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Impact of treated sugar mill effluent irrigation on growth and yield of rice and cowpea in Cauvery command area

M. S. DINESHA, S. BHASKAR AND [1]C. A. SRINIVASAMURTHY

Department of Agronomy, [1]Department of Soil Science and Agricultural Chemistry
University of Agricultural Sciences, Bangalore, Karnataka-560065

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ABSTRACT

In many industries related to food and allied industries like sugar mill and distilleries, the waste waters rich in organic load and plant nutrients are amicable for use as irrigation water. However, one has to evaluate the beneficial effects of using such effluents for irrigation on various components of ecosystem before suggesting its use in agriculture. Adopting the recycling strategy of industrial effluents, treated sugar mill effluent was used in field experiment to investigate its effect on growth and yield of rice under rice-cowpea cropping sequence. The experiment was conducted at Research and Development Farm, M/s. Sri Chamundeshwari Sugars Ltd. Mandya District, Karnataka, India during 2012-14. The experiment was conducted in puddle Kharif rice and during summer season cowpea was taken to study the residual effect of sugar mill effluent applied to rice. The results revealed that continuous treated sugar mill effluent irrigation along with RDF produced significantly superior growth parameters viz., tall plants (85.7 cm), more number of tillers hill^{-1} (25.1) and total dry matter production hill^{-1} (115.4 g) at harvest. It also recorded significantly higher yield parameters viz., number of panicles hill^{-1} (13.2), panicle length (24.1cm) and number of grains per panicle (187.4) all of which contributed significantly higher grain yield (53.8 q ha^{-1}) and straw yield (61.1 q ha^{-1}) as compared to control. Subsequently, residual effect of the same treatment recorded higher seed yield and haulm yield (996 and 3113 kg ha^{-1}, respectively) in cowpea crop. Thus it can be concluded that higher grain yield of rice without having negative effect on salt sensitive cowpea could be obtained with treated sugar mill effluent irrigation along with recommended dose of fertilizers in rice – cowpea sequence.

Keywords: Grain yield, irrigation, rice, sugar mill effluent, utilization.

The disposal of wastewater is a major problem faced by industries due to generation of high volume of effluent and limited space for land based treatment. On the other hand, wastewater is also a resource that can be applied for productive uses since wastewater contains nutrients that have the potential for use in agriculture and other activities (Hussain *et al*., 2001). The wastewater effects on soils and crops are of more concern to people when the irrigantion is with untreated wastewater which may contain agents capable of inducing adverse effects on the soil media and the agricultural products.

The sugar industry is playing an important role in the economic development of the Indian sub continent. Sugar mill effluent when discharged into the environment without proper treatment poses a serious health hazard to the rural and semi-urban populations that uses stream and river water for agriculture and domestic purposes, with reports of fish mortality and damage to the rice crop. Farmers have been using these effluents unscientifically for irrigation and found that the growth, yield and soil health were reduced. Contaminants such as chloride, sulphate, phosphate, magnesium and nitrate are discharged with the effluent from various industries, which create a nuisance due to physical appearance, odour and taste (Baruah *et al*., 1993). Presently India has nearly 526 sugar mills that produce about 25 million tons of sugar and 6 million tons of molasses. Sugar mills which discharge huge amount of effluent per day without any or partially treatment during the crushing season. It has also been reported that sugar mill effluent contains high magnitude of pollutants load and caused adverse effect on soil and biological system (Arindam and Prasad, 1999; Sanjay, 2005 and Ayyasamy *et al*., 2008). Most crops give higher potential yields with wastewater irrigation and thus reduce the need for chemical fertilizers resulting in net cost savings to farmers. Thus it is important to understand the specificity of crop-effluent liaison for their appropriate application in irrigation practices (Kumar *et al*., 2010).

The present and future of India's food security depends on irrigated rice – a water guzzling crop that consumes nearly 50-60 per cent of the nation's finite water freshwater resources (Anon., 2008a). During recent years, the scarcity and competition for water have been increasing in the country due to increasing demand for other uses. Thus lack of water rather than land may become the principal constraint to augment food production and to sustain the world population (Sivanappan, 1997). Therefore, there is a need to utilize alternative source of water for rice production. Keeping in view the above facts, the present investigation entitled "Utilization of sugar mill effluent for rice-cowpea sequence in Cauvery command area" was carried out.

