a slight increase was noticed in quality parameters. Based on the results, it could be concluded that the treated paperboard mill effluent can be used as an effective irrigation source with addition of vermicompost along with NPK. Treated effluent irrigation combined with vermicompost had provided necessary plant nutrients in the soil thereby, resulting in higher yield of okra. These findings conclude that the future perspective of treated effluent in agriculture is favourable due to its effect on increased crop yield and growth, but there is also a possible accumulation of various nutrients and heavy metals in soil and in the ground water that may cause potential problems after long term reclaimed wastewater irrigation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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