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Performance of fabricated mountages on cocooning of two different silkworm hybrids of *Bombyx mori* L.

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Abstract

The study was conducted to evaluate the performance of three fabricated self mountages *viz.*, spiral, square and zig-zag mountages on various cocoon parameters in comparison with ribbon, plastic collapsible and bamboo mountages by using two different silkworm races *viz.*, the cross breed (CB) (PM x CSR2) and the double hybrid (DH) (Krishnaraja). The total number of larvae per mountage was highest in bamboo mountage (682.33 for CB and 546.33 for DH) followed by spiral mountage (488.33 for CB) and zig-zag mountage (284.67 for DH) with similar trend in interaction effect. The density of larvae per square feet of mountage was significantly higher in bamboo mountage (44.00 for CB and 44.67 for DH) followed by spiral mountage (25.67 each for CB and DH) with non-significant interaction effect. The number unspun larvae count was significantly higher in bamboo mountage (6.00 for CB and 7.00 for DH) and it was lowest in ribbon chandrike (1.33) for CB and in spiral, square and zig-zag (2.67) moutages for DH and non-significant difference was observed due to their interaction. The cocooning percentage was highest in spiral mountage for both the breeds and for the same interaction effect was found non-significant. The correlation study results revealed that, the total number of larvae per mountage showed significantly positive relation with larval density per square feet of mountage.

Keywords: cross breed, double hybrid, mountages, self-mounting structures

1. Introduction

India has a unique distinction of cultivating all four types of silks which are commercially known varieties of natural fibres of insect origin *viz.*, mulberry, tasar, muga and eri. Among them, the mulberry silk which is produced by the mulberry silkworm, *Bombyx mori* L. occupies a giant share of country's raw silk production. The mulberry silkworm is one of the most useful insect and it has contributed immensely to the cultural development of human beings, by providing finest textile material. As mulberry silkworms are monophagous in nature, they solely feed on mulberry leaf.

The silkworms (*Bombyx mori* L.) are holometabolous sericigenous insects which complete their larval stage in about 23-27 days, where they undergo four moults for completing the larval stage. The larvae attain maturity by about seven days after fourth moult. Silkworm spins silken armour around its body for protection during its metamorphosis, which forms the most economical part for human being. The spinning of cocoons, which is also the nest for silkworms to metamorphosize into pupa, is a crucial phase among silkworm rearing, that starts with identification and collection (picking) of mature larvae and transferring (mounting) them on to the cocooning structures. The time and method of mounting as well as mountages, play a vital role in influencing the quality of cocoons and thereby, the raw silk yield and quality. Even if the silkworm crop is healthy, improper mounting methods, spinning conditions, mounting density, mounting of pre or over matured larvae and poor type of mountages can results in inferior quality cocoons [4]. Thus, the equipments used for supporting the spinning larvae *i.e.*, the mountages play a crucial role in determining quality of cocoons and price fixation at the cocoon market.

Mountage is a device for providing the platform for mature silkworms to spin cocoon. Several types of mountages are available at the field, some of which are more popular. Farmers use different locally available materials for fabricating such mountages. The studies revealed that the type of material used, design and fabrication of the mountage will decide on the quality of the cocoon. In addition to support for spinning worms, the mountages should satisfy the requirements like, providing convenient and uniform space with suitable dimension for spinning good sized cocoons, discouraging formation of double cocoons and malformed cocoons, providing ventilation for drying up of the last excreta of the worm prior to spinning, enabling easy mounting and harvesting [5]. An improper use of mounting structure and lack of care during handling and management of mature silkworms results in formation of defective cocoons accounting to a loss of about 5 to 8 per cent of cocoon yield [2]. Thus, the quantity and quality of good cocoons depend largely upon the right selection and proper use of mountages during spinning of cocoons by the matured larvae.

