INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

Volume-1, Issue-3 Sept-Nov-2011 *www.ijpaes.com* *ISSN 2231-4490*

EVALUATION AND SELECTION OF SUPERIOR BIVOLTINE HYBRIDS OF THE SILKWORM *BOMBYX MORI* L. FOR TROPICS THROUGH LARGE SCALE IN-HOUSE TESTING

Dayananda[1*], S B Kulkarni[2], P Rama Mohana Rao[3], O K Gopinath[4] and S Nirmal Kumar[5]

[1]Central Sericultural Research and Training Institute, Mysore, Karnataka, India.
[2]Central Sericultural Research and Training Institute, Mysore, Karnataka, India.
[3]Central Sericultural Research and Training Institute, Mysore, Karnataka, India.
[4]Central Sericultural Research and Training Institute, Mysore, Karnataka, India.
[5] Central Sericultural Research and Training Institute, Mysore, Karnataka, India.

ABSTRACT : Bivoltine silk excels in quality and productivity but do not display the crop stability in the field. The main reason attributed to such instability is that the bivoltines suffer badly in adverse conditions, prevailed in the field. In order to study the potentiality of newly developed bivoltine hybrids under simulated conditions of farmers before recommending them for field evaluation the present study was taken. In the present study six new bivoltine hybrids developed at Central Sericultural Research and Training Institute (CSRTI), Mysore along with the control hybrid were assessed under simulated conditions of farmers in a large scale at CSRTI for their various economic traits. The hybrids evaluated expressed a varied degree for the economic traits over the control hybrid, CSR2 x CSR4. Among the hybrids evaluated two hybrids recorded the average multiple traits evaluation index value of more than 50 viz., CSR50 x CSR51 (67.25) and D2 x D13 (53.84). Further these new hybrids recorded higher improvement over control in respect of cocoon yield (28.17 and 10.81 %), single cocoon weight (18.59 and 4.75 %), cocoon shell weight (25.65 and 7.591 %), cocoon shell percent (6.00 and 2.66 %) and filament length (18.13 and 6.53 %). Further the cocoons of these two hybrids have exhibited uniformity in cocoon size. Overall data indicate the superiority in the performance of CSR50 x CSR51 and it has profound influence in expressing the full potentiality in the field compared to other hybrids studied.

Key words: Bivoltine hybrids, *Bombyx mori* L., Cocoon uniformity, Economic traits, Evaluation index,

INTRODUCTION

It is a paradox that India is the second largest producer of mulberry raw silk in the country and largest silk consumers; it is also the world's largest importers of silk. As per the statistics available with Central silk board, more than 90 % of the silk produced in the country is of multivoltines x bivoltine hybrid cocoons. The silk produced from such cocoons falling into the lower grades in the international grades for silk and cannot be suitable to use in the power looms especially for warp threads and they prefer imported silk for want of quality. Estimated demand of international quality silk in our country is around 6000 mt. It is a well-known fact that bivoltine silk excels in quality and productivity; it is inevitable to go in for large-scale production of bivoltine sericulture in the country. Elite bivoltine silkworm breeds are the basic and important input for the production of high-grade raw silk. Keeping in view of the demand for quality silk in the country an attempt made by Basavaraja *et al.*, [1]; Datta *et al.*, ., [3, 4]; Datta *et al.*, [5, 6]; Suresh Kumar *et al*., [20, 23]; Mal Reddy *et al*., [10]; Dandin *et al.,* [2] led to the evolution of highly productive CSR bivoltine breeds which have potential to produce international grade silk. These CSR breeds in various combinations Viz., CSR2 x CSR4, CSR2 x CSR5, CSR3 x CSR6, CSR13 x CSR5, CSR12 x CSR6, CSR16 x CSR17, CSR18 x CSR19, CSR20 x CSR29, CSR46 x CSR47, CSR50 x CSR51 and etc were developed for commercial exploitation.

