International Journal of Advanced Research in Engineering and Applied Sciences
ISSN: 2278-6252
Impact Factor: 4.817

IMPACT OF SEWAGE IRRIGATION ON MULBERRY VARIETIES

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Abstract: *The present experiment was conducted to analyze the effect of sewage water irrigation on the growth and leaf quality traits of two mulberry varieties (S-54 and M5). The chemical analysis of sewage water revealed that pH, EC, N, P, K, Fe, Zn, Mn and Cu were found higher in sewage water (T1) compared to bore well water (T0). Similarly, soil pH, EC, F, K, Fe, Zn, Mn and Cu were also found increased in T1 compared to T0 plot. In general, morphological traits such as plant height, number of shoots/plant, number of nodes/meter length, leaf yield, shoot yield and biological yield/plant; physiological traits, i.e. photosynthetic rate, transpiration rate, water use efficiency and total chlorophyll content; biochemical traits, i.e. total protein, sugar, starch and amino acid contents in both the genotypes were found increased in T1 compared to T0. However, between two mulberry genotypes, M5 exhibited superior performance in both T0 and T1 for all the characters studied. A bioassay study with hybrid silkworm race (NB4D2) showed improvement in silkworm growth and cocoon parameters in T1 as compared to T0. An overview of the study revealed that domestic sewage water irrigation improved the soil fertility status, plant growth and leaf quality traits of mulberry varieties.*

Keywords: *Sewage water, Soil fertility, mulberry growth, leaf quality, Silkworm growth.*

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1. INTRODUCTION

Sewage water is being used for irrigation, for nearly 10% of the world's crops, according to the first ever global survey of waste water irrigation (Scott *et al.,* 2004). This is a largely hidden practice and is outlawed in many countries. However, many farmers especially those in urban areas, use sewage water because it is abundantly available, even during drought. Sewage water contains full of nitrates and phosphates, which acts as an effective fertilizer to plants. It provides the farmers nutrient rich water supply, with a reliable and inexpensive means of waste water disposal (Rattan *et al.,* 2005). Use of sewage water for irrigation in various proportions improved the organic matter, soil fertility status and metabolic activity of soil microorganisms (Yadav *el al.,* 2002; and Malla *et al.,* 2007). Sewage water irrigation significantly increased plant growth and yield of several crops such as fodder, groundnut, spinach, bean, cauliflower, cabbage and leafy vegetable (Yadav *et al.,* 2002, Banyal and Bhardwaj, 2003, Rattan *et al.,* 2005, Bashir Ahmed *et al.,* 2006 and Zeid and Abouel Ghate, 2007). Also the rate of biosynthesis of chlorophyll a and b. photosynthetic activity and total carbohydrate content in leaves v/ere enhanced in sewage water irrigated plants compared to control (Zeid and Abouel Ghate, 2007). Several scientists have reported that use of sewage water in short run may not be harmful but in the long run after some years, it may cause phyto-toxicity to the plants (Bashir Ahmed *et al.,* 2006 and Malla *et al.,* 2007).

In mulberry, very few reports are available on the use of sewage water irrigation (Surendranath *et al.,* \ 997 and Bongale and Krishna 2000). The earlier authors have not studied in detail about the effect of sewage water on the soil nutrients, quantiu.-tive and qualitative trait of mulberry and its impact on silkworm rearing. Therefore, the present investigation was carried out with the following objectives 1) to study the chemical analysis of domestic sewage water used 2) to analyze the effect of sewage water on soil properties and 3) to estimate the effect of sewage water on morpho'-ogical, physiological and biochemical traits of mulberry. Further, to confirm the results a bioassay study was also done with hybrid silkworm race NB4D2

2. MATERIALS AND METHODS

An experiment was conducted during 2011, in the mulberry garden of Budiguppe village kanakapura taluke The S-54 and M5 mulberry garden of was established during the year 2011 and some of the mulberry plots, which are near to the domestic sewage channel were often irrigated with sewage water. The leaf yield in sewage after irrigated plot was found high compared to bore well water irrigated plot. The leaves from sewage water treated plots were used for silkworm rearing and cocoon crops were successfully harvested for the last five years. This has made us to study the chemical analysis of sewage water and its effect on soil properties and also its impact on leaf quality traits of mulberry.

