Madras Agric.J.,2025; https://doi.org/10.29321/MAJ.10.70JE24

RESEARCH ARTICLE

Effect of Tree Spacing on Silkworm Growth: A Comparative Analysis of Mulberry Varieties V1 and G4

Susikaran. S[1], Vijay. S[2*], Nithyadharshini K[3], Harishkumar J[4] and Arun Kumar M[5]

[1]Directorate of Open and Distance Learning, Tamil Nadu Agricultural University, Coimbatore-641003,

[2]Silkworm Seed Production Centre, National Silkworm Seed Organization, Central Silk Board, Dakshin Bhawanipur, West Bengal-733132

[3] Department of Nematology, Tamil Nadu Agricultural University, Coimbatore-641003

[4]Silkworm Seed Production Center, National silkworm Seed Organization, Central Silk Board, Berhampore, West Bengal-742101

[5]Silkworm Seed Production Center, National silkworm Seed Organization, Central Silk Board, Jorhat, Assam-785005

Received: 11 Apr 2025

Revised: 27 Apr 2025

Accepted: 03 May 2025

ABSTRACT

The study evaluated the impact of three spacing configurations—5 ft × 5 ft, 6 ft × 6 ft, and 7 ft × 7 ft—on the growth parameters of silkworms fed leaves from two mulberry tree types, V1 and G4. The results revealed differences in silkworm growth and yield based on the spacing arrangements. Notably, silkworms fed with 6ft x 6ft spaced leaves from the V1 variety showed the best performance, with improved parameters such as matured larval weight (3.30 g), ERR (92.51%), lowest mortality (7.25%), silk gland weight (788.56mg), silk productivity (6.70 cg/day), cocoon weight (1.80 g), shell weight (0.38 g), shell ratio (23.00%), cocoon yield (20.56 kg), pupal weight (1.29 g), filament length (1318.99 m), filament weight (321.51 mg), denier (2.45), and renditta (6.88 kg). The G4 variety showed similar trends, though slightly lower values than V1.

Keywords: *Growth; Silkworm; Spacing; Tree mulberry; Cocoon yield*

INTRODUCTION

Sericulture, the practice of silk production through the rearing of silkworms (*Bombyx mori* L.), is a significant agro-based activity that contributes to the economies of several countries. The success of sericulture is deeply intertwined with the availability and quality of mulberry leaves because they are the sole food source for silkworms. Mulberry leaves contribute 38.20% to silk production, followed by climate (37.00%), rearing techniques (9.30%), silkworm breed (4.20%), and other factors (8.20%) (Susikaran and Vijay, 2024). The growth and yield of mulberry silkworms are entirely dependent on the nutritional value of the leaves. Various factors influence the quality and quantity of mulberry leaves, including environmental conditions, mulberry variety, cultivation practices, and spacing. Among these, plant spacing is a crucial factor that determines the amount of light, nutrients, and space available for each plant, directly affecting production and quality of the leaf (Vijay *et al.,* 2023).

Mulberry varieties, such as V1 and G4, are widely cultivated for sericulture due to their adaptability, high leaf yield, and favourable nutritional composition. The choice of variety and the spacing between trees can significantly influence leaf morphology, growth patterns, and ultimately, the performance of silkworms (Vijay and Susikaran, 2023). The optimal tree spacing enhances leaf production, ensures better air circulation, reduces the risk of pest and disease outbreaks, and maximizes

*Corresponding author mail: vijayseri98@gmail.com

the utilization of available resources, such as sunlight and soil nutrients. However, the specific impact of different tree spacings on silkworm growth and cocoon production remains an area of ongoing research is to examine the effect of tree spacing on silkworm growth, comparing the performance of two popular mulberry varieties—V1 and G4—under different spacing.

MATERIALS AND METHODS

The study was conducted in the Agriculture Research Station, Bhavanisagar, Tamil Nadu, using the following treatments.

T1: 5'x 5' spacing plot

T2: 6'x 6' spacing plot

T3: 7'x 7' spacing plot

Double-hybrid silkworms were purchased from private Chawki Rearing Centres after the second moult. Disinfection of the rearing room was done, using bleaching powder and Sanitech solution.

