

Original Research Article

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Yield, Water Productivity and Economics of Green Chilli as Influenced by Engineered Constructed Wetland Treated and Untreated Domestic Sewage Water

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ABSTRACT

A field experiment was conducted to study the response of green chilli to engineered constructed wetland treated wastewater in comparison to other sources of water at University of Agricultural Sciences, Dharwad, Karnataka, India during *kharif* 2015. Effect of six different sources of water (domestic wastewater, engineered constructed wetland- (ECWL) treated wastewater, borewell water, domestic wastewater alternated with fresh water, fresh water alternated with ECWL treated wastewater; domestic wastewater alternated with ECWL treated wastewater) was evaluated in green chilli. Application of domestic wastewater resulted in significantly higher fruit weight per plant (749 g/plant) in comparison to borewell water (541 g/plant) and ECWL treated wastewater (583 g/plant). Higher green chilli yield was recorded in the plot irrigated with domestic wastewater (17.58 t/ha) which was on par with application of ECWL treated wastewater alternated with domestic wastewater (16.28 t/ha); borewell water alternated with domestic wastewater (16.18 t/ha); fresh water alternated with ECWL treated wastewater (15.61 t/ha). Application of borewell water alone resulted in lower yield (13.31 t/ha). Domestic wastewater irrigation resulted in significantly higher water productivity (268.8 kg/ha-cm) as compared to fresh water (203.5 kg/ha-cm). Application of the domestic wastewater resulted in higher net returns and B: C ratio (Rs. 2,20,553/ha and 2.68) followed by alternative application of engineered constructed wetland treated wastewater and domestic wastewater (Rs. 1,94,463/ha and 2.48).

Keywords

Green chilli yield,
Engineered
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Introduction

Limited water resources have probed into thought process of use of non conventional water source. Concomitantly growing urbanization has led to generation of the wastewater which is preferred marginal water source on account of reliable and uniform water supply round the year with copious nutrients embedded in it (Haruvy, 1997). The reduction in exploitation of water reserves through saving, recycling and pollution

control has gained importance in recent years. Estimates indicate 75-85 per cent of the water consumed is generated as wastewater (Qadir *et al.*, 2010). No doubt use of untreated domestic water is rich in nutrients and is valuable water resource throughout year giving farmers an opportunity to increase their income. On context of the sanitation and health concerns, reuse of wastewater needs to be treated primarily or secondary depending

on the embedded contaminant and the purpose for which it is to be used. Addressing the wastewater treatment and reuse will create win-win situation tackling twin problems of wastewater generation and water scarcity. Treated wastewater can be used as an alternative for irrigation of the crop which is eaten after cooking (Al-Lahham *et al.*, 2003). Increasing agricultural reuse of treated wastewater promotes sustainable agriculture, preserves the scarce water resource and environmental quality (Haruvy, 1997). Nevertheless reuse of treated water will have ramification pertaining to the cost of irrigation water and environment damage. Reuse of the treated wastewater needs to be looked into multi-functional perspective on several counts, be it economical, agricultural and environmental. Wastewater treatment has been lagging behind mainly because of high treatmental cost on establishment and maintenance of the units which are primarily centralized in approach. This opens thought to revamp the treatment scale to decentralized treatment and reuse of the treated water for agriculture (Raschid sally and Parkinson, 2004). In that thought process, decentralized engineered constructed wetland is feasible technology. Engineered constructed wetland technology for wastewater treatment is cheaper and more efficient to maintain in comparison to conventional treatment systems (Mthembu *et al.*, 2013). Further reuse of treated wastewater or conjunctive application of the domestic wastewater with good quality water will augment the irrigation system to lessen the load on the scarce portable water. Further it leads to improving agronomic quality of water for crop production (Pedrero *et al.*, 2010). Therefore, of late use of treated, partially treated and untreated wastewater for agricultural purpose has received more attention in context of water resource and nutrient recovery (Qadir *et al.*, 2010). Agronomic and economic evaluations of use of different sources of the water on crops

under field conditions are scarce. Studies on effect of engineered constructed wetland treated wastewater for reuse in agriculture are also meager. Therefore a field study was conducted with an objective to evaluate the effect of the different water sources on growth, yield, water productivity and economics of green chilli.

