Original Research Article

EFFECT OF MULBERRY IRRIGATED WITH TREATED SEWAGE WATER ON SILKWORMS AND COCOON PRODUCTION

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 of mulberry and subsequent effect on silkworm (PM × CSR_2) growth and cocoon parameters. The raw and treated sewage water was collected from GKVK sewage treatment plant and irrigated to mulberry garden. Silkworms fed with mulberry leaves raised on recommended dose of NPK kg/ha/year + FYM along with raw and treated sewage water irrigation showed positive influence on late age silkworms. Observations recorded on silkworm growth and cocoon parameters revealed that significant higher fifth instar larval weight (32.02 g/10 larvae), ERR (99.0 %), single cocoon weight (1.706 g), pupal weight (1.385 g), shell weight (0.321 g), shell ratio (18.65%) and shorter fifth instar larval duration (181.91 hrs). Similarly, reeling parameters of cocoons showed significantly longer filament length (853.00 m) and higher filament weight (0.28 g) in silkworms fed with mulberry leaves from the plots irrigated with raw sewage water.

Key words: Silkworm growth, cocoon parameters, raw sewage water, treated sewage water.

Introduction

"Mulberry foliage is the sole food for the silkworm (*Bombyx mori*, named after the mulberry genus *Morus.* Mulberry is a perennial crop which can be maintained for many years. Selection of land, recommended package of practices and water management are the imperial factors for producing quality leaf. Among these, irrigation water plays a significant role as one of the key inputs in mulberry cultivation. Water in the soil-plant system is a necessary medium for the distribution of nutrients through the plant. It acts as a solvent for biochemical reactions, a medium of distribution for solutes, temperature regulator and as a source of hydrogen in photosynthesis" (Subbaswamy *et al.*, 1987).

Bongale and Krishna (2000) evaluated "the effect of raw sewage and borewell water irrigation on leaf quality of mulberry (*Morus indica*) and cocoon crops of silkworm (*Bombyx mori*). The results showed that significantly higher cocoon yields were recorded in raw sewage water irrigated gardens, compared to borewell irrigated mulberry gardens".

Chandrakala *et al*. (2009) conducted a field survey to study "the cocoon yield pattern of the silkworm crops raised on mulberry irrigated with wastewater as against irrigation by bore wells in the vicinity of Bangalore city who irrigate their mulberry gardens with Vrishabhavathy stream water, which is polluted with domestic and industrial wastewater from the city. The average yield for 100 layings was 46 to 57 kg in the control group (borewell water) whereas in test groups (stream water), it ranged between 34 to 51 kg".

Chandraju *et al.* (2012) reared "Kolar gold, CSR19, and CSR_2xCSR_4 breeds of silkworm using M5 variety mulberry leaves cultivated by various proportions of spent wash (SW) irrigation. Influence of spent wash irrigated M5 Mulberry leaves on the yield of different breeds of silkworms was evaluated. Results showed that the cocoon yields of CSR19, Kolar gold and CSR_2xCSR_4 were high in case of mulberry leaves irrigated with 33 per cent spent wash than raw water and 50 per cent distillery spent wash irrigation. The percentage yield was maximum in the case of Kolar gold (26%) and minimum in CSR_2xCSR_4 (21.87%) and it was moderate in CSR19 (25.6%). This concludes that the diluted 33 per cent distillery spent wash irrigated mulberry leaves is most beneficial for the rearing of the above breeds of the silkworm, which increases the economy of the farmers".

Saad (2014) carried out a study to compare the silkworm performance by feeding mulberry leaves from mulberry gardens irrigated with borewell water and sewage water in spring season. The results revealed that the larvae reared on mulberry leaves from gardens irrigated with borewell water showed the same non-significant performance in larval weights, while larvae fed on leaves from mulberry garden irrigated with sewage water exhibited a significant increase in the mean weight of fresh cocoon, pupae and cocoon shell by about 18.9, 23.9 and 18 per cent respectively which is higher than silkworms reared on leaves from mulberry plants irrigated with borewell water.

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

Material and methods

The study was conducted during *Rabi* 2019 in 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, comprising of different proportions of raw sewage water, treated sewage water and borewell water. The II instar silkworms procured from Basaveshwara chawki rearing center, Devanahalli taluk, Bengaluru and reared in plastic trays by feeding three times a day with chopped tender mulberry leaves of V1 variety. Bed cleaning was done twice and thrice during II and III instars, respectively, by lifting unfed leaves and excreta of the silkworm. Optimum spacing was provided according to the age of the silkworms. After each bed cleaning and when all the silkworms settled for moulting, the lime powder was dusted on silkworms. Shelf rearing was conducted during third, fourth and fifth instar of silkworm by feeding raw sewage water and treated sewage water irrigated V1 mulberry leaves by following standard rearing practices (Dandin *et al*., 2001).

Chart 1: Experimental details

Silkworm Hybrid	PM × CSR_2 (Kolar gold)
Number of treatments	6
Number of replications	4
Number of worms/treatment/replication	50

The treatment details are presented below.