Bioassay on silkworm

The study was conducted using the 3rd to 5th instar worms and allowed to feed on healthy leaves of different spaced tree types of mulberry leaves. The silkworms were reared at an optimum temperature and RH. For every treatment, three replications were kept, and each replication had fifty silkworms. The following parameters were recorded during the experiment described below

i)Larval weight (in Grams)

ii)Effective rate of rearing (ERR) %.

$$ERR = \frac{\text{No. of cocoons harvested}}{\text{Total number of worms brushed.}} \times 100$$

iii)Mortality rate (%)

$$\text{Mortality} = \frac{\text{Number of worms died}}{\text{Total unit of worms brushed}} \times 100$$

(Dayananda et al. 2011)

iv)Silk gland weight (in Grams)

v)Silk productivity

$$\text{Silk productivity (cg/day)} = \frac{\text{Silk filament weight (cg)}}{\text{Total larval duration @ fifth instar (days)}}$$

(Aruna et al., 2018)

vi) Single Cocoon weight (in Grams)

vii) Pupal weight (in Grams)

viii) Shell weight (in Grams)

ix) Shell ratio (%)

$$\text{Shell ratio} = \frac{\text{Shell weight (g)}}{\text{Cocoon weight (g)}} \text{ X100}$$

x)Cocoon yield (by weight)

$$\text{Cocoon yield /10000 larvae} = \frac{\text{Weight of good cocoons}}{\text{Number of healthy worms retained in the fifth instar}} \text{ X 10000}$$

xi)Total Silk filament length

$L = R \times 1.125$

Where L = Total length of the filament

R = Number of revolutions made

1.125 = Circumference of the reeler machine in meters.

xii)Silk filament weight (in Grams)

Silk filament obtained during reeling activity was weighed individually and expressed in grams.

xiii)Denier (thickness of the silk filament)

$$\text{Denier} = \frac{\text{Weight of the filament in grams}}{\text{Length of the filament in meters}} \text{ X 9000}$$

xiv) Renditta

$$\text{Renditta (kgs)} = \frac{10000}{\text{Shell ratio in percentage x Raw silk recovery @70 \%}}$$

Statistical analysis

The data obtained from the experiments were critically analyzed using the Completely Randomized Design (CRD) method, as outlined by Fisher. The AGRES software package (version 0.74) was employed to analyze the stage-wise data.

RESULTS AND DISCUSSION

Effect of different spacing of tree-type mulberry leaves on silkworm larval parameters

The mature larval weight was observed to be high when silkworms were reared on the 6 ft x 6 ft leaves (3.30 g), followed by 7 ft x 7 ft (3.08 g) leaves. Among the different varieties, mature larval weight was recorded to be higher for V1 (3.13 g) and comparable to G4 (3.03 g). Notable variations are evident to the interaction of spacing and varieties when fed to the silkworm (Table 1). The present results align with Marin *et al*. (2022), who recorded larval weight of 3.59 g by feeding V1 leaves. Tree-type mulberry leaves significantly influenced ERR with a maximum of 92.51 per cent in 6 ft x 6 ft, closely followed by 7 ft x 7 ft (90.57 %), which were statistically on par with each other. Regarding varieties, ERR was significantly higher in V1 (93.56%) and was found to be comparable to the G4 (91.47%) variety. This agrees with Jini *et al.* (2022), who registered an ERR of 87.0 percent when offering V1 leaves to the silkworm. In interaction studies, there was a statistically significant difference with ERR in the spacing and varieties (Table 1). The silkworm mortality rate showed significant variation with respect to the different spacings of V1 and G4 leaves. Lowest mortality was evidenced in 6 ft x 6 ft (7.25 %), followed by 7 ft x 7 ft (8.70 %), and higher mortality occurred in 5 ft x 5 ft (10.06 %) (Table 1). Susikaran and Vijay (2024) reported that significant improvement in larval parameters was observed when fed with mini clonal mulberry leaves to silkworm, treatment 60 DAP-AC (V1) recorded an increase in larval weight (3.15 ng), higher ERR (86.34 %), and lower larval mortality (13.46 %) than the check.