Materials and Methods

A field experiment was conducted during *kharif* 2015 at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, Karnataka (15°26'N and 75°07'E, an altitude of 678 m above mean sea level). Climatologically, experimental site is located in the northern transitional zone of Karnataka. Initial soil physico-chemical properties of the experimental site were analysed using standard procedure indicated by Tandon (2008) and are presented in table 1. The soil of the experiment site was sandy clay loam belonging to with low organic carbon and soil available nitrogen and medium in available phosphorus and high in available potassium.

This study consisted of six treatments *i.e.*, six sources of irrigation water with four replications and was laid out in randomized complete block design. Details of the irrigation source are;

- T₁: Domestic wastewater (DWW)
 - T₂: Engineered constructed wetland treated wastewater (TWW)
 - T₃: Fresh water (FW, bore well water)
 - T₄: Freshwater alternated with domestic wastewater (FW-DWW)
 - T₅: Freshwater alternated with ECWL treated wastewater (FW-TWW)
 - T₆: ECWL treated wastewater alternated with domestic wastewater (TWW-DWW)
- Engineered Constructed Wetland (ECWL) was established under Water4crops project

with financial assistance of Department of Biotechnology, Government of India. Macrophytes of *Typha latifolia* and *Bracharia mutica* were used in the ECWL filled with filter bed material of gravels (< 40 mm) to a depth of 60 cm; fine sand to a depth of 25 cm and charcoal to a depth of 5 cm. Domestic wastewater generated from the UAS Dharwad campus was subjected to ECWL treatment and used in the experiment.

Healthy Chilli seedlings of Bydagi- Kaddi variety were transplanted after root treatment with the agrochemicals and biofertilizer. Transplanting was carried out on 8/07/2015. Spacing of 75 cm x 45 cm was followed. Gross plot size of the experimental unit was 24 m². Recommended dosage of fertilizer 150:75:75 kg N, P₂O₅ K₂O/ ha was applied to the crop. Fifty per cent of N; 100 per cent of P₂O₅ and K₂O was applied as basal. Remaining 50 per cent of N was top dressed at 4 weeks after planting. Urea, Di-ammonium phosphate and muriate of potash were used as the source of nutrients for the experimental crop. Cumulative weight of the periodic harvest was accounted and presented as yield per plant. Net plot yield of chilli as influenced by the treatment were arrived and expressed as t/ha. Irrigation was scheduled for green chilli at 50 per cent depletion of soil moisture. Volumetric method was used to measure the water applied to each plot. Discharge was calculated by ratio of time needed to fill the container to the volume of water stored in container. Altogether, eleven irrigations were applied to a total depth of 408 mm. Total water applied to the crop during the cropping period was 654 mm inclusive of effective rainfall (246 mm). Water productivity was arrived using the formula advocated by Joshi and Setty, (2006) and expressed as kg/ha-cm.

Influence of the treatments on crop performance in monetary terms was expressed as net return (Rs/ha), B: C ratio and net profit per cm of water used. Statistical analyses of the observed biometric and economic parameters were carried out as per Gomez and Gomez (1984). Water samples from different irrigation sources were analysed at fortnightly interval and mean of the data for the growing season is presented in table 2.

Results and Discussion

Influence of the different sources of irrigation water on growth was found to be significant (Table 3). Application of domestic wastewater resulted in higher plant height and number of branches. However it was on par with application of conjunctive application of ECWL treated wastewater (TWW) and domestic wastewater (DWW). Lower values with respect to the plant height and number of branches were recorded with application of freshwater (FW). Whereas, effect of sources of irrigation on the yield attributes i.e. fruits per plant and fruit weight per plant was significant. Higher number of fruits per plant of green chilli were recorded in plots irrigated with domestic wastewater (99.9) compared to freshwater (76.5) but it was on par with application of treated wastewater irrigation alternated with domestic wastewater (90.1) (Table 3).