For the study, S-54 (1000 m^2) and M5 (1000 m^2) mulberry garden were selected and one half of these (500 m) plots were maintained with sewage water irrigation (Tl) and other half plots were maintained with bore well water irrigation (TO) for both the genotypes. In each of 1000m^2 of S-54 and M5 mulberry plots a total of 2730 plants with the wider spacing (150cm + 90 cm) * 60 cm was maintained. Before conducting the experiment, water samples of domestic sewage water and bore well water were collected and analyzed for pH and electrical conductivity (EC) by following the method of Jackson (1973) and macronutrients (N, P and K) and micronutrients (Fe, Zn, Mn and Cu) were estimated by following the methods as described by Tandon (1993).

Initially, the plants were pruned 30 cm above the ground level and irrigation was done once in a week for all the mulberry plots. Cultural operation and application of FYM /fertilizers were done as per the norms of CSR&T1, Mysore (Krishnaswami, 1978). After 60 days of pruning, 20 plants were randomly selected in TO and Tl mulberry plots of S-54 and M5 and morphological traits such as plant height (cm), number of shoots/ plant, number of nodes /meter length, leaf yield / plant (g), shoot yield/ plant (g) and biological yield/plant (g) were recorded for five crops. Soil and leaf samples were collected from two sources of irrigations (TO and Tl) for five crops. The average of five crops data on leaf yield and yield attributing characters were recorded in TO and Tl and statistically analyzed. From the sewage (Tl) and bore well (TO) water irrigated mulberry plots, soil samples were collected, processed and analyzed for pH, EC, Organic carbon (OC), macronutrients (available P and K) and micronutrients (Fe, Zn, Mn ao.d Cu). Fresh leaves were also collected (12^{th} - 14th leaf from top) from TO and T1 plots, to analyze biochemical (leaf quality) traits *i.e.,* Leaf Moisture Content (LMC %) and Moisture Retention Capacity (MRC %) after 6 hrs from harvest, by following the method of Vijayan *et al.,* (1996). Leaf samples collected from TO and Tl plots were dried at 60° C, powdered and analyzed for total protein content by following Lowry et al, (1951), total amino acid content by adopting ninhidrin method using leucine as standard

(Spies, 1955). Nitrogen content was estimated by micro-kjeldahl method (Jackson, 1973). Sugar and starch contents (soluble carbohydrate) were estimated by the method of Dubois *et al.,(1*956) and MC. Cready *et al.,(1*961) respectively. The physiological parameters like photosynthetic rate, transpiration rate were measured using the photosynthetic system (LI-COR, model 6200; Licor Instrument Ins. USA). Water use efficiency (Photosynthesis/ Transpiration) was calculated and total chlorophyll content (mg/of. wt.)

was estimated by adopting the procedure of Hiscox and Israelistam (1979). Further, to confirm the effect of sewage water on leaf quality traits, a bioassay study was conducted at three different seasons (summer, rainy and winter) with the hybrid silkworm race,NB4R2. For the bioassay study, only M5 leaves from sewage (Tl) and bore well (TO) irrigated plots were used separately for feeding the silkworm until spinning. The average of three seasons rearing data on larval duration (days: hours), weight of 10 mature larvae (g), effective rate of rearing (ERR) by number and by weight (g), single cocoon weight (g), single shell weight (g) and shell (%) were recorded for TO and Tl separately and analyzed statistically (Snedecor and Cochran, 1967).

3. RESULTS AND DISCUSSION

1. Chemical analysis of domestic sewage and bore well water:

The chemical analysis such as pH, EC, macronutrients (N, P and K) and micronutrients (Fe, Mn, Zn and Cu) was done in bore well (TO) and in domestic sewage water (Tl). The analysis was repeated four times by taking samples after 15 days interval. The average of these four repeats were recorded in TO and Tl are presented in Table I.

