

Development of Fine Denier Silkworm Hybrid CSR48 × CSR5 of *Bombyx mori* L. for Superior Quality Silk

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Serious attempt for the improvement of quality parameters in silkworm hybrids came rather very late in India. Realising the need for productive breeds to the field and reorientation in breeding methodology, the silkworm breeders of CSRTI, Mysore were able to develop silkworm breeds with fine denier namely, JPN7, CSR48, B63 and B65 of specific industrial requirement through directional selection. As the success of silkworm breeds mainly depends on their combining ability, the developed breeds were subjected for hybrid evaluation. Out of 42 bivoltine hybrids studied, one hybrid, CSR48 × CSR5 was identified for its superiority over the existing bivoltine hybrids namely CSR2 × CSR4, CSR2 × CSR5 and CSR18 × CSR19 for majority of qualitative traits. Post cocoon testing of large quantity of cocoons of CSR48 × CSR5 resulted in the production of high quality "3A" grade silk. It is for the first time in the Indian Sericulture industry that high quality silk with longer filament length of 1474 m, denier of 2.47, standard size deviation of 0.983 d, maximum size deviation of 1.322, neatness of 96 p, reelability of 85%, tenacity of 3.87 g/d, elongation of 22.32% and cohesion of 110 strokes was produced. The superiority of fine denier silkworm breeds and their hybrids are discussed.

Key words: Filament length, Fine denier, Size deviation, Quality, Productivity merits

Introduction

Quality and productivity, which are the two factors for the success and survival of any industry, have to be dealt with utmost care. The improvement in quality and productivity is a long-term commitment in silkworm breeding. The utilization of exotic breeds / hybrids in the improvement of quality silk resulted in the isolation of Kalimpong A and Kalimpong B (Harada, 1961) and NB₄D₂, NB18, NB7, CC1 and CA2 (Datta, 1984). However, the real improvement in silk productivity could be achieved after the development of highly productive hybrids CSR2 × CSR4 and CSR2 × CSR5 with hybrid vigour (Datta *et al.*, 2000). Eventhough, these hybrids could produce 2A – 3A grade silk with superior quality traits failed to maintain uniformity in the yarn thickness. In order to overcome the lacunae in the productive hybrids, breeders made lot of efforts in reducing the thickness of the silk filament and also size deviation from outer to the inner layer of the cocoon and succeeded in developing thin denier breeds CSR48, JPN7, B63 and B65 with longer filament length (> 1500 m), fine denier (2.0 ~ 2.2) with less size deviation from outer to the innermost layer of the cocoon. To select a suitable hybrid from the isolated fine denier breeds, 42 hybrids were prepared and out of which, only one hybrid *viz.*, CSR48 × CSR5 with filament length (> 1400 m), denier (2.4 ~ 2.6) and less deviation (< 1) was identified for commercial exploitation (Kalpana *et al.*, 2002). The advantages of fine denier hybrid CSR48 × CSR5 on quality parameters when compared to the existing commercial hybrids CSR2 × CSR4 and CSR18 × CSR19 are discussed.

Materials and Methods

40 dfls each of fine denier hybrid CSR48 × CSR5 along with the productive hybrid CSR2 × CSR4 (control) and robust hybrid CSR18 × CSR19 (control) were reared in

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mass following the standard rearing technology of Krishnaswami (1978) and Datta (1992). The harvested cocoons were sorted and defective and deformed cocoons were separated and a total of 25 kg cocoons were reeled at Central Silk Technological Research Institute, Bangalore to study the post cocoon technology up to the manufacture of fine denier fabric. In addition, 25 cocoons each from the fine denier hybrid along with control were studied for size deviation to record the variation from the outermost layer of the cocoon to the innermost. The average deviation of filament size (MD) for the coarser portion as well as the finer portion was calculated by applying the formula :

For coarser portion

$$MD = \frac{\{\sum Bd - (Bn \times x)\}}{N} \times 2$$

For finer portion :

$$MD = \frac{\{(X \times G) - \sum cd\}}{N} \times 2$$

Where, $\sum Bd$ = the total sum of filament size tending to coarseness, Bn = No. of turns tending to coarseness, $\sum cd$ = total sum of filament size tending to fineness, N = total turn number of silk at every 100 revolutions, x = average filament size of cocoon silk

The rate of filament size from beginning to end (P_{AC})

$$P_{AC} = \frac{SC}{SA} \times 100$$

SA = Filament size in respect of 100 revolutions in the outermost (Coarser) layer

SC = Filament size in respect of 100 revolutions in the innermost (finer) layer

Results

The comparative rearing performance pertaining to fecun-

dity, total larval duration, fifth age larval duration, pupation rate, cocoon weight, shell weight and cocoon shell ratio are presented in Table 1.

