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Effects of Mini Clonal Leaves on Economic Traits of Mulberry Silkworm (*Bombyx mori* L.)

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Silkworm, Economic traits, *Bombyx mori,* Rearing performance, Mulberry

ABSTRACT

The performance of the *Bombyx mori* L. double hybrid was evaluated on two mulberry mini clones of *Morus* spp. based on economic characters. The present investigation were reported that significant improvement in larval parameters were observed when fed with mini clonal mulberry leaves to silkworm. Treatment 60DAP-AC (V1) recorded increase in larval weight (3.15g), higher ERR (86.34%) and low larval mortality (13.46%) than check. Silk gland parameters like silk gland weight (648.61mg) and silk productivity (6.24cg/day) and cocoon parameters like shell ratio (21.99%), single cocoon weight (1.62g), shell weight (0.34g), pupal weight (1.28g) and cocoon yield/10000 larvae (20.56kg). The reeling parameters *viz.,* filament length (1249.63m), filament weight (297.10mg), renditta (6.44kg) and denier (2.26) were also found to be superior in mini clones of V1 variety than check. In MR2 also maximum filament length (1235.53m), filament weight (295.71mg), renditta (6.94kg) and denier (2.22) were registered. All the mentioned factors were compared, and it was determined that 60DAP-AC (V1) is the best mulberry mini clone for rearing the mulberry silkworm.

INTRODUCTION

Sericulture involves indoor rearing of domesticated mulberry silkworm, *Bombyx mori* L. which feeds primarily on mulberry (*Morus* sp.). Genus *Morus* comprises of more than 70 species and a majority of them are confined to the Asian continent. Mulberry can grow well in ideal pH range of 6.2-6.8 pH which is slightly acidic in nature. In India, mulberry cultivation for commercial silkworm rearing was undertaken in three southern states *viz.,* Karnataka, Tamil Nadu and Andhra Pradesh (Bahar *et al*., 2011). Quality of mulberry leaf decides the success of silkworm rearing. Quality and quantity of mulberry leaf have a direct influence on cocoon yield. The protein content of mulberry leaves have contributed to 70 percent of silk protein synthesized by silkworm (Soliyeva *et al*., 2022). Leaf quality has a significant impact on cocoon production, quality, and quantity, as well as growth and development. The mulberry leaves contributes 38.20% to the production of silk, followed by the climate (37.00 %), rearing strategies (9.30 %), silkworm breed (4.20 percent), and other factors (8.20 %) (Seidavi *et al*., 2005). Vegetative and sexual reproduction are both present in the mulberry (*Morus* sp.). Depending on their soil type and environmental conditions, several countries employ a variety of propagation techniques (Taha *et al*., 2020). Mulberry plants are propagated sexually by using the seeds of mature fruit to make new plants. Due to limitations such limited fruit availability, laborious fruit gathering, low germination, short shelf life, and more time-consuming sapling manufacturing, seedling multiplication is not commercially viable. This technique of dissemination was frequently used for breeding research (Sudhakar *et al*., 2018).

In vegetative propagation, specialised reproductive components (buds) from plant sections or fragments are employed to reproduce an entire new plant. Cutting, grafting, and layering are three methods that are frequently used in vegetative propagation (Zenginbal and Eşitken, 2016). Layering has a number of drawbacks, such that it takes a lot of time and money, is not suitable for the rapid

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Abbreviations
AC, apical cuttings; SC, stem cuttings; DAP, days after planting; ERR, effective rate of rearing

multiplication Plants with low survival rates in grafting and layering are nevertheless used when cutting-based propagation fails to result in a new plant (Tikader and Karthiga, 2006). A well-developed root system, strong rooting capacity, homogeneity among saplings in the nursery, and a nearly halved nursery length period compared to conventional approaches are all benefits of mini clonal technology (Vijay *et al*., 2023). The mini clones were established in the main field for multiplication and for rearing of silkworm. The objectives of the study were to assess the economic traits such as larval duration, mortality, cocoon, pupa, shell weight and shell to cocoon ratio among different varieties and transplanting days on silkworm under rearing room conditions.