Vijayaprakash and Dandin, [24, 25] and Dayananda, [7] have reported that, though these bivoltine hybrids have the potentiality to produce more than 60 kg cocoons/100 dfls with 6-7 renditta and capable to produce 2-3A grade silk of international standard their full potential has not been exploited with the farmers due to various reasons. Suresh Kumar *et al*., [19, 21, 22] investigated that, even though these bivoltine breeds/hybrids are known for their productive merit, absence of genetic plasticity to buffer against adverse conditions prevailed in the field acts as a constraint to exploit the full economic potential of these new hybrids and these breeds/hybrids continue to suffer badly in adverse conditions prevailed in the field such as high temperature, humidity, germ load, poor leaf quality and low management. Tropical sericulture beset with wide and sudden fluctuation in the environment coupled with poor quality of mulberry and management practices by the farmers requires more flexible hybrids with genetic plasticity to buffer these adverse situations. The evolution of bivoltine breeds suited to farmer's conditions thus become necessary. Unless instability of bivoltine crop in the farmer's condition is suitably addressed, the farmers will not accept any productive hybrids with high quality silk traits. Selection of potential hybrids to serve as commercial exploitation material is one of the pre-requisites contributing to the success of hybrids under the prevailing environment. Dayananda, [7] reported that, evaluation of silkworm hybrids under large scale at in-house level helps to critically analyze the new hybrids in terms of effectiveness, easiness and economic benefit of them thereby to choose the most effective hybrid combination for commercial exploitation. In this background the present study has been undertaken to evaluate the newly developed productive bivoltine single hybrids under large scale at in-house level as per the simulated conditions of farmers and identify the suitable bivoltine hybrids for commercial exploitation to increase the quality silk production and raising the returns of the farmers to a higher level.

MATERIALS AND METHODS

The six newly developed robust/productive bivoltine hybrids of silkworm *Bombyx mori* L. viz., CSR50 x CSR51, CSR21DR x CSR28DR, CSR2DR x CSR4DR, D2 x D13, DNB7 x CSR2 and Gen1 x 4C along with the existing control hybrid, CSR2 x CSR4 were utilized in the study. These hybrids were reared thrice at Central Sericultural Research and Training Institute (CSRTI), Mysore during 2008-09 under large scale as per simulated conditions of farmer with a minimum of 50,000 eggs (Equaling to 100 disease free layings) per hybrid combination in four replications by following shoot rearing technique on V1 mulberry leaf and evaluated for their various economic traits. The cocoons were harvested on 6th day of mounting and assessed the following day. Samples of three kg cocoons from each replication were reeled on multiend reeling machine at Silk Reeling Unit of CSRTI, Mysore for assessing the reeling parameters. In order to know the cocoon size variability, one hundred cocoons were randomly picked up and three cocoon size variables viz., cocoon length, cocoon width and length/width index were determined. Cocoon length and width were measured by using vernier calipers. Variability in cocoon size was determined on the basis of standard deviation and co-efficient of variation as suggested by Mano [11].

Observations on various economic traits recorded from three rearing trials were pooled together and analyzed statistically by 2way ANOVA using Indo-stat package. Evaluation Indices (E.I) were also determined as per Mano *et al*. [12]:

$$\text{Evaluation Index} = \frac{A - B}{C} \times 10 + 50$$

Where,

A= Value of a particular hybrid for a character.
B= Mean value of particular trait of all the hybrids combinations.
C= Standard deviation of particular trait of all the hybrids combinations.
10= Standard Unit.
50= Fixed value