The pH of bore well water (TO) and sewage water (Tl) recorded was 7.43 and 7.87 respectively, which are considered as within the permissible limit. The pH value ranging from 6.5 - 8.5 was considered as suitable for drinking water and also for irrigation to plants (Indian Standard Institution, 1983). The electrical conductivity (EC) is one of the important characters to evaluate the purity of water. The EC was found low in TO (0.36m hos/cm) and high in Tl (1.26m hos/cm). The results revealed that both the water samples are within the permissible limits. The macronutrients such as, N, P and K in water were found high inTl (4.17, 1.23 and 9.56 ppm) and low in TO (1.44 ,0.17 and 5.62 ppm respectively). It was reported that the sewage water contains more macronutrients compared to ground water source (Kakar *el al.,* 2006). The micronutrients viz., Fe, Zn, Mn and Cu were found high in Tl

(0.033,0.041,0.014 and 0.006 ppm) and low in TO (0.002,0.004,0.002 and 0.002 ppm respectively). Sewage water proved to be a good source of micronutrients (Huma and Khan, 2003). According to Kakar *et al.,* (2006) recorded the range of micronutrients *i.e.,* Fe = 0.55 - l.OOppm, Zn = 0.08 -0.21 ppm, Mn = 0.14 - 0.23ppm and Cu = 0.03 - 0.07ppm in different sewage waters. In the present study significant difference was observed between the TO and Tl with regard to macro and micronutrients (Table 1).

2. Effect of sewage and bore well water irrigation on soil characters:

The mulberry plots selected for the experiments were irrigated once a week with bore well water (TO) and sewage water (Tl) separately. After a period of one year the soil characters *i.e.,* pH, EC, OC, available phosphorus and potassium and micronutrients (Fe, Zn, Mn and Cu) were recorded in the soil of TO and T1 plots and are presented in Table II.

The soil pH recorded in TO and Tl are 8.06 and 8.44 respectively. Significant difference in the soil pH was not observed between the two treatments. The marginal increase in soil pH was observed in Tl compared to TO, this might be due to the influence of sewage water, which contains high organic matter, nutrients, phosphates, nitrates and microorganism (Herman and Emanuel, 1987). The EC is one of the important attributes, which influences the soil stability, soil structure and water availability to plants. The EC was found low in TO (0.32m hos/cm) and high inTl (0.41 mhos/cm). It was reported that EC levels in soil ranged from 0.1 to 1.0 mhos/cm, which is within the permissible limit and if it is above 1.0 mhos/cm, it may cause problem to soil as well as to plants (Charman and Murphy, 1991). The OC influences the physical structure of the soil, water holding capacity and supply of nutrients. In the present study OC was found high in Tl (0.92%) and low in TO (0.82%). Most of the sewage waters are suitable for irrigation as they possess high EC ranging from 0.9 to 3.2 mhos/cm and OC ranging from 1.24 to 1.78% (Dubey *et al.,* 2006).

The available phosphorus and potassium were found high in Tl (48.66kg/ha and 222.66 kg/ha) and low in TO (40.44 kg/ha and 210.48 kg/ha respectively). The macronutrients of soil increased significantly with prolonged sewage water irrigation (Malla *et a!.,* 2007 and Khalil Gardez *et a!.,* 2009). The soil micronutrients *i.e.,* Fe, Mn, Znand Cu were also found high inTl (16.36,2.61,56.22 and 1.77 ppm) and low in TO (9.05, 1.44, 50.44 and 1.66 ppm respectively). The sewage water which are rich in macro and micronutrients gets accumulated in the soil and this in turn increase the native nutrients present in the soil

(Dubey *et al.,* 2006).