Different spacing of tree-type mulberry has a significant impact on silk gland weight (Fig.1). It was registered highest in 6 ft x 6 ft (788.56 mg), which was statistically superior compared to all other treatments, and this was followed by 7 ft x 7 ft (777.71 mg). Among the different varieties, the silk gland weight was recorded to be highest for V1 (789.99 mg), followed by G4 (766.00 mg). Statistically, no significant difference was observed in the interaction studies concerning silk gland weight. In silkworm rearing, maximum silk productivity was recorded on treatment 6 ft x 6 ft (6.70 cg/day) and next best performed by 7 ft x 7 ft (6.22 cg/day) (Fig. 1). The highest productivity was evidenced in V1 (6.59 cg/day), followed by G4 (6.07 cg/day). In an interaction between different spacings and varieties, significantly higher silk productivity (6.07 cm/day) was recorded in the V1 variety at 6 ft x 6 ft, statistically superior to all other treatments. At the same time, a minimum silk productivity of 5.82 cg/day was observed in G4 at 5 ft x 5 ft. Similarly, Murugesh *et al*. (2022) recorded silk productivity of 4 cg/day by offering V1 foliage to the silkworm.

Effect of different spacing of tree-type mulberry leaves on cocoon parameters.

Cocoon weight did vary statistically between spacing when the leaves were fed to the silkworm (Table 2). A higher cocoon weight of 1.80 g was observed in the 6 ft x 6 ft area, followed by 1.64 g. On comparing varieties, V1 had a statistically high value of cocoon weight (1.99 g), followed by G4 (1.87 g), mulberry leaves fed to the silkworm. Statistically, no significant difference was observed in the interaction studies concerning cocoon yield. These results are by the findings of Some *et al.,* (2019) who observed a cocoon weight of 1.87 g when fed with V1 mulberry leaves. Shell weight significantly varied between different spaced tree type mulberries,

Table 1. Effect of different spacing of tree-type mulberry leaves on silkworm larval parameters

Treatments		Larval weight (g)			ERR (%)			Mortality (%)		
		V1	G4	Mean	V1	G4	Mean	V1	G4	Mean
5ft x 5ft		2.92	2.86	2.89	89.08	87.98	88.53	8.56	11.56	10.06
6ft x 6ft		3.36	3.24	3.30	93.56	91.47	92.51	6.08	8.43	7.25
7ft x 7ft		3.12	3.01	3.06	91.43	89.71	90.57	7.74	9.67	8.70
Mean		3.13	3.03	3.08	91.35	89.72	90.53	7.46	9.88	8.67
CD (P=0.05)	T		0.17**			4.34**			0.56**	
	V		0.14**			3.64**			0.46**	
	T X V		0.32**			NS			NS	

*Significant, ** Highly Significant, NS – Non-Significant; Each value is the mean of six replications and the pooled mean of two crops

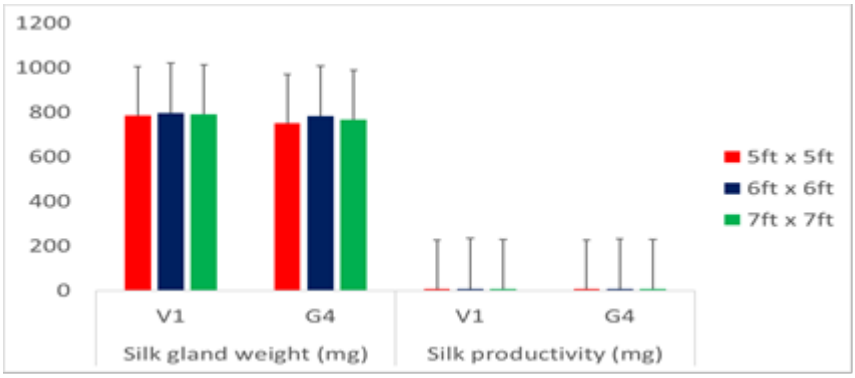

Fig. 1. Effect of different spacing of tree-type mulberry leaves on silk gland parameters