MATERIALS AND METHODS

Chawki worms

Double hybrid silkworms (CSR2 X CSR 27 X (CSR 6 X CSR 26)) were purchased from the private Chawki Rearing Center in the region of Annur in Coimbatore district. They were kept in a rearing room which was disinfected along with other equipment three days before of rearing using bleaching powder and sanitech solution 2.5% (stabilized chlorine-dioxide) + slaked lime (0.3%) solution.

Bioassay on silkworm

Larvae were fed on healthy leaves harvested from plants propagated using stem cuttings and apical cuttings. The third to fifth instar worms were used in the study. Larvae reared at optimum temperature of 24 to 26˚C and 75 to 80% RH. The larvae were fed on apical cuttings of variety V1 and MR2 transplanting on 60th day (T1), 70th day (T2) and 90th day (T3). The T4 larvae were fed on stem cuttings on 90th day.

For each treatment, three replicates were maintained and each replication consisted of fifty silkworms per replication. Ten worms from each replication of fifth instar (fifth day) was randomly picked and weighed individually and average value were mentioned in grams. In addition, effective rate of rearing (ERR), mortality rate, silk gland weight, silk productivity, single cocoon weight, pupal weight, shell weight, shell ratio, cocoon yield, silk filament length and weight, denier and renditta were also recorded and calculated according to the formulae given below:

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

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

(Sharma and Bukhari, 2020)

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

(Aruna and Murugesh, 2022)

$$\text{Shell ratio} = \frac{\text{Shell weight (g)}}{\text{Cocoon weight (g)}} \times 100$$

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

Silk filament length was calculated as follows and expressed in meters.

L = R x 1.125

Where, L is total length of the filament. R is number of revolutions made. 1.125 is circumference of the reeler machine in meters.

For silk filament weight, the silk filament obtained during reeling activity was weighed individually and expressed in grams.

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

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

Statistical analysis

The data collected from above experiments were critically analysed by adopting completely randomized design (CRD) as described by fisher. AGRES software package (version 0.74) was used to analyse the stage wise data.

RESULTS AND DISCUSSION

Effect on silkworm larval parameters

The larval weight varied significantly by feeding the foliage of V1 and MR2 mulberry leaves. The increase in larval weight was due to enhanced nutritive composition in mini clonal mulberry leaves. The experimental results revealed that in V1, larval weight gained by feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry leaves was 3.15 g and 2.93 g, respectively (Fig. 1). In MR2 variety, larval weight gained on 60 DAP-AC (MR2) and 90 DAP-SC (MR2) mulberry leaves was 2.89 g and 2.85 g, respectively. According to Tikader and Kamble (2007), mulberry leaf quality and quantity will directly impact silkworm growth and development which reflect ultimately on economic characters of cocoon. The present results are in line with Marin *et al*. (2022) who recorded larval weight of 3.59 g by feeding V1 leaves.

Effective rate of rearing (ERR) significantly differed by feeding leaves of V1 and MR2 to silkworm. The high ERR was attributed to enhanced macronutrient composition in mini clonal mulberry leaves. The present study have shown that in V1, ERR of feeding on 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry leaves was 86.04

percent and 83.05 percent, respectively (Fig. 1). Similarly, in MR2 variety, ERR on above treatment was 84.65 percent and 81.10 percent, respectively. This is in agreement with Jini *et al*. (2022) who registered ERR of 87.0 percent when offering V1 leaves to silkworm.

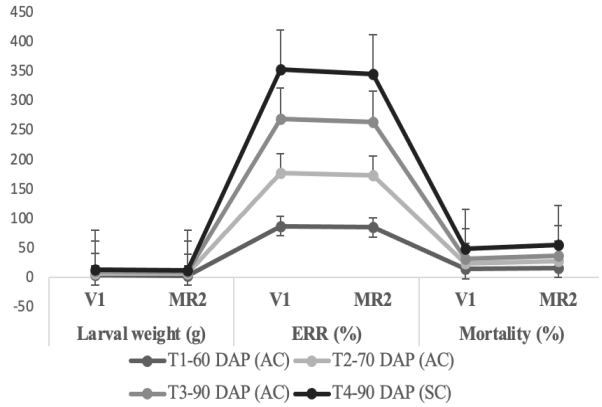

Fig. 1. Effect of different transplanting days on silkworm larval parameters.