Treatment details :

T_1 - 100% borewell water irrigation (control)
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

Silkworm growth and cocoon parameters of PM × CSR_2 hybrid

Ten silkworms and ten cocoons were randomly selected in each treatment for recording observations on growth and cocoon parameters such as V^{th} instar larval weight (g /10 larvae), V^{th} instar larval duration (hrs), Effective rate of rearing (%), mortality (%), single cocoon weight (g), pupal weight (g), single shell weight (g), shell ratio (%), cocoon filament length (m), non-breakable filament length (NBFL) (m) and denier.

Effective rate of rearing (%)

The number of cocoons harvested at the end of the rearing was recorded and the ERR was calculated by using the formula.

$$\text{ERR (\%)} = \frac{\text{Number of cocoons harvested}}{\text{Total number of silkworms reared}} \times 100$$

Mortality (%)

The number of silkworms dead at the end of rearing was recorded and the mortality rate (%) was calculated by using the formula.

$$\text{Mortality (\%)} = \frac{\text{Number of silkworms dead}}{\text{Total number of silkworms reared}} \times 100$$

Shell ratio (%)

Shell ratio indicates the total quantity of silk available from the single cocoon and is expressed as a percentage. It was calculated by using the following formula.

$$\text{Shell ratio (\%)} = \frac{\text{Weight of the cocoon shell}}{\text{Weight of the whole cocoon}} \times 100$$

Non-breakable filament length (NBFL) (m)

It is the average length of the filament that can be unwound from the cocoon without break.

$$\text{Nonbreakable ilament length (m)} = \frac{\text{Total ilament length}}{1 + \text{Number of breaks in ilament}}$$

Denier

The raw silk filament was removed from the Eprouvette and weighed after conditioning at room temperature for 24 hrs to determine the denier using the standard formula.

$$\text{Denier} = \frac{\text{Weight of single cocoon ilament (g)}}{\text{Length of single cocoon ilament (m)}} \times 9000$$

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.

Results and Discussion

Silkworms fed with mulberry leaves from the V1 mulberry variety raised on recommended dose of NPK kg/ha/year + FYM along with raw and treated sewage water irrigation showed positive influence on late age silkworms. However, the different parameters *viz.*, fifth instar larval weight, fifth instar larval duration, effective rate of rearing, mortality percentage, cocoon parameters and reeling parameters showed significant difference among the treatments.

Effect of raw and treated sewage water irrigation on rearing performance of late age silkworm (PM × CSR_2)

Raw and treated sewage water irrigation to mulberry significantly increased rearing performance of late age silkworm (PM × CSR_2) (Table 1). Significant higher fifth instar larval weight (32.02 g/10 larvae), ERR (99.0 %) and significantly shorter fifth instar larval duration (181.91 hrs) mortality (1.0%) were recorded when silkworms were fed with mulberry leaves from the plots irrigated with 100% raw sewage water and that were statistically on par with 100% treated sewage water irrigation. The lowest larval weight (26.86 g/10 larvae), longer fifth instar larval duration (191.64 hrs), lowest ERR (93.25%), higher mortality (6.75%) were observed when silkworms were fed with mulberry leaves from 100% borewell water irrigated plots.

Increase in larval weight is apparently due to superior leaf quality. The present investigation recorded higher larval weight, which was in accordance with the results of Chikkaswamy *et al*. (2014) who had recorded higher V^{th} instar larval weight (53.01 g/10 larvae) in NB_4D_2 larvae fed with leaves from raw sewage treated plot. Paramanik (2015) reported that sewage water had pronounced influence on biosynthesis of carbohydrates and proteins in leaves which help to improve the growth, metabolism and physiological activity of larvae. Similarly, shorter larval duration may be due to the balanced nutritional status of the leaves which enable the silkworms to mature early due to the faster metabolic activity (Shankar, 1990). Rao *et al.* (2010) reported that sewage water had pronounced influence on biosynthesis of three amino acids namely threonine, methionine and histidine which help to improve the growth of the silkworms.

Effect of raw and treated sewage water irrigation on Cocoon parameters of silkworm (PM × CSR_2)

The cocoons harvested from silkworms fed with mulberry leaves from the plots irrigated with 100% raw sewage water recorded maximum single cocoon weight (1.706 g), pupal weight (1.385 g), shell weight (0.321 g), cocoon shell ratio (18.65%) and cocoon yield per 100 dfls (74.25 kg) were recorded when silkworms were fed with mulberry leaves from the plots irrigated with 100% raw sewage water (Table 2). The lowest single cocoon weight (1.337 g), pupal weight (1.114 g), cocoon shell ratio (16.56%), shell weight (0.223 g) and the cocoon yield (56.47 kg) were observed when silkworms were fed with mulberry leaves from 100% borewell water irrigated plots.

Same trend was observed by Chandraju *et al.* (2012) who reported increase in cocoon yield of CSR_2 × CSR_4 by 28 per cent with the application of distillery spentwash water. In line with the present observations, Shankar *et al*. (1990) also reported that “feeding of mulberry leaves with higher concentration of nutrients recorded significantly higher pupal weight compared to control. Therefore, the quality of leaves largely determines the performance of silkworms during their development and spinning of cocoons”.