A significant portion of investment during commercial rearing of silkworm, *B. mori* involves in the wages towards labour. Maximum number of labours are employed during spinning, to pick and mount the ripened worms on to mountages (approximately 15 mandays per 100 DFLs out of a total of 35 mandays) which involves maximum expenditure. Though several kinds of mountages are available, each one is coupled with its own disadvantages. Most popularly used bamboo mountages are involved with high cost as they cannot be used as self mounting structures. At present, the available self mounting structures are plastic mountages which are highly suitable for bivoltine breeds of silkworms. The self mountages have a drawback, uniformity in shape, size and compactness of the cocoon cannot be maintained or assured in the self mounting plastic mountages. The reelers adopted improvised reeling machines offer less price for the cocoons harvested from plastic mountages as they experience that the cocoon shell with more moisture content which reduces the reelability and ultimately affect the raw silk quality. The present was conducted to know the suitability and performance of fabricated mountages on spinning of mulberry silkworm *B. mori* L.

2. Material and methods

The effect of different mountages on cocoon parameters of silkworm, *B. mori* L. were studied during 2017–2018. Well established V-1 (Victory-1) mulberry plants with recommended 90 x 90 cm spacing were used for the silkworm rearing. 50 Disease Free Layings (DFLs) of each of young age silkworms of cross breed (PM X CSR2) and bivoltine double hybrid, Krishnaraja {FC1 (CSR6 x CSR26) X FC2 (CSR2 x CSR27)} were procured from Registered Chawki Rearing Centres for each rearing separately and they were reared by following the procedure recommended by [3].

Treatment details

Six different mountages *viz.*, Spiral mountage (T_1), Square mountage (T_2) and Zig – Zag mountage (T_3) were newly designed and fabricated for the present study. Thalaghattapura Ribbon Chandrike (T_4), Plastic collapsible mountage (T_5) (Control-1) and Bamboo chandrike (T_6) (Control-2) were involved for analysis. Three replications were maintained for all the treatments.

The self mounting structures (T_1 – T_5) were placed over the silkworm rearing bed for a period of one and a half hours when the silkworms attained the ripening stage. After one and a half hours, mountages were removed from the rearing bed whereas in T_6 manual mounting method *i.e.*, picking up of ripened worms and mounting on to the mountages was practiced. The cocoons were harvested from each mountage on fifth and seventh day of spinning in cross breed (CB) and double hybrid (DH), respectively which ensures complete cocoon formation. The different larval-cocoon parameters were recorded as follows:

Total number of silkworms per mountage for two consecutive rearings (No. mountage^{-1})

The self mounting structures (T_1 – T_5) were placed over the silkworm rearing bed for a period of one and a half hours when the silkworms attained the ripening stage. After one and a half hours, mountages were removed from the rearing bed and then the number of worms crawled on to each mountage was counted and also in T_6 number of silkworms present were counted where manual mounting method *i.e.*, picking of ripened worms and mounting on to the mountages was practiced. Then the average was calculated for each mountage and it is expressed in number per mountage.

Density of worms per square feet (No. square feet^{-1})

The density of ripened silkworms per square feet area of mountage was computed by counting the number of larvae crawled on to the self mountages per square feet area at four corners and the centre of the mountage and the average of five observations was calculated separately for each mountage.

Unspun larvae number (No. mountage^{-1})

Unspun larvae number was calculated by counting the total number of worms (dead and diseased) present in each mountage at the time of cocoon harvesting and the average was calculated which is expressed in number per mounatge.

Per cent cocooning (%)

Per cent cocooning is the ratio of number of cocoons formed to the total number of silkworms mounted on the mountages.

$$\text{Per cent cocooning (\%)} = \frac{\text{Number of cocoons formed}}{\text{Number of worms mounted}} \times 100$$

Statistical analysis

The experimental data collected on various cocoon and reeling parameter were subjected to Fisher's method of analysis of variance (ANOVA) as per the methods outlined by [7]. The data were also subjected to Factorial CRD and Correlation to know the interaction effect between the mountages and silkworm hybrids and degree of relationship between different cocooning parameters, respectively. Wherever the interaction effect found non significant then the main effect was observed.