Table 2 clearly indicates the comparative quality parameters of fine denier hybrid along with productive and robust hybrid. The filament size deviation from outermost layer to innermost layer is depicted in Fig. 1. The average size deviation (MD) of the hybrids utilized for the study is presented in Table 3.

Among the cocoon characteristics, the fine denier hybrid expressed superiority over CSR2 \times CSR5 and CSR18 \times CSR19 for cocoon weight, shell weight, filament length, non breakable filament length and denier. However, CSR2 \times CSR5 excelled in cocoon shell ratio. The higher cocoon shell ratio in productive hybrid could be attributed to thicker filament with shorter filament length when compared to CSR48 \times CSR5. Among the reeling characters, the reelability in fine denier hybrid is less (77%) and it is mainly due to less denier (2.47) and longer filament length (1474 m). The silk waste in fine denier hybrid is also less (7.5) when compared with CSR2 \times CSR5 and CSR18 \times CSR19. Among the quality parameters, the standard deviation in CSR48 \times CSR5 is less than 1 when compared to CSR2 \times CSR5 (1.1) and CSR18 \times CSR19 (1.33). The elongation strength in CSR48 \times CSR5 is high (22.32) when compared with the control CSR2 \times CSR5 (20.5) and CSR18 \times CSR19 (20.98) as shown in Table 2.

There is not much difference between the total sum of coarser portion and finer portion in fine denier hybrid, while the coarser portion is more (26.3) in CSR2 \times CSR5 and finer portion is more in CSR18 \times CSR19 (20.38). However, the MD of coarser and finer portion is same in CSR48 \times CSR5 and CSR2 \times CSR5 and less in CSR18 \times CSR19 (0.268 and 0.261 respectively). The PAC in CSR2 \times CSR5 (41.63) is less than fine denier hybrid and is more (233.71) in CSR18 \times CSR19 (Table 3).

The average denier variation from outer most layer of the cocoon to innermost layer of the cocoon in thin denier hybrid along with productive and robust hybrids are well

Table 1. Comparative rearing performance of fine denier breed JPN8 along with CSR2, CSR5, CSR18 and CSR19

	Fecundity	Total larval duration Days : Hrs	5 th instar larval duration Days : Hrs	Pupation rate (%)	Cocoon weight (g)	Shell weight (cg)	Cocoon shell ratio (%)
JPN8	634	23 : 06	6 : 06	93.5	1.87	40.35	21.6
CSR2	593	23 : 20	7 : 06	93.2	1.84	41.40	22.6
CSR5	538	24 : 00	7 : 18	85.4	1.65	37.40	22.8
CSR18	544	23 : 06	7 : 00	91.0	1.96	42.30	21.8
CSR19	533	23 : 00	6 : 18	88.1	1.57	32.90	21.2

Table 2. Comparative performance of productive, robust and special hybrid for quality parameters