Effect of raw and treated sewage water irrigation on cocoon reeling parameters of silkworm hybrid (PM × CSR$_2$)

The filament length (853.00 m), non-breakable filament length (373.25 m), Filament weight (0.28 g) were significantly longer when silkworms fed with V1 mulberry leaves from plots irrigated with 100% raw sewage water. While comparatively shorter filament length (797.75 m), non-breakable filament length (297 m) and lower filament weight (0.22 g) was recorded when silkworms were fed with mulberry leaves from 100% borewell water irrigated plots. The filament denier was non significant among the different treatments. However, lower denier (2.44) was recorded when silkworms were fed with mulberry leaves from 100% borewell water irrigated plots. (Table 3)

The results showed same trend as of Chandraju *et al.* (2012) who recorded significantly higher filament lengths (800.00 m, 868.35m and 878.34m) in three different breeds of silkworm CSR 18, CSR 19 and Kolar gold, respectively with the application of distillery spentwash as one of the treatments to mulberry. Further he reported that spentwash irrigation results enhanced nutrition in mulberry leaves which in turn influenced better growth of silkworms, yielding higher proportions of silk proteins and spinning of long silk thread. These results only signify the close relationship between higher nutrient status of the leaf and silkworm nutrition which resulted in higher cocoon parameters.

Table 1: Effect of V1 mulberry leaves on silkworm (PM × CSR2) as influenced by raw and treated sewage irrigation

Treatments	Vth instar larval weight (g/10 larvae)	Effective rate of rearing (%)	Mortality (%)	Vth instar larval duration (h)
T$_1$ (100 % BW)	26.86	93.25	6.75	191.64
T$_2$ (25% TSW + 75% BW)	28.62	94.00	6.00	190.80
T$_3$ (50% TSW + 50% BW)	29.35	95.25	4.75	188.33
T$_4$ (75% TSW + 25% BW)	29.74	96.00	4.00	184.55
T$_5$ (100% TSW)	31.26	99.00	1.00	183.50
T$_6$ (100% RSW)	32.02	97.50	2.50	181.91
F-test	**	*	*	**

S.Em.±	0.33	1.07	1.07	1.59
CD	1.40	3.21	3.21	6.31

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

Table 2: Effect of V1 mulberry leaves on cocoon parameters of PM × CSR2 as influenced by raw and treated sewage water irrigation

Treatments	**Single cocoon weight (g)**	**Pupal weight (g)**	**Single shell weight (g)**	**Cocoon shell ratio (%)**	**Cocoon yield kg/100 dfls**
T_1 (100 % BW)	1.337	1.114	0.223	16.56	56.47
T_2 (25% TSW + 75% BW)	1.464	1.216	0.248	16.73	62.15
T_3 (50% TSW + 50% BW)	1.495	1.234	0.261	17.28	64.12
T_4 (75% TSW + 25% BW)	1.530	1.253	0.276	17.81	66.15
T_5 (100% TSW)	1.618	1.321	0.294	17.96	72.19
T_6 (100% RSW)	1.706	1.385	0.321	18.65	74.25
F-test	**	*	**	**	**
S.Em.±	0.030	0.048	0.009	0.407	0.956
CD	0.131	0.146	0.040	1.228	3.951

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

Table 3: Silk filament characteristics of PM × CSR2 as influenced by raw and treated sewage water irrigation to V1 mulberry

Treatments	**Filament length (m)**	**Non-breakable filament length (m)**	**Filament weight (g)**	**Denier**
T_1 (100 % BW)	797.75	297.00	0.22	2.44
T_2 (25% TSW + 75% BW)	810.75	310.75	0.23	2.56
T_3 (50% TSW + 50% BW)	814.25	321.25	0.24	2.64
T_4 (75% TSW + 25% BW)	821.00	329.75	0.26	2.79

T_5 (100% TSW)	841.75	366.75	0.27	2.84
T_6 (100% RSW)	853.00	373.25	0.28	2.93
F-test	**	NS	**	NS
S.Em.±	5.76	-	0.01	-
CD	23.98	-	0.02	-

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

a. Raw sewage water irrigation (T_6)

b. Borewell water irrigation (T_1)

Fig 1: V^th instar larvae fed with V1 mulberry leaves from plots irrigated with raw sewage water and borewell water

Fig 2: General view of silkworm rearing (PM × CSR_2)

Conclusion

The Raw sewage water irrigation along with recommended dose of NPK and FYM had positive influence on cross breed silkworm PM x CSR_2 when fed with mulberry leaves. The mulberry irrigated with raw sewage increased the nutrient content of leaves with carbohydrates and proteins which in turn influenced the cocoon parameters positively. Further analyses should be carried out on the biochemical parameters of silkworm to find out the bio-transportation and bio accumulation of heavy metals from mulberry to silkworms which affects the silkworm growth.

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