with higher values recorded in 6 ft x 6 ft (0.38 g). The subsequent best treatment was 7 ft x 7 ft (0.37 g). Regarding varieties, notably high in V1 (0.38 g) and the next best was G4 (0.35 g). The interaction between spacing and variety indicates that a significantly higher shell weight was found in V1 (0.40 g) with 6 ft x 6 ft, and the lowest shell weight was recorded in 5 ft x 5 ft (0.32 g). Tulu et al. (2016) also reported similar results, recording a shell weight of 0.37 g when provided with V1 mulberry leaves. Singh *et al.* (2021) further supported it, who registered 0.29 g shell weight by offering V1 leaves. Significantly higher shell ratio was obtained when silkworms were reared on 6 ft x 6 ft spaced leaves (23.00 %), followed by 7 ft x 7 ft (22.49 %) leaves. of varieties, both V1 and G4 had maximum shell ratios of 22.37 and 22.07 per cent, respectively, which were statistically on par with each other. Significantly more shell ratio was found in V1 of 6 ft x 6 ft (23.12%) in interaction of spacing and varieties followed by G4 of 6 ft x 6 ft (22.89%) and lowest shell ratio of 21.01 per cent was noted in the 5 ft x 5 ft of G4 (Table 2). The present results are also with the findings of shell ratio of 20.26 percent when feeding V1 leaves.

Different spacing treatments have significantly influenced cocoon yield (Table 3). A higher cocoon yield was found in 6 ft x 6 ft (20.56 kg), which performed statistically well compared to all other treatments, followed by 7 ft x 7 ft (19.49 kg). In respect to varieties, it was notably high in V1 (20.30 kg) and followed by G4 (18.81 kg) variety. Interaction studies show that V1 registered the highest cocoon yield in 6 ft x 6 ft planted with 21.56 kg, and the lowest yield was noticed in 5 ft x 5 ft (18.21 kg) planted G4 leaves. Similar findings were recorded by Dayananda *et al.* (2011) in the double-hybrid silkworm. Pupal weight readings were statistically analyzed and showed significant variation due to the different spacing of tree type mulberry (Table 3). It ranged from 1.22 g, 1.33 g, and 1.25 g, respectively, with their spacing. By feeding V1 leaf foliage, maximum pupal weight was observed in 6 ft x 6 ft (1.29 g) and found statistically superior, followed by 6 ft x 6 ft (1.24 g) of G4. In the interaction studies, V1 planted 6 ft x 6 ft spaced

Table 2. Effect of different spacing of tree-type mulberry leaves on cocoon parameters

Treatments		Cocoon weight (g)			Shell weight (g)			Shell ratio (%)		
		V1	G4	Mean	V1	G4	Mean	V1	G4	Mean
5ft x 5ft		1.54	1.51	1.52	0.36	0.32	0.34	21.34	21.01	21.17
6ft x 6ft		1.82	1.78	1.80	0.40	0.37	0.38	23.12	22.89	23.00
7ft x 7ft		1.68	1.60	1.64	0.38	0.36	0.37	22.67	22.32	22.49
Mean		1.68	1.63	1.65	0.38	0.35	0.38	22.37	22.07	22.67
CD (P=0.05)	T		0.11**			0.02**			1.46**	
	V		0.08**			0.01**			1.18**	
	T X V		NS			0.04*			3.54*	

*Significant, ** Highly Significant, NS – Non-Significant; Each value is the mean of six replications and the pooled mean of two crops

Table 3. Effect of different spacing of tree-type mulberry leaves on cocoon parameters

Treatments		Cocoon yield/10,000 larvae			Pupal weight		
		V1	G4	Mean	V1	G4	Mean
5ft x 5ft		19.02	18.21	18.61	1.24	1.20	1.22
6ft x 6ft		21.56	19.56	20.56	1.36	1.31	1.33
7ft x 7ft		20.30	18.67	19.49	1.28	1.23	1.25
Mean		20.30	18.81	19.55	1.29	1.24	1.26
	T		1.23**			0.07**	
CD (P=0.05)	V		1.01**			0.05**	
	T X V		2.85**			1.01**	

*Significant, ** Highly Significant, NS – Non-Significant; Each value is the mean of six replications and the pooled mean of two crops

leaves fed to silkworm with a pupal weight of 1.36 g, and the lowest was recorded in 5 ft x 5 ft of G4 (1.20 g). The results align with Balasundaram *et al.* (2013) who reported pupal weights of 1.03 g and 1.57 g by feeding MR2 and V1 leaves to the double hybrid silkworm.