3. Results and discussion

Total number of larvae per mountage (Number mountage^{-1})

There was a significant ($P\leq0.01$) difference with respect to the total number of silkworms per mountage among the different mountages for both CB and DH (Table 1 and Table 2). T_6 (Control 2) showed significantly ($P\leq0.01$) higher number of larvae per mountage in both CB (682.33) and the DH (546.33). Among the self mounting structures, the highest number of larvae crawled was in T_1 followed by T_3, T_2 and T_5 (Control 1), while the number of larvae was least on T_4 for CB and for the DH, the number of larvae was highest on T_3 followed by T_2, T_1 and T_4 while it was least on T_5 (Table 1 & Table 2; Fig. 1).

The interaction between silkworm breeds and different mountages exhibited a noticeable difference with respect to the total number of larvae per mountage. The CB silkworms showed considerably highest number of larvae per mountage on regular bamboo chandrike (682.33) followed by DH with bamboo chandrike (546.33), CB with spiral mountage (488.33) while the least number of worms were crawled on Thalaghattapura ribbon chandrike (137.67), which was also seen in CB (Table 3).

The common practice of ripened silkworm management during rearing of silkworm *B. mori* L. is hand picking and mounting them manually on to the regular bamboo mountages which is common in both CB and the DH. Such practice of manual mounting might have been attributed for higher number of larvae per mountage in T_6. The self mounting structures were kept on the rearing bed only for about one and a half hours duration that might the reason for reduced number of larvae per mountage among both the silkworm breeds used for experimentation. Further, the breed character of bivoltines is that the larvae are highly active, which crawl in search of suitable place to build their cocoons and they lay the foundation only after 18-24 hours after they are mounted. Whereas, the observations were recorded after one and a half hours after placing the mountages on rearing bed, in case of self mounting structures. The higher crawling habit of the breed could be the reason behind less number of DH larvae on different mountages compared to CB larvae. The results of the present study are not in conformity with the results of [6], where they reported that the mounting capacity was better in Thalaghattapura ribbon chandrike than that of bamboo mountage.

Density of larvae on mountage (Number Square feet^{-1})

The density of larvae expressed in terms of number of larvae present per square feet area on the mountage varied significantly ($P\leq0.01$) when observed individually amongst the two silkworm hybrids. A significantly ($P\leq0.01$) higher density of ripe worms were recorded inT_6 followed by T_1, T_3, T_2, T_5 and the least was in T_4 for CB and T_6 followed by T_1, T_2, T_3, T_4 and the least was showed in T_5 for DH, respectively (Table 1 and Table 2; Fig. 2).

A significantly ($P\leq0.01$) higher density of larvae (25.22) was observed on krishnaraja (DH) than CB (23.11). Irrespective of silkworm breeds, the higher density of larvae was recorded on regular bamboo mountage while it was highest in spiral mountage among the self mounting structures, followed by T_3, T_2 and the least density of larvae was observed on T_4 (Table 3). When considered both breeds and mountages together, the interaction between the two did not show a significant influence over the density of worms per unit area of mountage. However, higher density was recorded with both double hybrid (44.67) and cross breed (44.00) on bamboo mountage and it was least with cross breed and ribbon chandrike (12.00) that was on par with cross breed (15.67) and double hybrid (16.67) on plastic mountage (Table 3).

The ripened worms were picked and mounted manually on the regular bamboo mountage used as Control 2 (T_6). Whereas, the larvae were allowed to crawl on to other self mounting structures used in the experiment, for a specific period of time of one and a half hours. The correct practice to mount silkworms on to bamboo mountage should enable maintenance of 40-50 worms per square feet [1]. The studies conducted by [6], mentioned that the density was high in Thalaghattapura ribbon chandrike (65-75 No. per square feet of mountage) when compare to bamboo chandrike (45-50 No. per square feet of mountage). However, they did not indicate the duration of mounting and the silkworm breed.