Nutrient supplemented through, organics added and nutrients supplemented through water source in addition to the recommended dose of fertilizer induced progressive growth and development of the plant which was reflected in the reproductive parts i.e. fruit number and fruit weight per plant. Further application of domestic wastewater which is rich in organic matter has positive effect on the soil physical parameters (Varkey *et al.*, 2014).

Embedded nutrients in wastewater promoted the growth of the plant as evidenced in the

present study (Table 2). Jogan and Dasog, (2015) opined that differential accumulation and mineralization of nutrients added to the soil through water source and moderation of the nutrients in the soil might have contributed to the differential response of the crop to the

nutrient and organic load present in the water which was applied. Findings of the present study clearly evidenced the differential response with respect to the observed yield and yield attributes among source of irrigation used in the study.

Table.1 Initial soil physico- chemical properties of the experimental site

Properties	Soil
pH	7.68
EC (dS m ⁻¹)	0.37
Organic carbon (g kg ⁻¹)	4.1
Available nitrogen (kg ha ⁻¹)	186.1
Available Phosphorus (kg ha ⁻¹)	24.2
Available Potassium (kg ha ⁻¹)	287.3
Exch-Ca [cmol (p ⁺) kg ⁻¹]	16.7
Exch-Mg [cmol (p ⁺) kg ⁻¹]	13.6
Available zinc (mg/kg)	1.3
Available iron (mg/kg)	5.9
Bulk density (Mg m ⁻³)	1.46
Water soluble aggregates (%)	41.2

Table.2 Mean values of chemical properties of the different source of irrigation during the cropping period

Quality Parameters	Source of irrigation water		
	Fresh water/ bore well water	Domestic wastewater	ECWL treated wastewater
pH	7.68	7.51	7.48
EC (dS m ⁻¹)	0.79	1.37	1.21
Total N (mg/l)	0.65	20.8	11.5
NH ₄ ⁺ - N (mg/l)	0.35	12.0	5.8
NO ₃ ⁻ N (mg/l)	0.2	5.2	2.7
Phosphate (ppm)	0.3	10.1	5.6
Ca + Mg (me/l)	4.2	10.8	7.4
Sodium (ppm)	3.2	8.1	5.6
Potassium (ppm)	5.1	5.4	3.8
Chloride (ppm)	2.1	7.2	4.8
Bicarbonate (me/l)	2.5	10.3	4.9

Table.3 Influence of different sources of water on biometric parameters of green chilli

Treatment	Plant height (cm)	No. of branches/plant	Number of fruits /plant	Fruit wt./plant (g)	Yield (t/ha)
T ₁ : Domestic wastewater (DWW)	78.76	13.41	99.89	749	17.58
T ₂ : Treated wastewater (TWW)	72.92	11.75	77.67	583	14.63
T ₃ : Freshwater (FW)	67.17	10.75	76.45	541	13.31
T ₄ : Freshwater alternated with Domestic wastewater (FW - DWW)	70.46	12.92	81.08	626	16.18
T ₅ : Freshwater alternated with Treated wastewater (FW -TWW)	67.58	10.17	83.40	611	15.61
T ₆ : Treated wastewater alternated with Domestic wastewater (TWW- DWW)	74.75	12.75	90.13	739	16.28
SEm±	2.53	0.81	4.85	46	0.94
CD (P=0.05)	7.64	2.43	14.63	138	2.83

Table.4 Influence of different source of water on water productivity and economics of green chilli

Treatment	Water productivity (Kg/ha-cm)	Net returns (Rs/ha)	B:C ratio	Net profit/cm of water applied (Rs/cm)
T ₁ : Domestic wastewater (DWW)	268.8	220553	2.68	3372
T ₂ : Treated wastewater (TWW)	223.7	161546	2.23	2470
T ₃ : Freshwater (FW)	203.5	135147	2.03	2066
T ₄ : Freshwater alternated with Domestic wastewater	247.4	192487	2.47	2943
T ₅ : Freshwater alternated with Treated wastewater	238.7	181123	2.38	2769
T ₆ : Treated wastewater alternated with Domestic wastewater	248.9	194463	2.48	2973
SEm±	-	18766	0.14	-
CD (P=0.05)	-	56566	0.43	-