Mortality rate showed significant variation due to different days of transplanting. It ranged from 7.09 to 16.95 percent and 8.85 to 18.90 percent by giving V1 and MR2 leaves, respectively (Fig. 1). The present work revealed that in V1, mortality rate of feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry foliage was 13.46 percent and 16.95 percent, respectively. In MR2 variety, mortality rate of rearing silkworm by feeding 60 DAP-AC (MR2) and 90 DAP-SC (MR2) mulberry foliage was 15.35 percent and 18.90 percent, respectively. Findings of Dayananda *et al*. (2011) supports present observations by reporting mortality of 15.8 percent when DH fed with V1 mulberry leaves.

Effect on silk gland parameters

Different days of hardening had a significant impact on silk gland weight. The study revealed that by offering V1 leaves, silk gland weight of 60 DAP-AC and 90 DAP-SC were 648.61 mg and 589.47 mg, respectively (Fig. 2). In MR2 variety, it was 623.81mg and 562.74 mg for above treatments, respectively. The increase in silk gland weight was due to high protein and macronutrient composition in leaves. These results are also in agreement with observations of Rawgol *et al*. (2011).

The increase in silk productivity was found proportional to increase in silk gland weight. The results of the experiment clearly indicates that in V1, silk productivity of feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry leaves was recorded 6.24 cg/day and 5.80 cg/day, respectively. In MR2 variety, silk productivity of silkworm by feeding 60 DAP-AC (MR2) and 90 DAP-SC (MR2) mulberry leaves was found to be 5.96 cg/day and 5.33 cg/day, respectively. Similarly, Murugesh *et al*. (2022) recorded silk productivity of 4cg/day by offering V1 foliage to silkworm.

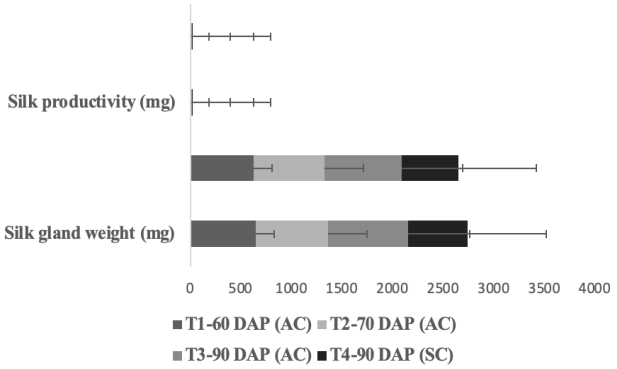

Fig. 2. Influence of different transplanting days on silk gland properties.

Effect on cocoon parameters

The statistical analysis of different treatments showed significant variation in cocoon weight by feeding both V1 and MR2 leaf foliage. The increase in cocoon weight might be due to enhanced soluble protein content in mulberry leaves. The current study clearly indicates that in V1, cocoon weight by feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry leaves was found to be 1.62g and1.48g, respectively (Table I). In MR2 variety, cocoon weight by feeding 60 DAP-AC (MR2) and 90 DAP-SC (MR2) was 1.51g and 1.42g, respectively. These results are in accordance with the findings of Some *et al*. (2019) who observed cocoon weight of 1.87g when fed with V1 mulberry leaves.

The statistical analysis clearly shows there was a significant difference between shell weight due to the effect of feeding leaves from different treatment plots. The shell weight, cocoon weight and shell ratio parameters are positively correlated. The present study indicates that in V1, shell weight by feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry leaves was calculated 0.34g and 0.31g, respectively. In MR2 variety, shell weight by feeding 60 DAP-AC (MR2) and 90 DAP-SC (M2) mulberry leaves was registered 0.30g and 0.28g, respectively (Table I). Similar results was also reported by Tulu *et al*. (2016) who recorded shell weight of 0.37g when provided with V1 mulberry leaves. It was further supported by Singh *et al*. (2021) who registered 0.29g shell weight by offering V1 leaves.