RESULTS

The six newly developed bivoltine hybrids of silkworm *Bombyx mori* L. viz., CSR50 x CSR51, CSR21DR x CSR28DR, CSR2DR x CSR4DR, D2 x D13, DNB7 x CSR2 and Gen1 x 4C along with the existing control hybrid, CSR2 x CSR4 were evaluated under large scale as per the simulated field conditions at TVDC (Technology Validation and Demonstration Center) of CSRTI, Mysore. Performance of the newly developed hybrids was compared with that of control CSR2 x CSR4 to choose the promising one. Comparative performance and its statistical analysis along with Evaluation Index values of different bivoltine hybrid combinations are presented in Table 1. Among the hybrids tested, two hybrids Viz., CSR50 x CSR51 and D2 x D13 exhibited maximum average evaluation index value of 67.25 and 53.48 respectively and CSR50 x CSR51 was characterized itself by exhibiting evaluation index values of >50 for all the nine characters studied. D2 x D13 has recorded index value > 50 for seven out of nine characters. Analyses of data indicate that all the hybrids utilized in the study vary significantly in respect of most of the parameters studied. The highest cocoon yield/10,000 larvae brushed (by number) was recorded in CSR50 x CSR51 (8425) and the lowest in CSR21DR x CSR28DR (7247). The same trend was recorded in respect of cocoon yield by weight. The highest cocoon yield /50,000 eggs (79.602 kg) was recorded in CSR50 x CSR51 followed by D2 x D13 (68.817 kg) and the lowest in CSR21DR x CSR28DR (58.127 kg). The highest cocoon weight (2.073 g), cocoon shell weight (0.480 g) and cocoon shell percent (23.15) were recorded in CSR50 x CSR51 followed by D2 x D13 which recorded 1.831 g, 0.411 g and 22.42 of cocoon weight, shell weight and shell percent, respectively. The highest filament length of 1140 m was recorded in CSR50 x CSR51 followed by 1028 m in D2 x D13 and the lowest filament length of 961 m was recorded in DNB7 x CSR2. Raw silk percent has ranged from 15.2 (DNB7 x CSR2) to 18.24 % (CSR50 x CSR51) and neatness ranged from 92.67 p (CSR21DR x CSR28DR) to 91.33 p (Gen1 x 4C and CSR2 x CSR4).

Table 1: Performance and average evaluation indices of improved bivoltine hybrids under large scale in-house testing

S.No.	Hybrid combination	Cocoon yield /10,000 larvae brushed		Cocoon yield/ 50000 eggs (kg)	Cocoon Weight (g)	Cocoon Shell Weight (g)	Cocoon Shell (%)	Filament Length (m)	Raw Silk (%)	Neatness (p)	Average E.I value #
		No.	Wt (kg)								
1	CSR50 x CSR51	8425 (59.62)	17.47 (68.45)	79.602 (69.63)	2.073 (71.17)	0.480 (71.72)	23.15 (70.10)	1140 (70.99)	18.24 (65.55)	92.33 (58.02)	67.25
2	CSR21DR x CSR28DR	7247 (36.25)	13.11 (40.10)	58.127 (40.26)	1.809 (47.15)	0.394 (46.08)	21.80 (44.26)	990 (47.24)	17.11 (54.15)	92.67 (64.25)	46.64
3	CSR2DR x CSR4DR	7321 (37.72)	13.47 (42.47)	59.500 (42.14)	1.840 (49.97)	0.399 (47.57)	21.70 (42.34)	967 (43.60)	16.00 (42.95)	91.67 (45.55)	43.81
4	D2 x D13	8407 (59.26)	15.40 (54.97)	68.817 (54.88)	1.831 (49.16)	0.411 (51.15)	22.42 (56.12)	1028 (53.26)	16.15 (44.47)	92.33 (58.02)	53.48
5	DNB7 x CSR2	8360 (58.33)	15.33 (54.55)	66.102 (51.17)	1.834 (49.43)	0.399 (47.57)	21.77 (43.68)	961 (42.65)	15.20 (34.88)	91.67 (45.55)	47.53
6	Gen1 x 4C	7787 (46.97)	13.60 (43.31)	62.489 (46.23)	1.747 (41.51)	0.385 (43.40)	22.02 (48.47)	1001 (48.98)	17.09 (53.95)	91.33 (39.31)	45.79
7	CSR2 x CSR4	8033 (51.84)	14.04 (46.15)	62.106 (45.70)	1.748 (41.60)	0.382 (42.50)	21.84 (45.02)	965 (43.28)	17.10 (54.05)	91.33 (39.31)	45.50
Mean		7940	14.63	65.249	1.840	0.407	22.10	1007	16.70	91.90	
SD±		504.18	1.54	7.31	0.11	0.03	0.52	63.16	0.99	0.53	
CV		6.35	10.51	11.21	5.97	8.24	2.36	5.27	5.94	0.58	
CD		602.831**	1.554**	11.033*	0.169*	0.038**	1.381	76.69**	2.23	1.821	
SE±		196.642	0.504	3.581	0.055	0.012	0.448	24.888	0.723	0.590	