Particulars	CSR2 × CSR5	Grade	CSR18 × CSR19	Grade	CSR48 × CSR5	Grade
Rearing Parameters						
1. Total larval duration	23 days : 00 hrs		22 days : 00 hrs		23 days : 00 hrs	
2. Fifth instar larval duration	6 days : 12 hrs		5 days : 12 hrs		6 days : 04 hrs	
3. Pupation rate (%)	89.7		94.2		96.8	
4. Cocoon yield/ 100 dfls (kg.)	87.75		70.50		96.25	
Cocoon characteristics						
1. Cocoon weight (g)	1.892		1.613		2.153	
2. Shell weight (g)	0.462		0.338		0.488	
3. Cocoon shell ratio (%)	24.42		20.95		22.6	
4. Average filament length (m)	1091		903		1474	
5. Non breakable filament length (m)	987		753		1135	
6. Average filament denier	2.90		2.45		2.47	
Reeling Characteristics						
1. Reelability (%)	90.50		80.80		77	
2. Renditta	5.13		6.66		5.3	
3. Raw silk recovery (%)	79.83		69.83		82.3	
4. Waste % on silk weight	10.00		14.40		7.5	
Quality Characteristics						
1. Average size (d)	21.90		20.30		14.98	
2. Windingbreaks/40 skeins/hour	4	4A	4	4A	6	4A
3. Standard deviation (d)	1.10	4A	1.33	3A	0.983	3A
4. Max. size deviation (d)	2.9	4A	3.0	4A	1.322	4A
5. Evenness variation	I	4A	140	4A	170	3A
(No. of stripes/ 100 panels)	II	4A	0	4A	0	4A
	III	4A	0	4A	0	4A
6. Neatness (%)	95	4A	96	4A	96	4A
7. Low neatness (%)	92	4A	93	4A	95	4A
8. Cleanness (%)	98	4A	98	4A	97	4A
9. Tenacity (g/d)	3.90	4A	4.00	4A	3.70	4A
10. Elongation (%)	20.50	4A	20.98	4A	22.32	4A
11. Cohesion (Strokes)	90	4A	66	4A	110	3A
Overall Grade		4A		3A		3A

depicted in Fig. 1. The fine denier hybrid and one of the control (CSR2 × CSR5) exhibits gradual slope of the curve, while CSR18 × CSR19 has shown lower denier in the beginning followed by slight increase in the denier (From 200 m to 400 m) and again decrease from 500 m onwards (Fig. 1).

Discussion

The fine denier hybrid expressed lower reelability when compared to the control indicating that longer the filament lesser will be the reelability and size of the filament. The present findings parallels the earlier findings (Ooi and Yamashita (1977); Miyajima *et al.* 2001). The low reelability in fine denier hybrid is well compensated with

low renditta, silk waste percentage and higher silk recovery (Table 2).

The comparative quality parameters in the hybrids indicated the production of fine denier (14.98 d) silk for the first time in India. This is mainly because of finer denier (Individual cocoon denier: 2.48 d) of CSR48 × CSR5 when compared to the control. To produce 15 denier silk, 6 cocoons are to be constantly maintained in CSR48 × CSR5, while in CSR2 × CSR5 five cocoons are required. This shows that the strength of the yarn produced from CSR48 × CSR5 is higher with less variation in the filament size when compared to the control. The fine denier hybrid scored "4A" grade for almost all quality parameters except for standard size deviation and evenness variation-I ("3A" grade). For 15 denier silk, the standard deviation should be 0.90, but in the fine denier hybrid, the

	Slope	Filament length	Maximum size	Minimum size	Difference in the size
CSR48 × CSR5	-0.0022	1365	3.9	1.4	2.6
CSR2 × CSR5	-0.0026	1133	4.4	1.3	3.1
CSR18 × CSR19	-0.0014	1197	3.1	1.4	1.7

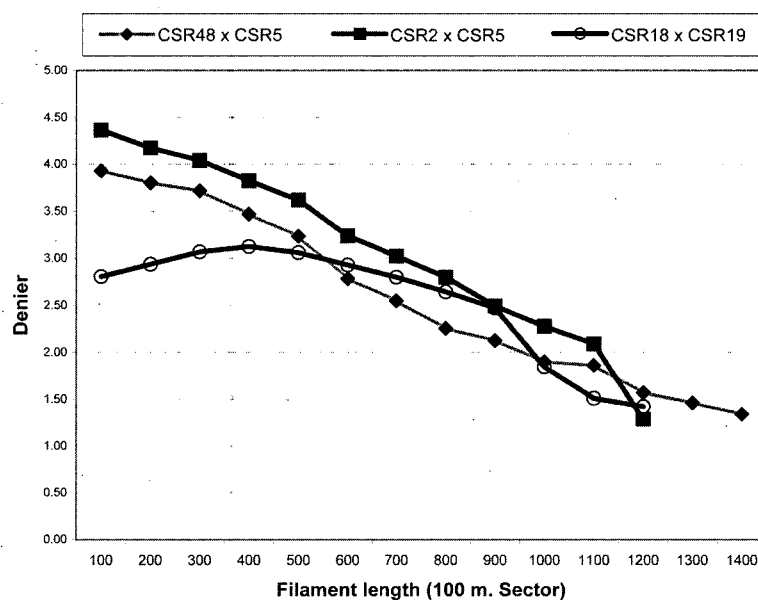


Fig. 1. Size deviation in bivoltine hybrids.

size deviation is 0.983. This negligible difference has resulted in the production of “3A” grade silk. The evenness variation-I is slightly at the higher side and this demerit has been well compensated by higher neatness, cleanness, tenacity, elongation and cohesion. In addition, it has been well documented that “evenness variation is not a racial character and it is dependent on reeling aspects (Rui, 1998). The present findings is similar to the results of Yamamoto *et al.* (1995), who succeeded in developing super fine silk producing hybrid Hakugin with longer filament, less denier, low reelability with higher tenacity, neatness and cohesion.