Effect of different spacing of tree-type mulberry leaves on reeling parameters.

Silkworm fed with tree-type mulberry leaves showed significant variation concerning filament length of cocoon (Fig.2). Significantly higher filament length of 1318.99 and 1283.34 m was recorded in 6 ft x 6 ft and 7 ft x 7 ft leaves, respectively, and were on par with each other. Regarding varieties, the longest filament length was reeled in V1 (1286.00 m), followed by G4 (1258.83 m) variety. In interaction studies concerning filament length, there was no statistically significant difference in spacing and varieties. It was supported by Lalfelpuii *et al.* (2014) who reported a silk filament length of 1197 m by feeding V1 variety leaves to a double hybrid silkworm. Filament weight showed variation among plants spaced at different distances when fed to silkworms. Among these treatments, highest filament weight of 321.51 mg in 6 ft x 6 ft followed by 7 ft x 7 ft with 303.38 mg was recorded (Fig. 2). On comparing varieties, highest filament weight of 303.00 mg was recorded in V1 mulberry leaves fed to silkworm over the G4 (297.11 mg). With respect to the interaction of spacing and varieties, a significantly high value of filament weight of 324.46 mg was noticed in 6 ft x 6 ft, and a low value of filament weight of 271.45 mg was observed in 5 ft x 5 ft of G4. The present results are in correspondence with Thangaroja *et al.*, (2018).

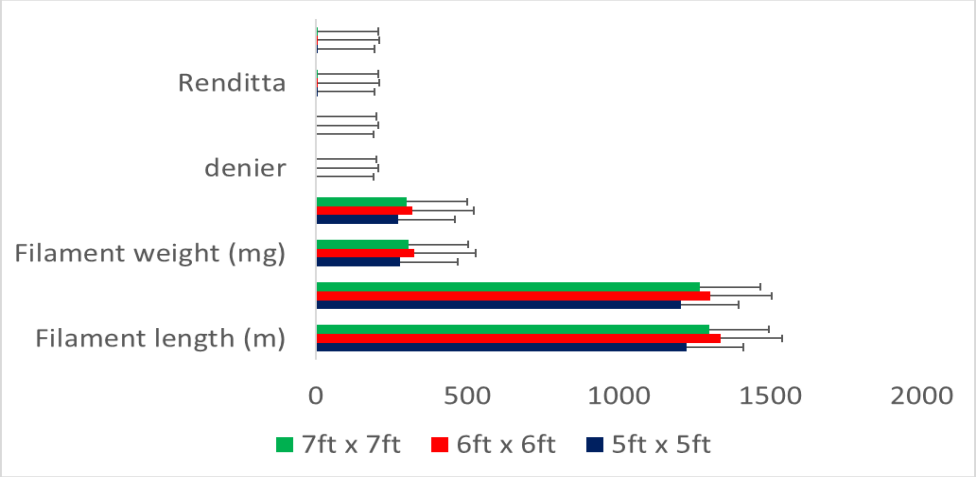

Fig. 2. Impact of different spacing on reeling parameters of tree-type mulberry

Notably higher denier of 2.45 was recorded in 6 ft x 6 ft among treatments (Fig. 2). This was followed by 7 ft x 7 ft (2.30), which was found to be on par with 5 ft x 5 ft (2.16). Regarding varieties, the maximum denier was found in V1 (2.37) and G4 (2.23), which were statistically comparable to each other. In the interaction between them, 6 ft x 6 ft had a high value of denier of 2.56, which was found to be superior to all other treatments. The present results confirm those of Anusha and Bhaskar (2018), who reported a denier of 2.28 when feeding V1 variety leaves to double hybrid silkworms. The observations regarding renditta was found maximum in 6 ft x 6 ft (6.88 kg) compared to 7 ft x 7 ft spacing (Fig. 2). By giving V1 variety, 6 ft x 6 ft (6.98 kg) recorded statistically high renditta compared to 7 ft x 7 ft (6.82 kg), 5 ft x 5 ft (6.58 kg). By giving G4 leaves, 6 ft x 6 ft (6.79 kg) recorded statistically high compared to 5 ft x 5 ft (6.34 kg). In interaction studies concerning renditta, there was no statistically significant difference in the spacing and varieties. This is by the results of Rao *et al.,* (2004), who recorded 7.75 kg renditta by feeding V1 variety leaves to the double hybrid silkworm.