Data in parentheses are evaluation Indices for the trait; # indicates average of evaluation indices; * and ** denote significant differences at 5% and 1% levels, respectively.

Improvement percent in the performance of new hybrids over the control hybrid, CSR2 x CSR4 are presented in Table 2.

Maximum improvement was recorded in CSR50 x CSR51 for all the nine characters studied viz., cocoon yield/10,000 larvae brushed by number (4.88 %), by weight (17.47 %), cocoon yield/50,000 eggs (28.17 %), cocoon weight (15.59 %), shell weight (25.65 %), shell percent (6.00 %), filament length (18.13 %) raw silk (6.67 %) and neatness (1.09 %) over the control hybrid, CSR2 x CSR4. The hybrid D2 x D13 expressed improvement over the control for eight out of nine characters studied. CSR21DR x CSR28DR and DNB7 x CSR2 recorded the improvement for six out of nine characters. Improvement over control for five out of nine characters was found in another two hybrids studied.

Table 2: Improvement percent in the performance of improved bivoltine hybrids over control (CSR2 x CSR4) under large scale in-house testing

S.No	Hybrid combination	Cocoon yield/10,000 larvae brushed		Cocoon yield/50000 eggs (kg)	Cocoon Weight (g)	Cocoon Shell Weight (g)	Cocoon Shell (%)	Filament Length (m)	Raw Silk(%)	Neatness (p)
		No.	Wt							
1	CSR50 x CSR51	4.88	17.47	28.17	18.59	25.65	6.00	18.13	6.67	1.09
2	CSR21DR x CSR28DR	-9.78	13.11	-6.41	3.49	3.14	-0.18	2.59	0.06	1.46
3	CSR2DR x CSR4DR	-8.86	13.47	-4.20	5.26	4.45	-0.64	0.21	-6.43	0.36
4	D2 x D13	4.66	15.40	10.81	4.75	7.59	2.66	6.53	-5.56	1.09
5	DNB7 x CSR2	4.07	15.33	6.43	4.92	4.45	-0.32	-0.41	-11.11	0.36
6	Gen1 x4C	-3.06	13.60	0.62	-0.06	0.79	0.82	3.73	-0.06	0.00

Cocoon size variability in the different hybrids studied is presented in Table 3. It is evident from the data that standard deviation on cocoon indices of the hybrids studied ranged from 7.88 to 10.86 with a minimum value of 7.88 observed for D2 x D13. Co-efficient of variation on cocoon indices of the hybrids studied ranged from 4.60 to 6.40 with a minimum value of 4.60 observed for D2 x D13. Cocoons of CSR50 x CSR51 and D2 x D13 exhibited standard deviation of 8.00 and 7.88 with coefficient variation of 4.71 and 4.60, respectively. Only these two hybrids exhibited standard deviation < 8 (considered as optimum) and their CV % was 4.71 and 4.60, respectively.