Email: dineshagron@gmail.com

MATERIALS AND METHODS

A field study was conducted in the premises of research and development farm M/s Sri Chamundeshwari Sugars Ltd., K.M. Doddi, Maddur taluk, Mandya District located in Southern Dry Zone of Karnataka. The experimental site is situated at 12º 362 North latitude and 77 º 42 East longitude and at an altitude of 662 meters above mean sea level. The experiments were conducted during 2012-13 and 2013-14 for examining the effect of treated sugar mill effluent irrigation on growth and yield of rice crop. The experiment was conducted with eight treatments during *Kharif* 2012 and 2013 with rice and the residual effect of the said treatments was studied during summer seasons of 2013 and 2014 with cowpea crop the pooled data of two seasons were presented. The experiment was conducted in Randomized Complete Block Design and the treatments were replicated thrice. The soil was sandy clay loam in texture with medium organic carbon (0.56) per cent. The pH of the soil was neutral in reaction and electrical conductivity was low. It had medium available K_2O (308.6 kg ha^{-1}) and available sulphur (13.2 ppm), but was low in available nitrogen and P_2O_5 (251.4 and 21.8 kg ha^{-1}, respectively). Salt resistant rice variety IR30864 was used during both the years. The recommended nutrient dose @ 100:50:50 N, P_2O_5, K_2O was applied to all the treatments except for the treatment (Sugar mill effluent alone) using Urea, SSP and MOP. A common dose of 10 t FYM ha^{-1} was applied to all the treatments. For residual treatments the recommended nutrient dose @ 25:50:25 N, P_2O_5, K_2O and a common dose of FYM 7.5 t ha^{-1} was applied to all the treatments and irrigation was given with fresh water only for all the treatments.

The sugar mill effluent was characterized by following standard procedures and methods and the rice crop was irrigated with fresh water up to 20 DAT there after 5 cm depth of water was maintained with application of respective cycles of effluent and fresh water throughout the crop growth period. Pre-emergent herbicide pretilachlor 50% EC @ 1.5 litre ha^{-1} was mixed with sand and applied 3DAT of rice and later on hand weeding at 30 DAT was done to keep weeds under control throughout the crop growth period. The crop was infected with leaf roller during 30 DAT. Spraying of chlorpyriphos 20 EC @ 1.5 mll-11 was taken up to control the incidence. Cowpea was infested with aphids two sprays of dimethoate @ 1.7 mlL^{-1} were taken at 30 and 45 days after sowing. Observations of growth and yield attributing characters were recorded at 30, 60, 90 DAT and at harvest. The cost of cultivation and returns were calculated by taking into account the prevailing cost of inputs and prices of output.

RESULTS AND DISCUSION

Growth parameters of rice

The pooled results over two years revealed that continuous irrigation with sugar mill effluent along with RDF recorded significantly higher plant height at harvest (86.9 cm), maximum LAI at 90 DAT (5.30), more number of tillers hill^{-1} (21.0) and higher dry matter production (115.4 g hill^{-1}) at harvest compared to all the other treatments but it was on par with alternate irrigation with fresh water (FW) and treated sugar mill effluent (SME) + recommended dose of fertilizers (RDF), cycle of 1 irrigation with FW + 2 irrigations with treated SME along with RDF and cycle of 1 irrigation with FW + 3 irrigations with treated SME along with RDF. This enhancement in growth characters was attributable to favourable pH and chemical composition of the treated effluent. Presence of nitrogen, phosphorus, magnesium and sulphur *etc*. in effluent played an important role in improving growth parameters of the crop (Table 1). The increased plant height might be due to increased efficiency in nutrient availability which contributed for prolonged greenness and larger leaf surface as indicated by leaf area in the present study. Increase in dry matter production per unit area is a first step for achieving higher yield. Dry matter production and its accumulation in different parts of plants during various growth phases of life cycle of any crop is an important pre-requisite for higher yields as it signifies photosynthetic ability of the crop and also indicates other synthetic processes during developmental sequences (Table 1). Indeed, considerable increase in growth parameters due to effluent application have also been earlier reported in field crops by several workers (Anoop *et al*., 2002; Selim, 2008 and Rajesh *et al*., 2013).

Yield parameters and yield of paddy

The data pertaining to number of panicles hill^{-1}, panicle length, number of grains panicle^{-1}, test weight, grain yield, straw yield and harvest index (HI) as influenced by irrigation with treated sugar mill effluent are presented in tables 2 and 3. Application of recommended dose of fertilizers (RDF) and continuous irrigation with treated sugar mill effluent recorded significantly maximum number of panicles hill^{-1} (13.2), longer panicle length (24.1 cm) higher number of grains panicle^{-1} (187.4), higher grain and straw yield (53.8 and 61.1 q ha^{-1}, respectively) compared to rest of the treatments and it was on par with cycle of 1 irrigation with fresh water (FW) + 3 irrigations with treated SME along with RDF (12.4, 23.6 cm, 179.1, 52.2 and 59.2 q ha^{-1}, respectively).

