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Research article

IDENTIFICATION OF IMPROVED CROSSBREEDS OF SILKWORM, *BOMBYX MORI* L. SUITABLE FOR SOUTHERN INDIA

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ABSTRACT: Majority of Indian Sericulture Industry is crossbreed oriented and contributes more than 80% of mulberry raw silk production. The most popular crossbreed in Southern India is PM x CSR2 (Kolar Gold), which has limitations like lower cocoon shell content and silk quality and high renditta. Central Sericultural Research and Training Institute (CSRTI), Mysore has developed several alternative crossbreeds to replace PM x CSR2 with higher shell content and improved fibre quality. In the present investigation, all the crossbreed combinations (99) utilizing nine multivoltine and eleven bivoltine breeds were evaluated in the laboratory and to short-list nine crossbreed hybrids based on multiple trait evaluation index. These were further evaluated in the laboratory for a period of two years and two promising crossbreeds *viz.*, NDV6 x CSR51 and L14 x CSR50 based on rearing and reeling performance encompassing economic traits. The promising crossbreeds have excelled for most of the quantitative and qualitative cocoon traits as compared to PM x CSR2. The better performance of improved crossbreeds (ICBs) might be due to the utilization of parental stocks with productive merits and vigour. These ICBs could be further subjected large scale field testing to increase the power loom quality raw silk production in India.

Key words: Cocoon productivity, improved crossbreed, economic traits, multiple trait evaluation.

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INTRODUCTION

More than 80% of the mulberry raw silk production in India depends on multivoltine x bivoltine hybrids (crossbreed). Owing to the field constraints, economic/social compulsions and agro-climatic conditions; crossbreed silk cocoons would continue to hold a place of importance. The general feeling in the silk industry that lustre and stiffness of crossbreed silk is superior to that of bivoltine silk and is preferred over by the handloom sector. The crossbreed production in Southern India is mainly by crossing females of Pure Mysore (PM) race with males of productive bivoltine breed, CSR2. Pure Mysore, though a hardy race and withstands varied climatic conditions, spins poor quality cocoons resulting in the production of low quality raw silk. Therefore, there is an urgent need to replace PM x CSR2 with better quality polyvoltines for improving qualitative and quantitative improvement in crossbreed silk production. Realizing the importance of hybrid vigour for commercial exploitation, PM x C.Nichi was utilized as first commercial crossbreed in South India [1], which was replaced by PM x NB4D2 during 1970's. Several studies were undertaken to evaluate and identify silkworm hybrids to improve productivity [2, 3, 4, 5, 6, 7, 8 & 9].

Based on multiple trait evaluation studies, several cross breeds including MY1 x NB18, BL24 x NB4D2, BL23 x NB4D2, P2D1 x NB18 and PM x CSR2 were developed at Silkworm Breeding laboratory of CSRTI-Mysore and authorized by Central Silk Board, Bangalore for commercial exploitation. Presently >90% of crossbreed dfls (Disease free layings) reared are from PM x CSR2. The existing crossbreed, PM x CSR2 has certain limitations like low cocoon shell, cocoon shell percentage and high renditta (quantity in kg of green cocoons required to produce one kg of raw silk) besides inferior silk quality.

Recently, there has been a remarkable development in bivoltine and polyvoltine silkworm breeding and many new productive silkworm breeds have been developed. There is tremendous scope to evaluate newly developed silkworm breeds and their hybrids in order to realize the complete potential in the field.
Keeping these in view, Silkworm Breeding laboratory of CSRTI-Mysore undertook a study to identify the improved crossbreeds utilizing productive bivoltine and multivoltine genetic resources through hybrid evaluation.