Number of unspun larvae per mountage (Number mountage^{-1})

Some of the larvae remained on the mountages without spinning the cocoons. The number of such larvae was recorded individually on each mountage. Among six treatments, T_6 recorded significantly ($P\leq0.01$) highest number of unspun larvae per mountage (6.00) followed by T_5, T_1, T_2 & T_3 and T_4 in CB (Table 1) and T_6 followed by T_5, T_2, T_1 and T_3 & T_4 in DH (Table 2).

The number of unspun larvae differed significantly ($P\leq0.01$) among the two silkworm breeds that was highest for double hybrid (3.72) compared to the cross breed (3.22) (Table 3). When considered the mountages along, there is a significant difference among the different mounting structures with respect to the number of unspun larvae per mountage. It was recorded highest number on bamboo mountage (T_6) followed by plastic mountage (T_5) and lowest was on ribbon chandrike (T_4). The other new self mountages exhibited on par results with least number of unspun larvae per mountage with that on ribbon mountage 2.50 on spiral mountage (T_1), 2.67 on zig-zag mountage (T_3) and 2.83 on square mountage (T_2) (Table 3). The interaction between silkworm breeds and mountages exhibited no significant influence over the number of unspun larvae per mountage. However, the bamboo mountages expressed highest number of larvae among both the breeds (7.00 for CB and 6.00 for DH). Among the self mounting structures, the plastic mountage recorded higher number of unspun larvae among both the breeds (4.33 larvae per mountage) (Table 3).

The unspun larvae count increases with increase in larval density per square feet of mountage [8]. The total number of larvae per mountage and the density of larvae per square feet were highest in bamboo mountage among both the breeds, which might probably be the reason for highest number of unspun larvae on the regular bamboo mountage (T_6) used as a Control-2. When compared, the BV hybrid *i. e.*, DH examined showed maximum number of unspun larvae per mountage which clearly reflects comparatively higher probability of tolerance to various stresses by CB. The poor interaction effect of the breed and the mounting structure states that the number of unspun larvae is dependent on other factors such as the total number of larvae and the density of larvae on the mountage.

Per cent cocooning (%)

The observation made on different mountages showed significant ($P\leq0.01$) variation for per cent cocooning among both the breeds of silkworm, *B. mori* L. The T_1 recorded highest cocooning percentage for both CB (99.52 %) and DH (99.15 %) while it was least on T_5 among both the breeds (97.91 % for CB and 97.74 % for DH) and the cocooning percentage of other treatments were on par with T_1 (Table 1 & Table 2; Fig. 2).

The interaction effect of different mountages and silkworm hybrids showed no significance with respect to cocooning percentage. However, the highest percentage was found with cross breed and spiral mountage (99.52 %) and the lowest was observed with double hybrid with plastic mountage (97.74%). The cocooning percentage was significantly higher in spiral mountage (99.34 %) followed by zig-zag (99.18 %), square (99.05 %) and bamboo mountages (99.02 %) and the lower cocooning percentage was observed in plastic mountage (97.82 %) followed by ribbon chandrike (98.93 %) (Table 3).

There was a significant ($P \leq 0.01$) difference between the breeds with respect to cocooning percentage. The highest was recorded with CB (99.03 %) and the lowest was with DH (98.75 %) which is attributed to occurrence of more unspun larvae in DH compare to CB (Table 3). The per cent cocooning is a parameter computed by considering total cocoons formed on each mountage against the total larvae mounted. The results indicated the least per cent cocooning were observed on plastic mountage among both CB and DH. This could be attributed due to the use of plastic material for the fabrication of plastic mountage and wherein, substratum used influences the cocooning percentage. The above results are in conformity with the results of [2] where they reported that, the cocooning percentage was higher in bamboo moutage (94.00 %) compare to plastic mountage (92.16 %).