Cycle of 1 irrigation with fresh water (FW) + 2 irrigations with treated SME along with RDF

Table 1: Effect of treated sugar mill effluent irrigation on growth parameters of rice in cauvery command area

Treatments	Plant height at harvest (cm)	Leaf area index at 90 DAT	No. of effective tillers hill^{-1} at harvest	Dry matter production (g hill^{-1}) at harvest
Irrigation with FW + RDF	75.1	3.63	14.8	79.7
Irrigation with SME + RDF	86.9	5.30	21.0	115.4
Alternate irrigation with FW and SME + RDF	82.7	4.88	18.5	101.8
Cycle of 2 irrigations with FW + 1 irrigation with SME + RDF	75.9	4.50	17.5	89.0
Cycle of 1 irrigation with FW +2 irrigations with SME + RDF	84.3	5.06	19.0	105.2
Cycle of 3 irrigations with FW + 1 irrigation with SME + RDF	75.4	3.86	16.7	83.6
Cycle of 1 irrigation with FW + 3 irrigations with SME + RDF	85.9	5.11	20.1	109.2
Irrigation with SME alone	60.7	1.94	9.0	54.8
SEm (±)	**4.15**	**0.23**	**0.91**	**6.08**
LSD(0.05)	**12.00**	**0.67**	**2.61**	**17.55**

FW: Fresh water, RDF: Recommended dose of fertilizer, SME: Sugar mill effluent, DAT: Days after transplanting

Table 2: Yield parameters of rice as influenced by treated sugar mill effluent irrigation in rice-cowpea cropping sequence

Treatments	No. of panicles hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	1000 grain weight (g)
Irrigation with FW + RDF	9.6	20.1	149.0	23.8
Irrigation with SME + RDF	13.2	24.1	187.4	26.0
Alternate irrigation with FW and SME + RDF	11.6	22.7	170.8	25.1
Cycle of 2 irrigations with FW + 1 irrigation with SME + RDF	10.5	20.8	154.7	24.4
Cycle of 1 irrigation with FW +2 irrigations with SME + RDF	12.1	23.2	174.0	25.3
Cycle of 3 irrigations with FW + 1 irrigation with SME + RDF	10.2	20.6	151.3	23.9
Cycle of 1 irrigation with FW + 3 irrigations with SME + RDF	12.4	23.6	179.1	25.5
Irrigation with SME alone	6.8	17.4	113.1	23.5
SEm (±)	**0.67**	**0.74**	**6.53**	**0.90**
LSD(0.05)	**1.93**	**2.13**	**18.86**	**NS**

Table 3: Grain yield, straw yield and harvest index of rice as influenced by treated sugar mill effluent irrigation in rice-cowpea cropping sequence

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index
Irrigation with FW + RDF	41.4	47.8	0.463
Irrigation with SME + RDF	53.8	61.1	0.468
Alternate irrigation with FW and SME + RDF	47.3	53.7	0.468
Cycle of 2 irrigations with FW + 1 irrigation with SME + RDF	44.0	50.0	0.468
Cycle of 1 irrigation with FW +2 irrigations with SME + RDF	49.2	56.3	0.466
Cycle of 3 irrigations with FW + 1 irrigation with SME + RDF	42.1	48.0	0.467
Cycle of 1 irrigation with FW + 3 irrigations with SME + RDF	52.2	59.2	0.469
Irrigation with SME alone	27.9	32.9	0.460
SEm (±)	**2.35**	**2.63**	**0.018**
LSD(0.05)	**6.80**	**7.58**	**NS**

Table 4: Seed yield, haulm yield and harvest index of cowpea as influenced by residual effect of treated sugar mill effluent irrigation in rice-cowpea cropping sequence

Treatments	Seed yield (kg ha^{-1})	Haulm yield (q ha^{-1})	Harvest index
Irrigation with FW + RDF	907	2866	0.240
Irrigation with SME + RDF	996	3113	0.243
Alternate irrigation with FW and SME + RDF	962	3056	0.239
Cycle of 2 irrigations with FW + 1 irrigation with SME + RDF	949	2957	0.243
Cycle of 1 irrigation with FW +2 irrigations with SME + RDF	981	3068	0.243
Cycle of 3 irrigations with FW + 1 irrigation with SME + RDF	945	2961	0.242
Cycle of 1 irrigation with FW + 3 irrigations with SME + RDF	990	3108	0.242
Irrigation with SME alone	781	2686	0.225
SEm (±)	**40**	**104**	**0.011**
LSD(0.05)	**114**	**299**	**NS**