MATERIAL AND METHODS

Nine multivoltine (ND7, ND5, NP1, NDV6, AGL3, AGL5, L14, L15, PM) and eleven bivoltine breeds including two foundation crosses (CSR2, CSR2-SL, CSR4, CSR6, CSR17, CSR26, CSR27, CSR50, CSR51; foundation crosses: FC2, CSR2 x CSR27 and FC1, CSR6 x CSR26) were selected as parents based on productive merits for the preparation of all possible ninety-nine crossbreeds. These crossbreed combinations were evaluated once in the laboratory and nine crossbreeds were short-listed (ND7 x CSR4, ND7 x CSR26, ND7 x CSR27, NDV6 x CSR51, NP1 x FC2, AGL3 x CSR4, AGL3 x CSR17, AGL5 x CSR17 and L14 x CSR50) based on multiple traits evaluation index. The short-listed crossbreeds along with PM x CSR2 (control) were further evaluated for two years in the laboratory for ten economic characters. Based on rearing and reeling performance, two crossbreeds viz., NDV6 x CSR51 and L14 x CSR50 were identified as promising hybrids.
The rearing of crossbreeds was conducted during 2013-2014 following the standard package of rearing practices [10] at CSRTI-Mysore. Six rearings were conducted with three replications each and 300 larvae were retained after third-moult to assess the performance of crossbreed combinations. The post-cocoon parameters were analysed at Post Cocoon Evaluation Unit, CSRTI-Mysore adopting standard reeling procedure [11]. The data were recorded for cocoon yield per10000 larvae by number and weight, single cocoon weight, single shell weight, shell percent, filament length, raw silk percent, reelability, neatness and boil-off loss ratio. The rearing and reeling performance data recorded were pooled and statistically analysed using ANOVA. Multiple Trait Evaluation Index was computed for all the traits studied, except Boil-off loss by the following formula [12]:

$$\text{Evaluation Index} = [(A-B) \times 10/C] + 50$$

Where, as evaluation index for Boil-off loss was computed by using the modified formula [13]:

$$\text{Evaluation Index} = [(B-A) \times 10/C] + 50$$

Where,

A = Value of a particular crossbreed for a character
B = Mean value of particular trait of all the crossbreeds
C = Standard deviation of particular trait of all the crossbreeds
10 = Standard Unit
50 = Fixed value

RESULTS

The performance of polyvoltine and bivoltine breeds utilized in the study is presented in Table 1 and 2, respectively. The selected polyvoltines recorded fecundity ranging from 470-561, pupation (88-95%), cocoon weight (0.900-1.361g), shell weight (0.127-0.240g) shell percent (14.11-18.28), average filament length (490-694m) and neatness (86-88p). Similarly, the bivoltine parents recorded fecundity ranging from 464-576, pupation (90.2-97.90), cocoon weight (1.640-2.00g), shell weight (0.362-0.469g), shell percent (21.20-24.80), filament length (889-1212m) and neatness (92-93p).
The Rearing and reeling performance of nine shortlisted crossbreeds and PM x CSR2 (control) along with evaluation index (EI) values for five economic traits are shown in Table 3 and 4, respectively. Among the nine crossbreeds tested, NDV6 x CSR51 exhibited maximum average EI value of 62.11 followed by 58.67 in L14 x CSR50 for all the five rearing characters. The cocoon yield per 10000 larvae by number ranged from 9005 to 9360 showing insignificant difference among the crossbreeds tested; whereas significant variation ($p<0.05$) was observed in the other rearing parameters. The maximum cocoon yield per 10000 larvae by weight (19.243kg) was recorded in L14 x CSR50 followed by NDV6 x CSR51 (19.2kg). Higher cocoon weight (2.154g) and shell weight (0.459g) was recorded in NDV6 x CSR51. The maximum shell percentage of 21.70 was recorded in ND7 x CSR26 followed by 21.57 in L14 x CSR50.