Table I. Effects of various transplantation days on cocoon traits.

Treatment	Cocoon weight (g)		Shell weight (g)		Shell ratio (%)		Cocoon yield/10,000 larvae (By weight)		Pupal weight	
	V1	MR2	V1	MR2	V1	MR2	V1	MR2	V1	MR2
T1-60DAP (AC)	1.62^{a}	1.51^{b}	0.34^{b}	0.3^{b}	21.99^{bc}	21.72^{b}	20.56^{a}	17.9^{b}	1.28^{a}	1.21^{bc}
T2-70DAP (AC)	1.64^{a}	1.56^{b}	0.35^{ab}	0.31^{b}	22.38^{ab}	22.12^{b}	20.78^{a}	18.23^{ab}	1.29^{a}	1.25^{b}
T3-80DAP (AC)	1.7^{a}	1.69^{a}	0.37^{a}	0.35^{a}	23.56^{a}	23.25^{a}	21.08^{a}	19.52^{a}	1.33^{a}	1.34^{a}
T4-90DAP (SC)	1.48^{b}	1.42^{c}	0.31^{c}	0.28^{c}	20.78^{c}	20.31^{a}	18.13^{b}	17.49^{b}	1.17^{b}	1.14^{c}
SE(d)	0.06	0.03	0.01	0.00	0.63	0.61c	0.3	0.67	0.04	0.03
CD (P=0.05)	0.13*	0.08**	0.02**	0.01**	1.38**	1.33**	0.66**	1.46**	0.09**	0.07**

AC, Apical cuttings; SC, Stem cuttings; **Highly significant, *Significant Each value is the mean of four replications. Means followed by same alphabets are on par with each other by LSD (P=0.05).

Shell weight and cocoon weight have considerable impact on shell ratio. The bioassay indicated that by feeding V1, shell ratio of 60 DAP-AC and 90 DAP-SC mulberry leaves was noticed as 21.99 percent and 20.78 percent, respectively. In MR2 variety, shell ratio (%) was 21.72 percent and 20.31 percent for above treatments, respectively. It was supported by Kanafi *et al*. (2007) who recorded shell ratio of 22.84 percent and 22.81 percent by feeding V1 and MR2 leaves. The present results are also in accordance with the findings of Devi and Yellamma (2013) who registered shell ratio of 20.26 percent by feeding V1 leaves.

Different hardening treatments significantly influenced cocoon yield offering V1 and MR2 leaves to double hybrid silkworm. High effective rate of rearing (%) have correlated with the increase in cocoon yield. The present study revealed that in V1, cocoon yield when giving 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry foliage was recorded 20.56 and 18.13 kg/10,000 larvae, respectively (Table I). In MR2 variety, for above treatments it was 17.90 and 17.49 kg/10,000 larvae, respectively. Similar findings were recorded by Dayananda *et al*. (2011) in double hybrid silkworm.

Pupal weight also showed significant variation for both varieties. The present study revealed that in V1, pupal weight was 1.28 g and 1.17 g by feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry leaves, respectively. In MR2 variety, for above treatments pupal weight was 1.21 and 1.14 g, respectively. The results are in line with Balasundaram *et al*. (2013) and Akram *et al*. (2017) who reported pupal weight of 1.03g and 1.57g by feeding MR2 and V1 leaves to double hybrid silkworm.

Effect on silk reeling parameters

In V1 variety, filament length by feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry foliage was calculated 1249.63 and 1192.89 m, respectively (Fig. 3). In MR2 variety, 1235.53 m and 1181.35 m filament length recorded by feeding 60 DAP-AC (MR2) and 90 DAP-SC (MR2). It was observed that the filament length was significantly varied in two varieties. The increase in filament length was due increased protein synthesis by silkworm feeding on mulberry leaves containing high protein. It was supported by Lalfelpuii *et al*. (2014) who reported silk filament length of 1197m by feeding V1 variety leaves to double hybrid silkworm.