Table 3: Cocoon size uniformity in improved bivoltine hybrids under large scale in-house testing

S.No	Hybrid combination	Cocoon length (cm)	Cocoon width (cm)	Cocoon Index (L/Wx100)	C.V
1	CSR50 x CSR51	3.52±0.15	2.07±0.10	170.18±08.00	4.71
2	CSR21DR x CSR28DR	3.28±0.19	1.94±0.14	169.82±10.86	6.40
3	CSR2DR x CSR4DR	3.27±0.18	1.96±0.14	167.02±10.65	6.38
4	D2 x D13	3.49±0.13	2.04±0.10	171.41±07.88	4.60
5	DNB7 x CSR2	3.26±0.19	1.98±0.13	164.91±09.05	5.49
6	Gen1 x4C	3.31±0.15	2.01±0.13	165.23±08.36	5.06
7	CSR2 x CSR4	3.33±0.16	2.01±0.17	166.01±08.09	4.87

L: Cocoon length; W: Cocoon width; Data are the mean ± SD of 100 cocoons and measurement of cocoon width was taken in the central region

DISCUSSION

As Indian sericulture is being dominated by polyvoltine x bivoltine hybrids, which yields low quality silk, it necessitated the bivoltine sericulture in India. Attempts to improve bivoltine rearing in the field did not yield sustainable results. Even though they are known for their productive merit, absence of genetic plasticity to buffer against adverse conditions prevailed in the field acts as a constraint to exploit the full economic potential of these new hybrids as studied by Suresh Kumar *et al*., [19, 21, 22]. Dayananda, [7] reported that proper evaluation and identification of bivoltine hybrids under simulated farmer's conditions at in-house is very important and plays major role to derive suitable hybrids for commercial exploitation. Analysis of data on the basis of multiple traits in the hybrids tested revealed that the hybrid, CSR50 x CSR51 with average evaluation index value of 67.25 ranked first among the bivoltine hybrids tested. Besides, the hybrid D2 x D13 was also found promising with an average evaluation index value of 53.48.

Multiple traits evaluation index method of Mano *et al*., [12] is an important tool for the identification of promising silkworm hybrids. Naseema Begum *et al.,* [16] Narayanaswamy *et al*., [13]; Ramesh Babu *et al.,* [18]; Gangopadhyay *et al*., [9]; Nazia Choudhary and Ravindra Singh, [14]; Rama Mohana Rao *et al*., [17] and Nirupama *et al.,* [15] studied on the identification of promising silkworm hybrids using multiple traits evaluation index method. Higher survival, a measure of robustness coupled with higher cocoon weight, shell weight and shell percent recorded in the new hybrid, CSR50 x CSR51 confers its superiority with regard to tolerance against adverse conditions and consistency in the expression of productivity traits. Cocoon filament length is one of the important economic traits and is considered to have direct bearing on the merit of the hybrid. CSR50 x CSR51 recorded significantly higher filament length among the hybrids tested. Higher values recorded for raw silk percent are due to the recombinant genetic vigor of the breeds utilized in the hybrid preparation.

The less cocoon size variability observed in CSR50 x CSR51 is due to more uniformity of cocoons shape and size, which are important for getting the quality yarn. To obtain uniform filament size especially in auto and semi-automatic reeling machine cocoon size uniformity is very important as studied by Mano, [11]. Cocoon size variability was found less in the new hybrid CSR50 x CSR51 as indicated by standard deviation for cocoon index, which is within the admissible limit (≤8.00) with a minimum Co-efficient of Variation. The results are in agreement with that of Dandin *et al.,* [2]and Dayananda and Rama Mohana Rao, [8]. Results clearly indicate that, new silkworm hybrid CSR50 x CSR51 has profound influence in expressing the full potentiality in the field.

Evaluating and identifying the promising silkworm hybrid under large scale at in-house level as per the farmers simulated conditions should be the first step before popularization of new hybrids in the field in order to judge the potentiality of the new hybrids in the field. CSR50 x CSR51 was found to be significantly superior in most of the quantitative and qualitative traits consistently over the existing hybrid CSR2 x CSR4 and other hybrids tested. Hence CSR50 x CSR51 can be taken up effectively for further systematic evaluation and popularization in the field to increase the quality silk productivity in India. Besides the other factors responsible for sustainable crop production are protection of silkworm crops from diseases through fool proof disinfection procedure, introduction of high yielding mulberry variety, introduction of improved rearing technology, extension support and constant R & D support will revolutionized the sericulture industry in India.

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