Table 1. Performance of polyvoltine breeds selected for the study

Breed	Fecu-ndity (no.)	Pupation Rate(%)	Cocoon weight(g)	Shell weight(g)	Shell Ratio(%)	Filament length(m)	Neatness (points)
ND7	529	93.30	1.327	0.235	17.71	659	87
NDV6	561	95.00	1.361	0.240	17.63	694	87
ND5	543	91.00	1.305	0.235	18.00	626	88
NP1	480	88.42	1.225	0.219	17.87	605	87
AGL3	470	90.95	1.200	0.213	17.75	538	87
AGL5	495	89.72	1.201	0.210	17.48	518	86
L14	543	88.09	1.304	0.237	18.14	632	87
L15	551	89.03	1.258	0.230	18.28	560	87
PM	518	90.24	0.900	0.127	14.11	450	86

Table 2. Performance of bivoltine breeds selected for the study

Breed	Fecundity (no.)	Pupation Rate(%)	Cocoon weight(g)	Shell weight(g)	Shell Ratio(%)	Filament length(m)	Neatness (points)
CSR2	548	90.30	1.650	0.386	23.40	1116	92
CSR2 (SL)	464	91.80	1.640	0.362	22.10	1212	93
CSR4	515	91.10	1.680	0.369	22.00	1033	93
CSR6	520	90.30	1.650	0.363	22.10	898	92
CSR17	512	90.20	1.840	0.421	22.88	1048	92
CSR26	540	87.60	1.650	0.368	22.00	889	92
CSR27	518	93.70	1.730	0.428	24.80	1070	93
CSR50	549	97.90	1.840	0.433	23.40	1029	93
CSR51	520	90.60	1.600	0.339	21.20	1038	93
(FC2)	557	93.20	2.000	0.469	23.60	1208	93
(FC1)	576	94.20	1.790	0.385	21.50	1009	93

Table 3. Rearing performance of short listed crossbreeds

Crossbreed	Cocoon yield/10,000 larvae		Cocoon weight (g)	Shell weight (g)	Shell Ratio (%)	Average Evaluation Index
	Number	Weight (kg)				
ND7 x CSR4	9040 (37.61)	18.200 (51.92)	2.013 (55.48)	0.425 (54.29)	21.11 (51.80)	50.22
ND7 x CSR26	9040 (37.61)	17.840 (46.87)	1.973 (51.48)	0.429 (55.48)	21.70 (58.81)	50.05
ND7 x CSR27	9240 (53.44)	18.400 (54.72)	2.064 (60.58)	0.442 (59.38)	21.41 (55.15)	56.65
NDV6 x CSR51	9280 (56.61)	19.200 (65.93)	2.154 (69.58)	0.459 (64.48)	21.31 (53.98)	62.11
NP1 x FC2	9280 (56.61)	17.800 (46.31)	1.881 (42.28)	0.400 (46.79)	21.27 (53.49)	49.10
AGL3 x CSR4	9005 (34.83)	17.450 (41.41)	1.937 (47.88)	0.400 (46.79)	20.65 (46.66)	43.52
AGL3 x CSR17	9320 (59.78)	17.900 (47.71)	1.867 (40.88)	0.395 (45.29)	21.16 (52.29)	49.19
AGL5 x CSR17	9200 (50.28)	17.500 (42.11)	1.883 (42.48)	0.390 (43.80)	20.71 (47.34)	45.20
L14 x CSR50	9360 (62.95)	19.243 (66.53)	1.980 (52.18)	0.427 (54.89)	21.57 (56.83)	58.67
PM x CSR2 (Control)	9200 (50.28)	17.100 (36.50)	1.830 (37.18)	0.340 (28.81)	18.58 (23.65)	35.28
Mean	9197	18.06	1.958	0.411	20.95	
SD	126.27	0.71	0.10	0.03	0.90	
CD at 5%	NS	0.594**	0.119**	0.031**	0.211**	

Values in parentheses indicate evaluation indices

Reeling performance (Table 4) of the crossbreeds tested has also shown significant variation ($p<0.05$) in all the parameters. Similar to the rearing performance, reeling characters in NDV6 x CSR51 also exhibited maximum average EI value of 59.01 followed by 58.20 in L14 x CSR50. Average filament length ranged from 781 m (PM x CSR2) to 998m (L14 x CSR50), raw silk percent ranged from 12.68 (PM x CSR2) to 16.60 (AGL5 x CSR17), reelability ranged from 80.40 (ND7 x CSR4) to 86.50 (AGL5 x CSR17). Maximum boil-off loss was recorded in PM x CSR2 (27.89%) and the minimum was recorded in NDV6 x CSR51 (21.18%).