Table 1: Influence of different mountages on various parameters of spinning larvae of the Cross Breed, PM x CSR_2

Particulars	Total worms (No. mountage^{-1})	Density of worms (No. Square feet^{-1})	Unspun larvae (No.mountage^{-1})	Per cent cocooning (%)
T_1	488.33	25.67	2.33	99.52
T_2	282.33	18.00	2.67	99.17
T_3	394.00	23.33	2.67	99.31
T_4	137.67	12.00	1.33	99.01
T_5	212.33	15.67	4.33	97.91
T_6	682.33	44.00	6.00	99.27
F-test	**	**	**	**
SE. m ±	17.85	1.47	0.45	0.18
CD	77.10	6.36	1.95	0.80

** significant at 1%

Table 2: Influence of different mountages on various parameters of spinning larvae of the Double Hybrid, Krishnaraja

Particulars	Total worms (No. mountage^{-1})	Density of worms (No. Square feet^{-1})	Unspun larvae (No.mountage^{-1})	Per cent cocooning (%)
T_1	277.33	25.67	2.67	99.15
T_2	278.00	24.00	3.00	98.92
T_3	284.67	22.67	2.67	99.05
T_4	178.00	17.67	2.67	98.86
T_5	165.67	16.67	4.33	97.74
T_6	546.33	44.67	7.00	98.78
F-test	**	**	**	**
SE. m ±	15.62	1.10	0.36	0.12
CD	67.47	4.74	1.56	0.53

** significant at 1%

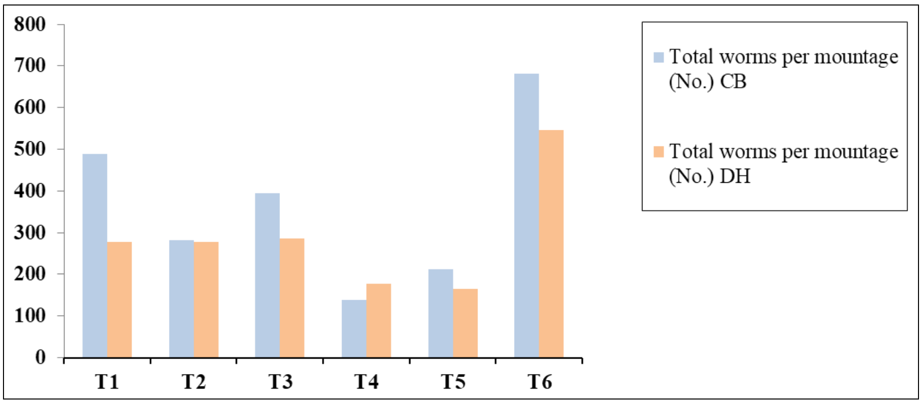

Fig 1: Total number of worms among PM x CSR_2 (CB) and Krishnaraja (DH) as influenced by different mountages

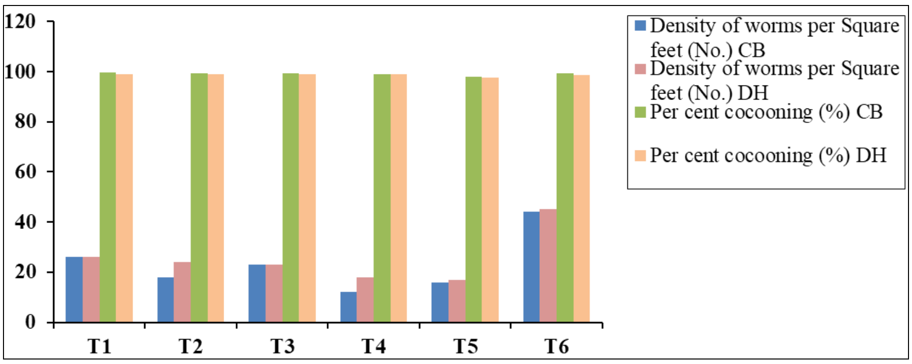

Fig 2: Density of worms per square feet and per cent cocooning among Cross Breed (CB) and Double Hybrid (DH) as influenced by different mountages.

