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Effect of Treated Sewage Water Irrigation on growth and Yield of Mulberry

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ABSTRACT: A field experiment was conducted in a V1 mulberry garden established under paired row system to study the influence of raw and treated sewage water irrigation on growth and yield of mulberry. The raw and treated sewage water were collected from GKVK sewage treatment plant and irrigated to mulberry garden. Application of different proportions of raw sewage, treated sewage and borewell water irrigation significantly influenced the growth parameters of V1 mulberry. Data recorded on growth parameters of mulberry revealed that raw sewage water irrigation significantly increased the plant growth parameters such as plant height (184.33 cm), highest shoot height (129.16 cm), number of shoots/plant (25.18), shortest internodal distance (5.36cm), number of leaves/plant (417.16), leaf area (202.16) than borewell water irrigation and also leaf yield (804.31 g/plant) is significantly increased in 100% raw sewage water irrigation. An overview of the study revealed that raw sewage water irrigated plot significantly improved the fertility status of the mulberry soil.

Keywords: Mulberry growth, leaf yield, raw sewage water, waste water and treated sewage water.

INTRODUCTION

Water in the soil-plant system is a necessary medium for the distribution of nutrients through the plant, works as a solvent for biochemical reactions, represents as a medium of distribution for solutes and helps in temperature regulation as well as a source of hydrogen in photosynthesis (Subbaswamy *et al.,* 1987). It plays a significant role as one of the key inputs in mulberry cultivation. Even though borewell water is a common source of irrigation in South India, its availability is getting scarce day by day due to quick groundwater depletion which often leads the farmers to fail to irrigate their mulberry gardens according to requirements.

Due to increasing demand for water from industry, urbanization, and population explosion, the resources are decreasing day after day all over the world and this inspired to recycle, reuse, and recover methods to cut back the prevailing load on resources, rather than polluting them through releasing the wastes into air, water and land. In India, only 23 per cent of sewage water is treated (primary treatment only) before it is used in agriculture or letting into rivers (Singh *et al.,* 2012).

Untreated wastewater is widely used for agriculture in many countries (Kalpana *et al.,* 2018). This is one of the world-leading serious environmental and public health concerns. Instead of using untreated wastewater, treated wastewater has been found more applicable and eco-friendly option.

Mulberry is the sole food for the silkworm (*Bombyx mori*). As mulberry is a perennial plant, it persists in the same field for multiple years, the soil fertility and irrigation encompass a direct relation on the nutrient content of the leaf and sustained leaf yield. Among these, irrigation water plays a significant role as one of the key inputs in mulberry cultivation.Mulberry leaf quality alone contributes 38.2 % in successful silk production (Miyashita, 1986), thus adequate supply of water and nutrients are essential in moriculture. Moisture content in mulberry leaves improves the palatability, ingestion, digestion and assimilation of nutrients in silkworms.

Mousavi and Shahsavari (2014) conducted experiment on effects of treated municipal wastewater on growth and yield of maize (*zea mays*).Results showed that irrigation with treated municipal wastewater led to significant effect in all characters than control. The highest stem height and diameter were observed in irrigation with 25% well water and 75% treated municipal wastewater, which was statistically different than other proportionate treatments, also similar results were obtained in other growth parameters such as flag leaf length, flag leaf width, ear diameter and ear length.

Paramanik (2015) studied the impact of domestic sewage water and borewell water on two mulberry varieties (S-54 and M5). Plant growth and leaf quality parameters were observed. Plant growth parameters such as plant height, no. of shoots/plant, no. of nodes/meter length, leaf yield, shoot yield and biological yield/plant were significantly increased in sewage water irrigated mulberry garden over borewell water irrigated M-5 mulberry garden.

Si *et al.,* (2018) conducted an experiment on effect of urban sewage sludge composted with garden waste on mulberry (*Morus alba* L.) growth and accumulation of heavy metals in soil. The maximum mulberry plant height, plant biomass, and crown width of the trees were increased by 12.2, 33.4, and 45.6 per cent respectively, compared with the control treatment *i.e.,* applying sewage sludge alone.

In 2014, the Karnataka government envisaged two projects *viz.,* Koramangala-Challaghatta (KC) Valley project and Hebbal-Nagavara (HN) Valley project to supply treated waste water from Bengaluru to irrigation tanks in neighbouring districts of Kolar and Chikkaballapur in the view of recharging groundwater levels and making water available for irrigation. By considering above scope and problems the present study was conducted to evaluate the effect of treated sewage water on mulberry garden soil.