Notes: FW: Fresh water, RDF: Recommended dose of fertilizer, SME: Sugar mill effluent, NS: Non-significant

(12.1, 23.2 cm, 174.0, 49.2 and 56.3 q ha^{-1}, respectively) and alternate irrigation with FW and treated SME + RDF (11.6, 22.7 cm, 170.8, 47.3 and 53.7 q ha^{-1}, respectively), The plots which received treated sugar mill effluent alone recorded significantly minimum number of panicles $hill^{-1}$ (6.8), shorter panicle length (17.4 cm), lower number of grains $panicle^{-1}$ (113.1), lower grain and straw yield (27.9 and 32.9 q ha^{-1}, respectively). However test weight and harvest index was found non-significant (Table 2 and 3). The results are very much corroborated with the findings of Beg *et al.* (2010) who found that brassica crop irrigated with sugar mill effluent showed vigorous enhancement in almost all the vegetative and yield characteristics and generally it was seen that the enhancement was directly related to the number of irrigations with sugar mill effluent. Presence of nitrogen, phosphorus, magnesium and sulphur *etc*. in effluent played an important role in improving growth and yield parameters of the crop.

Higher values of above mentioned yield components were due to better growth parameters particularly total dry matter production which was significantly higher at harvest stage in continuous irrigation with treated SME + RDF, cycle of 1 irrigation with FW + 3 irrigations with SME + RDF, cycle of 1 irrigation with FW + 2 irrigations with treated SME + RDF treatments and alternate irrigation with SME and freshwater (115.4, 109.2, 105.2 and 101.8 g plant^{-1}, respectively) (Table 1). The results are also in conformity with Pradhan *et al*. (2001), Moazzam *et al*. (2010) and Kumar and Chopra (2013) who observed that increase in dry matter production with effluent irrigation.

Increase in grain yield of paddy was attributed to higher plant height, more number of tillers, leaf area index, total dry matter accumulation, higher number of panicles hill^{-1}, more panicle length, number of grains panicle^{-1} and test weight observed in this treatment. These results are also in conformity with the findings of Anoop *et al*. (2002), Manjunatha (2011) and Kumar and Chopra (2013) who reported increased yields due to enhanced growth and yield parameters with the application of waste water in field crops like wheat, sorghum, barley, maize and paddy.

Residual effect of application of RDF along with treated sugar mill effluent irrigation to preceding rice crop recorded significantly higher grain and haulm yields (996 and 3113 kg ha^{-1}, respectively) compared to all the other treatments. However, it was on par with all the other residual treatments except treated sugar mill effluent irrigation alone without RDF to preceding rice crop where it recorded significantly lower grain and haulm yields (781 and 2686 kg ha^{-1}, respectively).

Residual effect of treated sugar mill effluent on harvest index was found to be non-significant. However, application of recommended dose of fertilizers along with continuous treated sugar mill effluent irrigation to preceding rice crop resulted in higher harvest index (0.243). (Table 4). Higher yields obtained with residual effect of RDF + continuous treated SME irrigation could be attributed to significantly higher growth and yield component values under this treatment. Sugar mill effluent being originated from plant source, provided some amount of nutrients to the residual cowpea crop and increased the yield and yield attributes of the crop. These results are in accordance with the findings of Suganya (2008) who reported that the application of higher doses of distillery spentwash to the first crop significantly increased the haulm yield, kernel yield and the dry matter production of residual groundnut crop. The results also corroborates the findings of Manjunath (2011) who found that more number of effective tillers m^{-2}, length of ear head, grains ear head^{-1} and test weight were observed with residual and cumulative application of 150 per cent recommended N through treated brewery waste water (TBWW) as 50 per cent basal and 50 per cent in three irrigations. Significantly higher grain and straw yield were recorded due to residual (22.1 and 29.5 q ha^{-1}) effect of 150 per cent recommended N through TBWW as 50 per cent basal and 50 per cent in three irrigations compared to other treatments.

It can be concluded that higher grain yield of rice could be obtained with treated sugar mill effluent irrigation along with recommended dose of fertilizers. Residual effect of treated sugar mill effluent irrigation did not cause any adverse effect on cowpea crop. Besides, increased seed yield of cowpea is possible with residual effect of sugar mill effluent irrigation along with RDF in paddy – cowpea sequence.

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