Table 3: Effect of different mountages and silkworm hybrids on parameters of spinning larvae

Particulars	Total worms per mountage (No.)	Density of worms per Square feet (No.)	Unspun larvae (No. mountage^{-1})	Per cent cocooning (%)
Silkworm hybrids (H)				
H_1 (CB)	366.17	23.11	3.22	99.03
H_2 (DH)	288.33	25.22	3.72	98.75
F	**	**	NS	**
S.Em±	6.85	0.53	0.17	0.06
CD @ 1%	27.00	2.09	0.66	0.25
Mountages (T)				
T_1	382.83	25.67	2.50	99.34
T_2	280.17	21.00	2.83	99.05
T_3	339.33	23.00	2.67	99.18
T_4	157.83	14.83	2.00	98.93
T_5	189.00	16.17	4.33	97.82
T_6	614.33	44.33	6.50	99.02
F	**	**	**	**
S.Em±	11.86	0.92	0.29	0.11
CD @ 1%	46.77	3.62	1.14	0.44
Interaction (H x T)				
H_1x T_1	488.33	25.67	2.33	99.52
H_1x T_2	282.33	18.00	2.67	99.17
H_1x T_3	394.00	23.33	2.67	99.31
H_1x T_4	137.67	12.00	1.33	99.01
H_1x T_5	212.33	15.67	4.33	97.91
H_1x T_6	682.33	44.00	6.00	99.27
H_2x T_1	277.33	25.67	2.67	99.15
H_2x T_2	278.00	24.00	3.00	98.92
H_2x T_3	284.67	22.67	2.67	99.05
H_2x T_4	178.00	17.67	2.67	98.86
H_2x T_5	165.67	16.67	4.33	97.74
H_2x T_6	546.33	44.67	7.00	98.78
F	**	NS	NS	NS
S.Em±	16.77	1.30	0.41	0.16
CD @ 1%	66.14	5.12	1.61	0.62

** significant at 1%; NS- Non significant

Relationship between various parameters of spinning larvae

The correlation analysis among various spinning larval parameters showed highly significant positive association between total number of worms per mountage and density of worms per square feet among both the breeds (r=0.9729 for CB and r=0.9919 for DH) while number of unspun larvae and the per cent cocooning exhibited poor relationship with each other and also with the total number of larvae in CB. However, the number of unspun larvae exhibited a significant positive association with both total number of worms per mountage (r=0.8280) and the density of worms per square feet area of mountage (0.8528) in the bivoltine hybrid, krishnaraja. The cocooning percentage was non significant with either of the larval parameter among both the breeds (Table 4 & 5).

The high significant positive association between the density and total number of larvae among both CB and DH reflects comparative uniformity in the distribution of larvae on the self mounting structures in a span of one and a half hours. Further, the unspun larvae showed significant association with the total number of larvae per mountage only in case of double hybrid which could be because of the reason that the disease percentage was little higher in krishnaraja due to racial character.

Table 4: Relationship between spinning larvae and its parameters of the Cross Breed, PM x CSR_2

Particulars	X_1	X_2	X_3	X_4
Total worms mountage^{-1} (X_1)	1.0000			
Density of worms square feet^{-1} (X_2)	0.9729**	1.0000		
Unspun larvae (X_3)	0.6383	0.7494	1.0000	
Per cent cocooning (X_4)	0.5410	0.4351	-0.2500	1.0000

** Significant at $P \leq 0.01$

Table 5: Relationship between spinning larvae and its parameters of the Double Hybrid, Krishnaraja

Particulars	X_1	X_2	X_3	X_4
Total worms mountage^{-1} (X_1)	1.0000			
Density of worms square feet^{-1} (X_2)	0.9919**	1.0000		
Unspun larvae (X_3)	0.8280*	0.8528*	1.0000	
Per cent cocooning (X_4)	0.3176	0.2884	-0.2189	1.0000

Significant at $P \leq 0.05$; ** Significant at $P \leq 0.01$

4. Conclusion
The results of the present study exhibit that, the fabricated mountages *viz.*, spiral and zig-zag mountages were better in comparison with existing plastic collapsible mounatge for different larval parameters *viz.*, total number of larvae per mountage, density of larvae on mountage, per cent cocooning. Whereas, number of unspun larvae per mountage was found least on spiral and zig-zag mountages. However, further investigations are required to know the performance of these new mountages as they help to reduce requirement of labourers which benefits the sericulturists.

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