#Market price for the produce @ Rs. 20 /kg

Nogueira *et al.*, (2013) indicated improvement in the growth and development of the plants irrigated with treated sewage water was due to increased supply of nitrogen in the form of

NH₄⁺ which promoted dry matter production and increase in leaf nitrogen accumulation in soil. Plant growth and yield was superior in the ECWL treated wastewater in comparison to

the freshwater application mainly because of the higher plant supporting nutrients supplemented through water (Table 2). Results were in line with findings of Cirelli *et al.*, (2012). ECWL technology for treating the wastewater for reuse in agriculture is beneficial in regard to the retention of considerable amount of plant nutrients to support growth and development (Lopez *et al.*, 2013).

Significantly higher fruit weight per plant were observed under domestic wastewater (749 g/plant) followed by treated wastewater alternated with domestic wastewater irrigation (739 g/plant) which were characteristically differing from other sources of irrigation. In an experiment evaluating various proportion of the treated wastewater with fresh water, Al-Lahham (2003) observed increase in the fruit size and weight with increase in quantity of the treated wastewater clearly indicating the increase in nutrient addition leading to increase in the yield. Thus conjunctive application of sources of irrigation resulted in differential response in green chilli. Lower and comparable fruit weight per plant was recorded in crop irrigated with fresh water and treated water alone (583 and 541 g/ plant, respectively).

Green chilli yield is a reflection of number of fruits per plant and fruit weight per plant which lead to significantly higher yield in plots irrigated with domestic wastewater irrigation (17.58 t/ha) which was closely followed by treated wastewater alternated with domestic wastewater treatment (16.28 t/ha) and freshwater alternated with domestic wastewater treatment (16.18 t/ha). Results obtained in the present study are in line with the findings of Thapliyal *et al.*, (2011) who observed response in order of untreated wastewater>treated wastewater> rainwater in okra crop. Similar results were observed by Balkhair *et al.*, (2013) with conjunctive application of wastewater and fresh water. The

lowest yield of chilli was registered with freshwater irrigation (13.31 t/ha) while, irrigation with treated wastewater recorded a yield of 14.63t/ ha. Prazeres *et al.*, (2014) observed improvement in yield of the tomato grown under treated wastewater in comparison to irrigating through fresh water.

In all, a total of 11 irrigations were applied to the crop amounting to 408 mm. The total water applied including effective rainfall (246 mm) was 654 mm for all the treatments. Water productivity was significantly higher with domestic wastewater irrigation (268.8 kg/ ha-cm). Lower values were recorded for freshwater (203.5 kg/ha-cm) and treated wastewater irrigation (223.7 kg/ha-cm) (Table 4). Similar findings were recorded by Hassanali *et al.*, (2009) in corn irrigated with wastewater compared to fresh water irrigation.

Adoption of the technology among the farmers is exclusively based on the income generation and profit accountable. Economical, agricultural and environmental aspects are important considerations in any decision making regarding wastewater treatment and reuse options (Haruvy, 1997).

Significantly higher net returns and B: C ratio were recorded in domestic wastewater (Rs. 2,20,553/ha and 2.68). However, it was on par with treated wastewater alternated with domestic wastewater irrigation (Rs 1,94,463/ha and 2.48) (Table 4). The highest and lowest net profit of Rs 3372 and Rs 2066 were obtained per cm use of water in case of domestic wastewater and fresh water irrigated green chilli. However the combination of freshwater alternated with domestic wastewater; treated wastewater alternated with domestic waste water also recorded higher net profit of Rs 2769 and 2973 per cm use of water, respectively (Table 4). Accounting the environmental damage and the resource recovery (water and nutrients) usage of treated sewage wastewater is

feasible in comparison to the irrigation through fresh borewell water (Nogueira *et al.*, 2013). Appropriate care should be executed in selection of the crops which don't come in direct contact with water to minimize the microbial contaminants associated with the direct use of domestic wastewater.

Water and nutrient resource recovery through wastewater treatment and reuse offers potential scope as irrigation source in areas of water scarcity. Conjunctive application of the Engineered Constructed Wetland treated wastewater and fresh water or domestic wastewater is viable alternatives.

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