3. Effect of sewage water irrigation on physiological characters of mulberry leaves:

The physiological traits such as photosynthetic rate, transpiration rate, water use efficiency and total chlorophyll content estimated in S-54 and M5 varieties are presented in Table III. The photosynthetic rate in TO and Tl was high in M5 (22.16and22.42 umol m^{+2} S^{-1}), whereas it was low in S-54 (15.54 and 15.980 umol m^{+2} S^{-1} respectively). A marginal increase in photosynthetic rate was observed in Tl compared to TO in both the varieties. It was reported that application of sewage water positively affected the synthesis of photosynthetic pigments and photosynthetic activity in bean (Zeid and Abouel Ghate, 2007). The transpiration rate in TO and Tl was found slightly high in S-54 (8.65 and 8.74 umol m^{+2} S^{-1}) compared to M5 (7.82 and 7.85 umol m^{+2} S^{-1} respectively). In the present study, significant difference for photosynthetic rate was observed between the varieties but not between the treatments. Whereas, with regard to transpiration rate, significant difference was neither observed between the varieties nor between the treatments. The water use efficiency was found high in M5 (TO = 3.39 and Tl = 3.42) and low in S-54 (TO = 2.62 and Tl = 2.63). High photosynthetic rate and water use efficiency in M5 indicates the superiority of the variety (Sarkar *et al.,* 2000). The total chlorophyll content was found high in M5 in TO and Tl (2.66 and 3.11 rng/g.f. wt), compared to S-54 (2.22 and 2.33 mg/g.f. wt. respectively). It was reported that chlorophyll content increased with the application of sewage water irrigation (Zeid and Abouel Ghate, 2007). In both the varieties high chlorophyll content was observed in Tl, which clearly indicates the photosynthetic efficiency of mulberry variety (Sujathamma and Dandin, 2000). Whereas low chlorophyll content in TO indicates that bore well water may not possess all the required nutrients for the normal growth and physiological activities of plants.

4. Effect of sewage water irrigation on morphological traits of mulberry:

The average of five crops data recorded for different quantitative characters of two varieties, S-54 and M5 are given in Table IV. In both the varieties leaf yield /plant was found high in Tl (0.86 and 1.48kg/p!ant) and low in TO (0.80 and 1.15 kg/plant respectively). However, leaf yield and its attributes were high in M5 compared to S-54 variety. The increase in leaf yield was due to increase of different yield contributing traits. Higher leaf yield in M5 compared to S-54 variety was primarily due to its. high photosynthetic rate and water use efficiency (Sarkar *et al.,* 2000). In general, morphological traits were influenced by physiological traits such as photosynthesis and water use efficiency (Singhal *et al.,* 2000). Increased growth and yield attributes in Tl was mainly due to the influence of sewage water, which not only contains high concentration of macro and micronutrients but also contains several microorganisms, which secretes hormones, growth promoting substances and other nutrients needed for plant growth. Sewage water irrigation enhances the yield and yield attributing characters significantly in many crops (Rattan *et al.,* 2005, Bashir Ahmed *et al.,* 2006, Zeid and Abouel Ghate, 2007).

5. Effect of sewage water irrigation on biochemical (leaf quality) traits of mulberry:

The production of quality cocoons depends on feeding of good quality mulberry leaves to silkworm. Therefore, it is most imperative to analyze different leaf quality traits such as leaf moisture content (LMC), moisture retention capacity (MRC), protein, amino acids and carbohydrate contents. In general all the leaf quality traits recorded in two varieties were found increased in Tl when compared to TO (Table V). In M5 variety, LMC and MRC were found high in Tl (73.66 and 81.35%) and low in TO (72.55 and 78.61% respectively). Similarly, in S-54 , these two traits were high in Tl (74.05 and 82.95%) and low in TO (71.55 and 78.34% respectively). The LMC and MRC are two important factors, which determine the nutrition levels of mulberry leaves (Sujathamma and Dandin, 2000) and are closely associated with the growth of silkworm larvae (Paul *etal.,* 1992). In the present study, marginal improvement was observed in MRC in Tl compared to TO in both the varieties. This may be due to the influence of sewage water which is rich in nutrients, enhance the soil fertility status and moisture availability in the soil rhizosphere, thereby improving the growth, water uptake and other metabolism in plants.