In Sericulture, irrigation with various waste waters like silk reeling waste water, distillery spent wash, industrial waste discharge are emphasized which are more in plants essential nutrients for mulberry growth and development.

MATERIAL AND METHODS

The study was conducted during *Rabi* 2019in pre-established irrigated V1 mulberry garden at Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India. The type of soil is clay loam and annual rainfall ranges from 528 mm to 1374.4 mm with the mean of 915.8 mm. The Experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications and six treatments, comprises of different proportions of raw sewage water, treated sewage water and borewell water. V1 mulberry garden was ploughed once, middle pruned and supplied with the recommended dose of FYM of 20t/ha/year. Recommended dose of fertilizer 350:140:140 kg NPK/ha/yr was applied in five splits in the form of urea, single super phosphate and muriate of potash as sources of nitrogen, phosphorus and potassium, respectively. The cultural practices were followed as per the recommended package of practices (Dandin *et al.*, 2003).

The observations on various growth parameters were recorded at 45 days after pruning (DAP) whereas, leaf yield was recorded at 60 DAP. The crop was irrigated through flood irrigation system once in 7 days for 70 days (totally 10 irrigations). The calculated total water requirement was 1, 15,500 liters for 342 m^2area in entire crop duration. Number of mulberry plants in experimental plot: 16 rows × 30 plants = 315 plants. Number of mulberry plants per plot: 4 rows × 5 plants = 20 plants (leaving border effect there were 6 plants for recording observations). The treatment details are presented below.

Treatment details:

T_1- 100% borewell water irrigation

T_2- 25% treated sewage water + 75% borewell water irrigation

T_3- 50% treated sewage water + 50% borewell water irrigation

T_4- 75% treated sewage water + 25% borewell water irrigation

T_5- 100% treated sewage water irrigation

T_6- 100% raw sewage water irrigation

Treatments	Treatment combinations			Total water requirement per irrigation (L)
	Raw sewage water (RSW) used per each irrigation (L)	Treated sewage water (TSW) used per each irrigation (L)	Borewell water (BW) used per each irrigation (L)	
T_1 – control	0	0	1925	1925
T_2	0	482	1444	1925
T_3	0	962	962	1925
T_4	0	1444	482	1925
T_5	0	1925	0	1925
T_6	1925	0	0	1925
Total water requirement per irrigation (L)	1925 (RSW)	4813 (TSW)	4813 (BW)	11550

The data recorded on various parameters were subjected to Fisher's method of Analysis of Variance (ANOVA) and interpreted according to Gomez and Gomez (1984).The level of significance used in F and t-tests was P=0.05 for RCBD. The critical difference (CD) values were computed where the F test was found significant.

Growth and yield parameters of V1 mulberry

1.Plant height (cm). Plant height was recorded from the base of the plant to the topmost fully opened leaf in five randomly selected plants under each treatment, in four replications on 45 DAP. The mean was worked out from the random five plants to obtain the plant height.

2. Number of shoots (branches) per plant. The number of shoots was counted from five randomly selected plants under treatment in four replication on 45 DAP and the mean was worked out.

$$\text{The average number of shoots per plant} = \frac{\text{Total number of shoots}}{\text{Number of plants}}$$

3. Number of leaves per plant. The total number of leaves in each branch of the plant was counted from five randomly selected mulberry plants under each treatment in four replication on 45 DAP and the mean was worked out.

$$\text{The average number of leaves per plant} = \frac{\text{Total number of leaves}}{\text{Number of plants}}$$

4. Internodal distance. The distance between two nodes on the main shoot of the plant was measured by using a scale. Five randomly selected plants were recorded for internodal distance under each treatment, in four replications on 45 DAP and the mean was worked out.

$$\text{Internodal distance (cm)} = \frac{\text{Total distance of nodes per shoot}}{\text{Number of nodes per shoot}}$$

5. Height of shoot. The shoot height was measured from the base of the shoot to the tip of the fully opened leaf shoots of five labeled plants and mean shoot height was calculated at 45 day after pruning.

6. Leaf area (cm^2/plant). The area of third fully opened leaf from the top was determined by multiplying the length and breadth and then with a constant factor 0.69. The product was then multiplied with a number of green leaves per plant to get the leaf area per plant.

7. Leaf yield (g/plant). Leaf yield per plant was recorded treatment-wise in each replication by harvesting fresh leaves from five randomly selected plants under each treatment at 60 DAP and the mean yield was calculated.