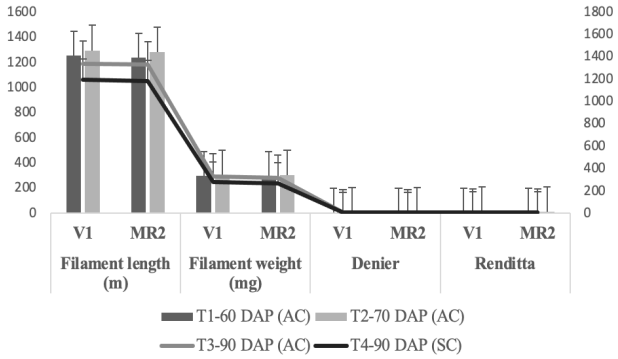

Fig. 3. Impact of different transplanting days on silk reeling characteristics.

In bioassay, it was noticed that in V1, filament weight (mg) by feeding 60 DAP-AC (V1) and 90 DAP-SC (V1) mulberry foliage was 297.10 and 273.63 mg, respectively (Fig. 3). In MR2 variety, it was 295.71 and 265.20 mg on above treatments, respectively. Significant variation noticed in filament weight (mg) by giving both V1 and MR2 mulberry leaves to silkworm. Increase in filament length proportionally increased filament weight. The present results are in correspondence with Thangaroja *et al*. (2018).

The statistical analysis showed significant variation

in denier due to the effect of feeding leaves from different treatments transplanted on different days. The present study revealed that in denier value of 2.26 and 2.15 on V1 leaves from 60 DAP-AC and 90 DAP-SC, respectively (Fig. 3). In MR2 variety, denier values were 2.22 and 2.12 for above treatments, respectively. The present results are in confirmation with the works of Anusha and Bhaskar (2018) who registered denier of 2.28 by feeding V1 variety leaves to double hybrid silkworm. Murugan *et al*. (2019) recorded 1.89 by feeding V1 variety leaves to double hybrid silkworm. Silk filament length, filament weight and denier were correlated with increased silk synthesis due to the supplementation of high protein diet to silkworm.

The observations regarding renditta (kg) was found maximum in V1 variety compared to MR2 variety. There is a significant difference among treatments because of different aged leaves due to different days of transplantation. The present study revealed that in V1, renditta (kg) by feeding leaves collected from 60 DAP-AC (V1) and 90 DAP-SC (V1) was 6.44 and 6.72 kg, respectively (Fig. 3). In MR2 variety, renditta (kg) by feeding 60 DAP-AC (MR2) and 90 DAP-SC (MR2) mulberry leaves was 6.94 and 7.19 kg, respectively. This is in accordance with the results of Rao *et al*. (2004) who recorded 7.75kg renditta by feeding V1 variety leaves to double hybrid silkworm. Increase in cocoon weight due to high protein diet have positively correlated with lower renditta value.

CONCLUSION

Significant differences were observed among all the parameters, and it was found that the double hybrid thrived well under parameters like- total as well as fifth instar larval duration in case of fertilizer schedule- T11 (N3P2K1), while as in case of larval weight, cocoon yield by number and weight and pupation rate, the hybrid performed better under T14 (N4P1K2) fertilizer Schedule Significant differences were observed among all the parameters, and it was found that the double hybrid thrived well under parameters like- total as well as fifth instar larval duration in case of fertilizer schedule- T (N3P2K1), while as in case of larval weight, cocoon yield by number and weight and pupation rate, the hybrid performed better under T14 (N4P1K2) fertilizer Schedule Mulberry silkworms were fed with 60 DAP-AC (V1) leaves shown to be superior in terms of larval, cocoon, reeling parameters. All the parameters shows significant variances silkworm fed with various mini clones and transplanting days. Mini clone technology has the advantage of shortening the time required for mulberry growing period and its improving silkworm economic performance.

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IRB approval

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Ethical issue

Not applicable

Statement of conflict of interest

The authors have declared no conflict of interests.

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