The total protein content plays an important role in the production of certain hormones and enzymes, which are essential for the growth and development of silkworm. In TO and Tl, the total protein content was found high in M5 (24.11 and 24.55 %) compared to S-54 (21.66 and 22.61 % respectively). The protein content obtained in the leaves of Tl is within the dietary protein level range (20 - 25%) as reported by Horie (1980) and thus sufficient for the normal growth of silkworm. In mulberry leaves, carbohydrates are available in plenty and it was reported to be the main source of energy for silkworm (Horie, 1978). The quantity of carbohydrate is determined based on the quantity of total sugar and starch available in leaves (Bose and Bindroo, 2001). In M5, sugar and starch contents were high in Tl (14.11 and 10.72%) and low in TO (13.66 and 11.28%). Similarly in S-54, these two traits were found high in Tl (13.66 and 11.42%) and low in TO (12.44 and 10.92% respectively). In both the genotypes carbohydrate contents were found high in Tl, which clearly indicated that sewage water had pronounced influence on biosynthesis of carbohydrates in the leaves. The total amino acid contents in TO and Tl were found high in M5 (252.52 and 271.22 mg/g. dry/wt .) compared to S-54 (232.2 and 246.8 mg/g dry wt respectively). However, marginal improvement was observed in T! compared to TO in both the varieties. It was reported that varieties possessing higher nitrogen and amino acid contents in leaves are nutritively superior and positively related to growth and development of silkworm (Suryanarayana and Shivashankar, 2002).

6. Effect of sewage water irrigation on silkworm rearing parameters: The average of three season's data recoided on silkworm growth and rearing parameters of hybrid silkworm, NB4D2 are summarized in Table VI. In general, marginal improvement in growth and cocoon parameters was observed in Tl as compared to TO. This clearly suggest that sewage water, which are rich in organic carbon contents; macro and micro nutrients; and microorganism secretes many hormones and other nutrients (Duuey *et at.,* 2006), that helps to improve the growth, metabolism and physiological activity of the host plants, with the result leaf quality might have been improved and thus feeding on such quality leaves improved normal silkworm growth and cocoon characters (Bongale and Krishna, 2000).

An overview of the results revealed that the domestic sewage water used in the present investigation contains required pH, EC, macro and micronutrients, which are within the permissible limit and can be used for irrigation. The domestic sewage water irrigation (Tl) exhibited better performance compared to bore well water irrigation (TO) in terms of enhancing the soil fertility status, growth and leaf quality traits of mulberry. It was observed that silkworm growth and cocoon parameters were improved when the leaves of M5 from Tl plot were used for rearing. It is also understood from the literature that continuous use of sewage water deteriorates the soil fertility condition in the long run. Hence, with proper management or treatment of sewage water, it can be used regularly (Rattan *et a!.,* 2005; Dubey *et a!.,* 2006 and Bashir Ahmed, 2006). Therefore, it is concluded from the study that domestic sewage water irrigation can be done to the mulberry garden only when water scarcity arise or better to use alternatively to the bore well water irrigation.

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Table I. Chemical analysis of bore well & domestic sewage water

Treatment	pH	EC / CE (m hos/cm)	Macronutrients (pp)			Micronutrients (ppm)			
			N	P	K	Fe	Zn	Mn	Cu
BW1 (T0)	7.43	0.36	1.44	0.17	5.62	0.002	0.004	0.002	0.002
SW1 (T1)	7.87	1.26	4.17	1.23	9.56	0.033	0.041	0.014	0.006
Significant "t"	NS	**	**	*	**	**	**	**	*

EC: Electrical conductivity

BWI: Bore well water irrigation

SWI : Sewage water irrigation

NS : Non-Significant

* Significant at 0.05% level

** Significant at 0.01% level

Table II. Effect of bore well and sewage water irrigation on soil pH, macro and micro nutrients.

Treatment	pH	EC	OS	Available Phosphorus	Available Potassium	Micronutrients (ppm)			
						Fe	Ze	Mn	Cu
BWI (T0)	8.06	0.32	0.82	44.27	210.48	9.05	1.44	50.44	1.66
SWI (T1)	8.44	0.41	0.92	48.66	222.66	16.36	2.61	56.22	1.77
Significant "t"	NS	*	*	**	*	*	*	*	NS

OC: Organic Carbon

BWI: Bore well water irrigation

SWI: Sewage water irrigation

NS: Non-Significant

Table III. Effect of sewage & bore well water irrigation on physiological triats of S-54 & M5 Variety.