RESULTS AND DISCUSSION

The data on the growth and yield parameters of V1 mulberry such as plant height (cm), number of shoots per plant, height of the shoots (cm), number of leaves per shoot, leaf area (cm^2/plant), internodal length (cm) and leaf yield as influenced by the different proportion of raw sewage, treated sewage and borewell water irrigation along with recommended dose of NPK and FYM are presented in Table 2, 3 and 4.

Table 1: Physio-chemical characterization of raw sewage water (RSW), treated sewage water (TSW) of GKVK STP and borewell water (BW) of GKVK.

Parameters	Raw sewage water	Treated sewage water	Borewell water
pH (1:2.5)	7.90	7.83	7.63
EC (dS/m)	0.79	0.60	0.85
Carbonates	Nil	Nil	Nil
Bicarbonates	88.00	62.00	52.00
Chlorides	190.00	149.00	235.00
Sulphates	2.60	2.20	Nil
Total nitrogen	53.00	25.1	9.30
Total PO_4	1.31	1.08	Nil
Total K	7.31	6.24	0.41
Calcium	13.42	7.21	14.21
Magnesium	1.61	1.03	2.10
Sodium	1.02	0.70	0.99
Iron	1.21	0.42	nd
Manganese	0.33	0.14	0.08
Zinc	0.19	0.10	0.01
Copper	0.16	0.01	nd
Arsenic	Nd	nd	nd
Cobalt	Nd	nd	nd
Nickel	0.04	0.03	nd
SAR	0.37	0.34	0.34
RSC (meq/L)	0.635	0.565	-0.33
Boron	Nd	nd	nd

Note: - All values are in mg L^{-1}, unless mentioned
- SAR - Sodium adsorption ratio, RSC - Residual sodium carbonate (meq/L)
- nd = not detected

A. Influence of raw and treated sewage water irrigation on plant growth parameters

Raw and treated sewage water irrigation significantly increased the plant growth parameters(Table 2). The significantly higher plant height of 184.33 cm, shoot height of 129.16 cm and number of shoots of 25.18 was recorded in 100% raw sewage water irrigation, which was statistically on par with 100% treated sewage water irrigation with 177.83 cm of plant height, 124.01 cm of shoot height and 24.86 number of shoots. Whereas, the lowest plant height (151.18 cm), shoot height (96.54 cm) and number of shoots (19.38) was recorded in100% borewell water irrigated plot at 45 DAP.

The results of current study is in agreement with the results of Chikkaswamy *et al*. (2014) who reported that the effect of sewage irrigation on two mulberry varieties S-54 and M-5 significantly increased the shoot numbers of 8.8 and 10.8, respectively when compared to borewell irrigation (8.4 shoots in S-54 and 9.6 shoots in M-5). The increase in growth attributes of mulberry is due to the presence of microorganisms which secretes growth promoting substances, enzymes, hormones and other nutrients which are necessary for the plant growth (Rao *et al*., 2011). The increased plant height in mulberry is may be due to the increased photosynthetic rate and water use efficiency when irrigated with raw sewage water (Paramanik, 2015).

B. Influence of raw and treated sewage water irrigation on plant growth parameters

Raw and treated sewage water irrigation significantly increased the plant growth parameters (Table 3). The significant shortest internodal distance (5.36cm), higher number of leaves per plant (417.16), higher leaf area per plant (202.16 cm^2) was recorded in 100% raw sewage water irrigated plot, which was statistically on par with 100% treated sewage water irrigation with internodal distance of 5.39 cm, number of leaves per plant of 407.25 and leaf area per plant of 198.88 cm^2. Whereas, the longer internodal distance (5.95 cm), lowest number of leaves/plant (336.94) and lowest leaf area per plant (150.51 cm^2) was recorded in 100% borewell water irrigationat 45 DAP.

The results of current study is in agreement with the results of Chikkaswamy*et al*. (2014) reported that the effect of sewage water irrigation on two mulberry varieties S-54 and M-5 significantly decreased the internodal distance of 15.2 nodes/meter and 18.1 nodes/meter, respectively when compared to borewell irrigation (14.6 nodes/meter in S-54 and 17.1 nodes/meterin M-5). Similarly, Rao *et al*. (2011) reported that raw sewage irrigation to mulberry increased physiological traits such as photosynthesis rate, water use efficiency, leaf chlorophyll which in turn increased the leaf area and leaf yield of mulberry. Further it was reported that chlorophyll content was increased with the application of sewage water irrigation (Zeid and AbouelGhate, 2007).