The average size deviation in fine denier hybrid and productive hybrid CSR2 × CSR5 is observed to be same (MD of coarser portion is 0.76 and finer portion is 0.75) indicating both the hybrids are highly productive (Table

3). In CSR18 × CSR19, the coarser portion is less (9.26) than the finer portion (20.38) indicating lesser silk content in CSR18 × CSR19 when compared to the productive hybrids. In fine denier hybrid CSR48 × CSR5, the total sum of filament size tending to coarser portion is 18.15 and the total sum of filament size tending to finer portion is 17.85 exhibiting almost 1 : 1 ratio between finer and coarser portion. Eventhough, the difference in MD in CSR48 × CSR5 and CSR2 × CSR5 is similar, but the total sum of filament size tending to coarser portion (26.3) is higher than the total sum of filament size tending to finer portion (10.95) in CSR2 × CSR5. This variation has resulted in lower P_{AC} in CSR2 × CSR5 indicating the thickness of the filament is higher and variation from the outer layer of the cocoon to inner layer is also high (Fig. 1). In robust hybrid, CSR18 × CSR19 the P_{AC} is very high

Table 3. Average size deviation (MD) in fine denier hybrid and the control

Hybrid	Total sum of filament size tending to		MD of coarser portion	MD of finer portion	Difference in MD between coarser and finer portion	P_{AC}
	Coarser portion	Finer portion				
CSR48 × CSR5	18.15	17.85	0.76	0.75	0.01	98.35
CSR2 × CSR5 (c)	26.3	10.95	0.76	0.75	0.01	41.63
CSR18 × CSR19(c)	9.26	20.38	0.268	0.261	0.07	233.71

(233.71) and this could be attributed to higher finer portion (20.38) than the coarser (9.26) portion (Table 3). The study is in concurrence with the findings of Mahadevappa *et al.* (2000) who have reported that among many important characteristics like filament length and denier, denier variation along the length of single cocoon and among the cocoons within the population decides minimum and maximum denier variation of raw silk. The overall results clearly indicate the superiority of fine denier hybrids in the important quality parameters such as denier, size deviation, higher neatness, tenacity, elongation and cohesion. Comparative denier variation for every 100 m in thin denier hybrid is found to be better than CSR2 × CSR5 and CSR18 × CSR19 as the difference between the maximum denier to minimum denier is high in CSR2 × CSR5 (Difference is 3.1d) and in CSR18 × CSR19 it is very less (Difference is 1.7), while in thin denier hybrid the difference is medium (2.6 d) (Fig. 1). This clearly indicates that the deviation of filament size in fine denier cocoon is gradual and confirms the findings of Miyajima *et al.* (2001) who have reported less size deviation in thin denier hybrid Hakugin than the control hybrid Kinshu × Showa. The robust hybrid exhibited lesser slope of the curve with less difference in denier between outer (3.1) and inner most layer (1.7) of cocoon (Fig. 1). In spite of this, the thin denier hybrid CSR48 × CSR5 overtakes the robust hybrid CSR18 × CSR19 in longer filament length of 1365 m (Fig. 1) and lesser difference in the total quantity of silk tending towards coarser and finer portion and lesser P_{AC} (Table 2). Eventhough, CSR18 × CSR19 produces 3A grade silk, the cohesion and elongation percentage are lesser than 14.98d producing hybrid, CSR48 × CSR5 (Table 2).

The new findings are highly beneficial to the Indian sericulture industry and the industry is badly in need of less denier silk for the manufacture of Zari and also to meet the demand of the present day generation who prefers lighter and thin fabrics such as georgette and chiffon. To conclude, it is the finer denier silk produced for the first time in our country is gifted with better quality and all merits to prevent the inflow of Chinese silk and thereby saving valuable foreign exchange.

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