CONCLUSION:

The study demonstrates that tree spacing significantly impacts silkworm growth and yield, with the 6ft x 6ft spacing emerging as the most effective configuration. Silkworms fed with leaves from the V1 variety of mulberry trees spaced at 6ft x 6ft exhibited superior growth and yield parameters, including increased larval weight, silk productivity, and cocoon yield, as well as improved quality traits such as filament length and weight. While the G4 variety also showed positive results, it performed slightly lower than V1 across most metrics. These findings suggest that broader spacing enhances the overall growth of mulberry trees and improves the quality of the leaves, thereby positively influencing silkworm biology and productivity. This study underscores the importance of selecting optimal spacing and mulberry variety to maximize sericulture productivity and silk quality.

Funding and Acknowledgment

There is no funding support for this work.

Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There was no conflict of interest in the publication of this content

Author contributions

All the authors equally contributed to the research work.

REFERENCES

Anusha, H.G. and Bhaskar, R.N., 2018. Identification of new pathogenic bacteria (*Alcaligenes faecalis)* and assessment of pathogenecity with mixed infection on rearing and cocoon parameters of silkworm (*Bombyx mori* L.). Res. Crops, 19: 120-126. http://dx.doi.org/10.5958/2348-7542.2018.00020.7

Jini, D.J., Ramanibai, M., Quraiza, M.T.F. and Jespa, J., 2022. Influence of micronutrients fortified mulberry leaves on larval growth and cocoon parameters of mulberry silkworm, *Bombyx mori* L. Uttar Pradesh J. Zool., 43: 582-588. https://doi.org/10.56557/upjoz/2022/v43i243369

Marin, G., Arivoli, S. and Tennyson, S., 2022. Effect of micronutrient supplemented mulberry leaves on larvae of silk worm *Bombyx mori.* Indian J. Ent., pp. 1-7. https://doi.org/10.55446/IJE.2022.584

Murugesh, K.A., Aruna, R. and Chozhan, K., 2022. Influence of amino acids on the economic characters of silkworm, *Bombyx mor*i L. Madras Agric. J., 108: 7-9. https://doi.org/10.29321/MAJ.10.000516

Singh, N.S., Vanlalruati, M.C., Kumar, K.S. and Tripathi, S.K., 2021. Soil and mulberry leaf quality affect silk worm cocoon production in Mizoram. Indian J. Ent., 83: 376-379. 10.5958/0974-8172.2021.00112.7

Susikaran, S., & Vijay, S. (2024). Effects of Mini Clonal Leaves on Economic Traits of Mulberry Silkworm (*Bombyx mori* L.). Pakistan J. Zool., pp 1-7, 2024. https://dx.doi.org/10.17582/journal.pjz/20230330170326

Thangaroja, K., Murugesh, K.A., Shanmugam, R. and Bharani, A., 2018. Efficacy of organic foliar formulations on the biometric and biochemical attributes of mulberry, Morus sp. Trends Biosci.,

11: 3152-3156. http://trendsinbiosciencesjournal.com/upload/02-10439_(K__THANGAROJA).pdf

Tulu, D., Aleme, M., Mengistu, G., Bogale, A., Shifa, K. and Terefe, M., 2022. Evaluation of mulberry (Morus spp.) genotypes and their feeding values on rearing performance of mulberry silkworm (*Bombyx Mori* L.) at Tepi, Ethiopia. Livest. Res. Results, 10: 794. 10.55446/IJE.2024.1767

Vijay S., Susikaran S., Shandeep S.G., Haran M.S.R., Deeikshana T. and Abinaya C. (2023). Biochemical Responses of Mulberry Varieties V1 and G4 to Different Spacing Conditions.. Biological Forum – An International Journal, 15(9): 693-697. 10.9734/ijpss/2023/v35i203787

Vijay, S. and Susikaran, S. (2023). Evaluation of Different Spacing for Growth and Yield Contributing Characters of Tree Type Mulberry. Madras Agricultural Journal, 110 (4-6), 1. https://doi.org/10.29321/MAJ.10.200789