Table 4. Reeling performance of short listed crossbreeds

Crossbreed	Average Filament Length (m)	Raw silk (%)	Reelability (%)	Neatness (p)	Boil-off loss Ratio (%)	Average Evaluation Index
ND7 x CSR4	975 (56.03)	16.00 (51.59)	80.40 (29.87)	89.00 (58.58)	26.21 (46.92)	48.60
ND7 x CSR26	935 (49.48)	16.00 (51.59)	85.50 (55.66)	89.00 (58.58)	25.45 (51.01)	53.26
ND7 x CSR27	990 (58.49)	16.20 (53.37)	84.50 (50.60)	89.00 (58.58)	25.48 (50.84)	54.38
NDV6 x CSR51	958 (53.24)	16.29 (54.17)	85.39 (55.10)	89.00 (58.58)	21.18 (73.96)	59.01
NP1 x FC2	950 (51.93)	16.10 (52.48)	83.50 (45.54)	88.00 (44.28)	26.38 (46.01)	48.05
AGL3 x CSR4	920 (47.02)	15.90 (50.69)	86.10 (58.69)	88.00 (44.28)	26.78 (43.86)	48.91
AGL3 x CSR17	950 (51.93)	16.10 (52.48)	82.60 (40.99)	88.00 (44.28)	25.98 (48.16)	47.57
AGL5 x CSR17	925 (47.84)	16.60 (56.93)	86.50 (60.72)	88.00 (44.28)	26.89 (43.26)	50.61
L14 x CSR50	998 (59.80)	16.35 (54.70)	86.32 (59.81)	89.00 (58.58)	24.13 (58.10)	58.20
PM x CSR2 (Control)	781 (24.24)	12.68 (22.01)	83.00 (43.02)	87 (29.98)	27.89 (37.89)	31.43
Mean	938	15.82	84.38	88.40	25.64	
SD	61.02	1.12	1.98	0.70	1.86	
CD at 5%	124**	1.25**	NS	0.354**	1.562*	

Values in parentheses indicate evaluation indices

DISCUSSION

The main challenge before the silkworm breeders of India is to develop suitable crossbreed to produce quality raw silk; accordingly CSRTI-Mysore developed and introduced several hybrids for improving the crossbreed cocoon productivity and silk quality [4, 14&15]. Selection of potential hybrid combination for commercial exploitation is one of the pre-requisites to the success of crossbreeds under the given environment. In the present study, nine newly developed multivoltine breeds were tested with eleven bivoltines to identify promising crossbreeds. Analysis of variance computed for economic traits clearly shows significant variation ($p<0.05$) for majority of the characters indicating presence of both additive and non-additive genetic effects for expression.

Multiple traits evaluation index method [14, 16, 17, 18, 19, 20 & 21] was employed by several breeders to identify the most promising hybrid combinations. In the present investigation, multiple trait evaluation index method was employed to identify the top ranked crossbreeds. Study on the hybrid performance reveals better performance by the new crossbreeds over PM x CSR2 for various economic characters. It was interesting to note that new crossbreed, NDV6 x CSR51 ranked first by recording an EI value of >50 for all the characters with an average index of 62.11 and 59.01 for rearing and reeling characteristics, respectively. L14 x CSR50 stood second by recording an EI of >50 for all the characters with an average EI of 58.67 and 58.20 for rearing and reeling parameters.

CONCLUSION

Higher survival (>90%) coupled with higher cocoon weight recorded in the newly identified improved crossbreeds viz., NDV6 x CSR51 and L14 x CSR50 confirms their superiority over the popular commercial crossbreed (PM x CSR2) with regard to consistency in the expression of productivity traits than that of.

Higher values recorded for shell weight and raw silk percent might be attributed to the productive merits and more vigorous nature of genetic resources (parents) utilized. The newly identified crossbreeds could further tested in large scale with famers to increase the quality of crossbreed silk produced in India.

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