C. Influence of raw and treated sewage water irrigation on plant yield

The data presented in the table 4 revealed that leaf yield per plant varied in the range from 696.63 g to 804.31 g at 60 DAP. The significant higher leaf yield per plant (804.31 g) was recorded in 100% raw sewage water irrigation, which was statistically on par with100% treated sewage water irrigation (795.14 g).

However, lowest leaf yield/plant (696.63 g) was recorded when mulberry was raised by irrigating borewell water alone. The significantly higher leaf yield/ha/yr (54319 kg) was estimated in 100% raw sewage water irrigation whereas, lower leaf yield/ha/yr (46760kg) was calculated when mulberry was raised by irrigating borewell water alone.

The results are in conformity with the earlier studies of Yokoyama (1975) reported that mulberry leaf yield depends on the number of shoots, length of the shoots, internodal distance, number of leaves per plant and weight of leaves per plant. The results of the present investigations are similar with the findings of Chikkaswamy *et al*. (2014) recorded higher leaf yield of 860 g/plant and 1480g/plant in S-54 and M-5 mulberry varieties respectively when irrigated with raw sewage water.

Khan *et al*. (2017) conducted an experiment on the effect of treated sewage on growth, yield and nutrient quality of sorghum (*Sorghum bicolor* L.) under field conditions. The results showed that plant height, sorghum stem thickness, grain weight/panicle and 1000 grain weight of sorghum, no. of grains/panicle were significantly increased when irrigated with treated sewage water while basal dose fertilizer increased only grain weight/panicle compared to control irrigation.

Table 2: Effect of raw and treated sewage water irrigation on growth parameters of V1 mulberry at 45 DAP.

Treatments	Plant height (cm)	Highest shoot height (cm)	No. of shoots/plant
T_1(100 % BW)	151.18	96.54	19.38
T_2(25% TSW + 75% BW)	158.10	106.96	20.25
T_3(50% TSW + 50% BW)	162.98	108.42	21.03
T_4(75% TSW + 25% BW)	167.49	113.89	21.14
T_5(100% TSW)	177.83	124.01	24.86
T_6(100% RSW)	184.33	129.16	25.18
F-test	**	**	*
S.Em.±	3.71	2.52	1.19
CD @ 5%	15.45	10.51	3.58

- BW= borewell water, TSW= treated sewage water and RSW= raw sewage water.
- *Significant at 5%, and**Significant at 1%.

Table 3: Effect of raw and treated sewage water irrigation on growth parameters of V1 mulberry at 45 DAP.

Treatments	Internodal distance (cm)	No. of leaves/plant	Leaf area /plant (cm^2)
T_1(100 % BW)	5.95	336.94	150.51
T_2(25% TSW + 75% BW)	5.75	358.81	168.36
T_3(50% TSW + 50% BW)	5.70	359.24	170.26
T_4(75% TSW + 25% BW)	5.70	363.50	170.35
T_5(100% TSW)	5.39	407.25	198.88
T_6(100% RSW)	5.36	417.16	202.16
F-test	*	**	**
S.Em.±	0.16	12.83	7.51
CD @ 5%	0.35	53.46	31.29

- BW= borewell water, TSW= treated sewage water and RSW= raw sewage water
- *Significant at 5%, and**Significant at 1%.

Table 4: Effect of raw and treated sewage water irrigation on leaf yield of V1 mulberry at 60DAP.

Treatments	Leaf yield (g/plant)	Leaf yield (kg/ha/yr)
T_1(100 % BW)	696.63	46760
T_2(25% TSW + 75% BW)	724.31	48641
T_3(50% TSW + 50% BW)	739.32	49649
T_4(75% TSW + 25% BW)	746.82	50153
T_5(100% TSW)	795.14	53412
T_6(100% RSW)	804.31	54319
F-test	**	**
S.Em.±	13.47	856.93
CD @ 1%	56.14	3571.08

- BW= borewell water, TSW= treated sewage water and RSW= raw sewage water.
- *Significant at 5%, and**Significant at 1%.

CONCLUSION

The raw sewage water irrigation along with recommended dose of NPK and FYM have given significantly positive results in terms of growth and yield parameters of V1 mulberry thusfodder and forage crops, where vegetative parts are of economic importance expressed better growth under sewage effluent irrigation. The above study showed that raw sewage water and primarily treated sewage water has high nutrient load and dissolved nitrates which are essential for mulberry growth and development. However long-term irrigation of raw sewage water containing higher concentration of heavy metals and poor irrigation water quality may deteriorates the soil health as well as the growth of plant. Therefore, it is concluded that primarily treated sewage water can be used for irrigation unless water scarcity arises.

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