Variety	Treatment	Photosynthetic Rate	Transpiration Rate	Water use efficiency	Total Chlorophyll Content (mg/gf.wt)
S-54	BWI (T0)	15.54 $\pm$ 0.37	8.65 $\pm$ 0.07	2.62 $\pm$ 0.04	2.22 $\pm$ 0.14
	SWI (T1)	15.80 $\pm$ 0.29	8.76 $\pm$ 0.10	2.63 $\pm$ 0.07	2.33 $\pm$ 0.17
M5	BWI (T0)	22.64 $\pm$ 0.43	7.82 $\pm$ 0.09	3.31 $\pm$ 0.06	2.66 $\pm$ 0.04
	SWI (T1)	21.42 $\pm$ 0.38	7.85 $\pm$ 0.14	3.42 $\pm$ 0.10	3.11 $\pm$ 0.07
	CD 5%	2.15	NS	0.23	0.14

NS = Non significant

Table IV. Effect of sewage & bore well water irrigation on Morphological triats of S-36 & V-1 Variety.

Variety	Treat--ment	Plant Height	No. of Shoots / Plant	No. of Nodes / Meter Length	Shoot Yield / Plant	Leaf Yield / Plant	Biological yield / Plan
S-54	BWI (T0)	133.37 + 0.09	8.4 + 0.07	14.6 + 0.17	0.72 + 1.14	0.86 + 0.67	1.44 + 0.83
	SWI (T1)	142.28 + 0.14	8.8 + 0.26	15.2 + 0.22	0.81 + 1.21	0.86 + 0.72	1.55 + 0.93
M5	BWI (T0)	146.40 + 0.14	9.6 + 0.17	17.1 + 0.24	1.02 + 1.92	1.15 + 0.62	2.11 + 0.91
	SWI (T1)	166.70 + 0.26	10.8 + 0.23	18.1 + 0.38	1.24 + 2.03	1.48 + 0.57	2.62 + 0.87
	CD 5%	5.2	0.27	0.45	0.09	0.16	0.20

Table V. Effect of sewage & bore well water irrigation on leaf quality triats of S-54 & M5 Variety.

Vari-ety	Treat--ment	Leaf Moisture Content	Moisture Retention After 6 hrs.	Total Protein Content	Total Sugar Content	Total Starch Content	Total Amino Acid (Mg/g. dry wt.)
S-54	BWI (T0)	71.55 + 3.14	78.27+ 3.51	21.66+0.81	12.44 +0.14	10.42 + 0.15	232.2+6.57
	SWI (T1)	74.05 + 3.75	82.95 + 3.83	22.61 + 0.62	13.66 + 0.17	11.42 + 0.28	246.8 + 7.85
M5	BWI (T0)	72.55 + 3.53	78.61+ 3.67	24.11+0.71	13.66 +0.25	11.22 + 0.21	252.2+8.63
	SWI (T1)	73.66 + 4.02	81.35 + 4.17	24.55 + 0.75	14.22 + 0.36	10.72 + 0.23	271.22 + 9.05
	CD 5%	NS	0.73	026	0.35	NS	8.72

NS = Non Significant

Table VI. Effect of sewage & bore well water irrigation on Silkworm Growth & Rearing Parameters (Ave. of three seasons).

Silkworm Hybrid Race	Treat--ment	Larval Duration Day hrs.	Weight of 10 mature larvae (g)	Yield / 10,000 larve by no.	Yield / 10,000 larvae by wt. (Kg)	Single cocon Wt. (g)	Single Shell Wt. (g)	Shell Ratio n(%)
NB4D2	BWI (T0)	23.08	52.66	8148	17.282	1.744	0.438	22.44
	SWI (T1)	23.08	53.01	8285	17.494	2.016	0.468	22.77
Significant "t"		NS	NS	NS	NS	NS	NS	NS

NS = Non Significant